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Three Mile Island Unit 1 Probabilistic Risk Assessment

HUMAN ACTIONS ANALYSIS REPORT

Project Director
B. John Garrick

Project Manager
Douglas C. Iden

Principal Investigator
Frank R. Hubbard

Task Leaders
Mardyros Kazarians
Ali Mosleh
Harold F. Perla
Martin B. Sattison
Donald J. Wakefield

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Pickard, Lowe and Garrick, Inc.
Engineers • Applied Scientists • Management Consultants
Newport Beach, CA Washington, DC

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LIST OF ACRONYMS

Abbreviation	Definition
ACR	air-cooled reactor
ADV	atmospheric dump valve
AOV	air-operated valve
ATOG	abnormal transient operational guidelines
ATWS	anticipated transient without scram
BOP	balance of plant
Btu	British thermal unit
BWR	boiling water reactor
BWST	borated water storage tank
CARS	condenser air removal system
CAS	chemical addition system
CBVS	control building ventilation system
CCF	common cause failure
CFT	core flooding tank
CIV	containment isolation valve
CSF	conditional split fraction
CST	condensate storage tank
CRO	control room operator
CWS	circulating water system
DHCCW	decay heat closed cooling water
DHR	decay heat removal
DHRS	decay heat removal system
DHRW	decay heat river water
EFW	emergency feedwater
EOF	emergency operations facility
EPRI	Electric Power Research Institute
ESD	event sequence diagram
ESAS	engineered safeguards actuation system
ETC	event tree code
FSAR	Final Safety Analysis Report
FTAP	Fault Tree Analysis Program
GCR	gas-cooled reactor
GPUN	GPU Nuclear Corporation
HCR	human cognitive reliability
HPI	high pressure injection
HPIS	high pressure injection system
HVAC	heating, ventilating, and air conditioning
ICCS	intermediate closed cooling system
ICCW	intermediate closed cooling water
ICS	integrated control system

LIST OF ACRONYMS (continued)

Abbreviation	Definition
LBIS	line break isolation system
LCO	limiting condition for operation
LER	Licensee Event Report
LOCA	loss of coolant accident
LOFW	loss of main feedwater
LONS	loss of nuclear services
LORI	loss of reactor coolant system inventory
LORW	loss of river water
LOSP	loss of offsite power
LPI	low pressure injection
LPIS	low pressure injection system
LSS	low speed stop
MCC	motor control center
MFPT	main feedwater pump trip
MFW	main feedwater
MGL	multiple Greek letter
MOV	motor-operated valve
MSIV	main steam isolation valve
MSLB	main steam line break
MSS	main steam system
MSSV	main steam safety valve
MSV	main steam valve
MUP	makeup and purification
NPE	Nuclear Power Experience
NRC	U.S. Nuclear Regulatory Commission
NSCCS	nuclear services closed cooling system
NSCCW	nuclear services closed cooling water
NSRW	nuclear services river water
NSSS	nuclear steam supply system
OPM	Operations Plant Manual
OTSG	once-through steam generator
PCL	panel center left
PCR	panel center right
PDS	plant damage state
PLF	panel left front
PLG	Pickard, Lowe and Garrick, Inc.
P&ID	piping and instrumentation drawing
PORV	power-operated relief valve
PRA	probabilistic risk assessment
PRF	panel right front
PSHX	primary to secondary heat transfer
PSV	pressurizer safety valve
PWR	pressurized water reactor

LIST OF ACRONYMS (continued)

Abbreviation	Definition
RBCU	reactor building cooler unit
RBEC	reactor building emergency cooling
RBD	reliability block diagram
RBS	reactor building spray
RBSS	reactor building spray system
RCDT	reactor coolant drain tank
RCP	reactor coolant pump
RCS	reactor coolant system
RPS	reactor protection system
SCCW	secondary closed cooling water
SCM	subcooled margin
SGTR	steam generator tube rupture
SLB	steam line break
SLRDS	steam line rupture detection system
SRO	senior reactor operator
SRW	secondary river water
SSCCS	secondary services closed cooling system
SSE	safe shutdown earthquake
SSS	support state system
STA	shift technical advisor
TBV	turbine bypass valve
TMI-1	Three Mile Island Nuclear Generating Station, Unit 1
ULD	unit load demand

1. OVERVIEW AND SUMMARY OF RESULTS

This report describes the methodology, analysis, and results of an evaluation of operator performance as it relates to the analysis of accident scenarios in the TMI-1 PRA.

1.1 OVERVIEW

The objective of the human actions analysis task is to enhance the completeness of the plant event sequence models with respect to both favorable and unfavorable operator actions. The purpose of the human actions analysis task is then to quantify the frequency of failure of selected human actions in order to help delineate the human contribution to the plant damage state frequencies.

Current techniques for human action analysis are limited. Different analytical models are required for different types of human errors, and there are few operator error data available that are relevant to the operation of nuclear power plants at a level of detail suitable for incorporation into this analysis. The field of human action analysis is evolving rapidly. The approach adopted in this study benefited from a review of recent publications in the field. In particular, References 1-1 through 1-6 provided many useful ideas. In deciding which approaches to adopt for this study, repeatability and clarity were highly valued. Plant-specific design and procedures were a major input to the analysis of human actions adopted in this study. However, the level of detail in these plant features explicitly accounted for was limited. For example, no attempt was made to distinguish human error rates on the basis of whether power was available to all the indications in the control room. This deemphasis on the level of detail associated with each action was chosen because the amount of data available were judged insufficient to justify more detailed models at this time. By focusing on a smaller number of key influence factors (described in Section 2) in determining the human error frequencies, an attempt is made to be consistent in quantifying the impact of these factors on each of the human actions evaluated. In this way, the relative importance of the human actions should be preserved.

Different approaches are used for evaluating different types of human actions. In this study, human errors are first separated by type, according to the timing of the action. Figure 1-1 illustrates this classification of human actions by type. Actions that take place prior to the accident initiator may involve test and maintenance errors that can inadvertently result in misalignment of a system. Such actions are performed routinely, and errors in their performance only impact the plant at or below the systems level; i.e., degrades parts or all of only one system.

A second type of human action includes those actions that inadvertently initiate plant events; e.g., cause a reactor trip. These events are implicitly included in the historical data base that is used to estimate the frequency of such events. Therefore, explicit quantification of the specific human actions that may initiate plant events was not performed.

The third type of human actions comprises those that may take place after some other event initiates a plant accident sequence. As illustrated in Figure 1-1, this third type of human error is conveniently divided into two subtypes: dynamic human errors and recovery actions. Actions of each subtype are described and evaluated in this study. Dynamic human actions are those that the operator performs to supplement the automatic response of plant systems for event mitigation, actions that he may take that change or detract from the automatic response of plant systems, and specific actions to restore previously failed systems by realigning the system to bypass the failed equipment.

This first category of dynamic human actions can also be considered a recovery action. However, for the purpose of presentation and because of a different analysis approach, the term, recovery actions, is used in this study to refer to more complex activities to restore previously failed systems. Such recovery actions may involve a variety of different restoration activities because the equipment failure modes may be due to any one of a number of failure causes and each failure cause may require a different course of recovery action. Also, the evaluation of such recovery actions may be further complicated because the time available to perform the recovery action may not be excessive; therefore, time constraints must also be explicitly considered in detailed recovery action analysis. Actions that involve the restoration to service of equipment previously known to have failed along an accident sequence must be modeled by a detailed recovery analysis; e.g., restore offsite power. Actions involving the restoration of a system by functionally bypassing equipment that has failed, using only other, operable equipment, may be modeled using the dynamic action analysis methods; e.g., isolate a leaking heat exchanger.

The human actions evaluated in this study may be categorized by type, as illustrated in Figure 1-1. Table 1-1 defines the human actions quantified in this study and categorizes them by type. The designators listed for the failure frequency of each human action are prefixed by the letter "H" to indicate that it is a human error rate. The next two letters identify the top event for which the human error rate is used in the analysis. Finally, an integer suffix is used to enumerate the different actions used in each analysis. For some top events, none or only one human action is evaluated. For the analysis of other top events, several human actions must be considered.

Review of Table 1-1 reveals that human actions are evaluated for both frontline (e.g., BW, C3, CA, CD, CS, etc.) and support system top events (e.g., CV, EA, and NS).

The methodologies for evaluating each type are described in Section 2. Information relevant to the assessment of all human actions for TMI-1 is presented in Section 3. Documentation for the assessed evaluation of each specific human action is provided in Section 4.

1.2 SUMMARY OF RESULTS

The human actions quantified in this study are defined in Table 1-1. A total of 137 distinct human actions were quantified separately. Of these, 31 were errors involving routine tasks that take place prior to initiation of a plant transient. There were 95 dynamic human actions and 11 recovery actions explicitly modeled. The quantification of these human errors is described in more detail in Section 4. Tables 1-2, 1-3, and 1-4 summarize the quantitative results for the actions defined in Table 1-1. Table 1-2 provides the probability of failure frequency distributions for the dynamic and recovery actions. Table 1-3 provides the distributions for the basic human error rates used for quantifying the error frequencies for routine human actions, nonviable dynamic actions, and errors of misdiagnosis. Table 1-4 indicates how the basic human error rates are combined to quantify the error frequencies for the routine human actions.

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TABLE 1-1. TMI HUMAN ACTIONS FOR QUANTIFICATION

Designator	Human Action Type	Description
HAM1	Dynamic	Operator fails to bypass the instrument air dryer transfer valve in the event it sticks between dryers restricting flow to both flow paths. It takes about 10 minutes for the air pressure to drop to low levels. After loss of air pressure, reserve bottles on the seal injection and intermediate cooling air-operated valves maintain their position for about another 10 minutes. The bypass must be established before these valves fail closed.
HAM2	Dynamic	Operator fails to manually reload the instrument air compressors following a loss of offsite power. One train of vital electric power is also assumed failed.
HBW1	Dynamic	Operator fails to start the HPI pumps and to open the BWST suction valves, MU-V14s (used in BW-2), and to open the MU-V16s to establish HPI cooling.
HBW2	Dynamic	Like HBW1, but after recovery from station blackout (used in BW-3, RE-1, or RE-3 success). EFW is conservatively assumed unavailable.
HBW3	Dynamic	Like HBW1, but after recovery from loss of river water (used in BW-4). EFW is assumed available.
HC31	Dynamic	Operator fails to isolate seal return using a push button in the control room for containment isolation purposes, given that the 30-psig reactor building pressure actuation system fails. A severe core damage sequence is assumed in progress. The action must be completed before the containment failure pressure is reached.
HCA2	Dynamic	Operator fails to manually actuate the reactor building 4-psig containment isolation signal, given that the reactor building is unisolated, preventing pressure from ever reaching the 4-psig setpoint (purge is in progress at the time of the accident). Operator assumes that a core damage sequence is in progress.

TABLE 1-1 (continued)

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Designator	Human Action Type	Description
HCA3	utine	Operator miscalibrates two or more ESAS channels during the refueling outage calibration.
HCA4	Routine	The independent verifier fails to detect the miscalibration of two or more ESAS channels.
HCD1	Dynamic	Operator fails to initiate cooldown and depressurization if the ADVs and pressurizer spray are available. Also includes the remote manual action to open the low pressure injection valves (DH-V-4A and DH-V-4B) and to start the DHR pumps [used in CD-1 and CD-1(OP)].
HCD2	Dynamic	Operator fails to perform a slow cooldown and depressurization, given that he originally decided to attempt the cooldown but the usual equipment (RCPs, spray valve, or ADVs) was not available. This action may include local control of the ADVs if they originally fail to respond or locally opening the DH-V-4A and DH-V-4B valves if they fail [used in CD-1 and CD-1(OP)].
HCD3	Dynamic	Operator fails to take action to cool down and depressurize by using ADVs and pressurizer spray and opens the DH-V4s for DHR cooling when vital bus ATA is not available. Operator must use the backup manual loader [used for CE-1(AA)]. A steam generator tube rupture sequence is assumed to have occurred.
HCD4	Dynamic	Like HCD1 except for steam generator tube rupture events. The decision to initiate cooldown and depressurization must be accomplished within 12 hours of the tube rupture [used in CE-1 and CE-1(OP)].
HCD5	Dynamic	Operator fails to initiate cooldown and depressurization using pressurizer vents and the PORV following a steam generator tube rupture and a loss of offsite power, which precludes pressurizer spray.
HCF1	Dynamic	Operator fails to remotely establish reactor building cooling after loss of river water using the industrial coolers.

TABLE 1-1 (continued)

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Designator	Human Action Type	Description
HCF2	Dynamic	Operator fails to remote manually regulate RBEC water pressure, given failure of RR-V6. The accident sequence evaluated is assumed to result in core damage and a continually rising containment pressure. It is assumed that 10 minutes are available for action before the pumps would fail.
HCS1	Routine	Frequency of misaligning the RBS test valves after testing.
HCS2	Routine	Error rate of the independent verifier failing to detect the misalignment in HCS1.
HCS3	Routine	Frequency of misaligning the RBS pressure switch isolation valves.
HCS4	Routine	Error rate of the independent verifier failing to detect the misalignment in HCS3.
HCS5	Dynamic	Frequency of the operator failing to actuate the containment spray system. The 30-psig actuation signal does not occur because a containment purge was in progress at the time of the accident and was not subsequently isolated. A core damage sequence is assumed to have occurred.
HCV1	Dynamic	Operator fails to realign the system to the normal (once-through) alignment in the event that the recirculation damper (AH-D-36) fails to open following an ESAS actuation or in the event chilled water is lost so that outside air is needed to limit the circulating air temperature.
HCV2	Dynamic	Operator fails to start a standby train of fans or.chilled water in the event that the operating.train fails. Offsite power is assumed available.
HCV3	Dynamic	Fraction of the year that the chilled water system is not needed because the outside air temperature is sufficiently low. The operator action to align for once-through flow is treated separately.

TABLE 1-1 (continued)

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Designator	Human Action Type	Description
HCV4	Dynamic	Similar to HCV8 except that no ESAS signal is present. Operators fail to establish alternative cooling for the control building, given an initial loss of ventilation. Used for the LOCV initiating event.
HCV5	Dynamic	Failure of operator to manually open a single control building ventilation damper, which transferred closed, prior to overheating equipment in the affected room. All support systems are assumed available. A plant trip is assumed to have occurred.
HCV6	Dynamic	Operator fails to restart the control building ventilation fans and chilled water train following a loss of offsite power. A failure of one train of engineered safeguards power is also assumed lost.
HCV7	Dynamic	Operator fails to align the control building ventilation system to the recirculation mode when no ESAS signal is present. One of AH-D-5, AH-D-37, or AH-D-39 is assumed to have transferred closed. It is assumed that the event occurs during the time of year when the system is primarily on outside air.
HCV8	Dynamic	Operator fails to establish alternative control building ventilation using portable fans (or hallway fans) and elephant trunks to direct the flow. Ventilation is assumed lost initially. An ESAS signal is assumed present. It is assumed that 2 to 8 hours are available to establish the alternate ventilation.
HCV9	Dynamic	Similar to HCV8 except that ventilation is lost only after an initial period of 2 hours. During the first 2 hours, DC power supplies the vital instrument buses, which hold the room dampers open although engineered safeguards electric power train B is assumed failed. An ESAS signal is assumed present.
HDEA1	Routine	Duration (in hours) until detection of multiple miscalibrated ESAS channels.

TABLE 1-1 (continued)

Designator	Human Action Type	Description
HDEA2	Routine	Duration until detection of single miscalibrated ESAS channel (in hours).
HDEF1	Routine	Duration until detection of a valve misalignment following testing of a pump in the EFW system.
HDEF2	Routine	Duration until detection of an error in the calibration of a sensor channel.
HDH1	Dynamic	Operators fail to turn off an operable DHR pump following ESAS actuation, given that cooling water flow from the corresponding DHCCW pump is not available. The operating DHR pump must be secured within approximately 20 minutes to avoid overheating.
HDH2	Routine	Operator misaligns the DHR system after pump testing (used in all LP and DH split fractions).
HDH3	Routine	Error rate of the independent verifier failing to detect the misalignment of HDH2.
HDT1	Dynamic	Operator fails to take action to prevent boron concentration effects following a LOCA when the plant is in recirculation from the containment sump.
HDRT1	Routine	Average duration until detection of error of failing to remove bypass from RPS after testing (used with HRT1 and HRT2).
HDRT2	Routine	Duration to detection of multiple errors of calibration of RPS channels (used with HRT3 and HRT4).
HDRT3	Routine	Duration to detection of error of miscalibration of a single RPS channel (used with HRT5 and HRT6).
HEA1	Routine	Frequency of miscalibrating two or more ESAS channels after testing.
HEA2	Routine	Error rate of the independent verifier failing to detect the miscalibration of HEA1.
HEA3	Routine	Frequency of miscalibrating one ESAS channel after testing.

TABLE 1-1 (continued)

Designator	Human Action Type	Description
HEA4	Routine	Error rate of the independent verifier failing to detect the miscalibration of HEA3.
HEF1	Dynamic	Operator fails to replenish the 2-hour backup air supply after a loss of offsite power in which the instrument air compressors were not successfully loaded onto a diesel generator in time or to send an auxiliary operator to open the EF-V30s.
HEF2	Dynamic	Operator fails to properly control EFW flow locally after a loss of automatic control. The EF-V-30s fail closed and must be opened locally to ensure success of Top Event EF-. System actuation was previously successful.
HEF3	Dynamic	Operator restores instrument air by changing air bottles in the 2-hour backup air system (used in the steam line break tree for a break in the intermediate building).
HEF4	Dynamic	Similar to HEF1 except for the case when all engineered safeguards electric power is lost. Operator fails to replenish the 2-hour backup air supply or to send an auxiliary operator to open the EF-V30s.
HEF5	Dynamic	Operator fails to manually actuate emergency feedwater, given that automatic actuation fails. The allowed time for action is 30 minutes.
HEF6	Routine	Operator fails to restore the EFW system to the normal alignment following test or maintenance. One train is then not available.
HEF7	Routine	Failure of the independent verifier to detect the EFW system restoration error described above for HEF6.
HEF8	Dynamic	Operator fails to properly control EFW flow locally after one or more of the EF-V-30s fails open mechanically or by failure to receive a signal to close down. This action is used in the evaluation of Top Event EF+.

TABLE 1-1 (continued)

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Designator	Human Action Type	Description
HEF9	Dynamic	Operator fails to properly control EFW flow remotely after one or more of the EV-V-30s fails open mechanically or by failure to receive a signal to close down. This action is also used in the evaluation of Top Event EF+.
HEF10	Dynamic	Operator fails to close CO-V-13 or CO-V-14B, given that the hotwell high level alarm comes in and the problem is due to CO-V-7 or CO-V-8 failing open.
HFW4	Dynamic	Operator fails to manually control OTSG level after automatic control has failed.
HFW5	Dynamic	Operator fails to manually control main steam pressure after automatic control has failed.
HGA1	Dynamic	A conservative estimate of the failure to recover offsite power within 6 hours, assuming at least one diesel generator is running.
HHA1	Dynamic	Operators fail to instruct divers clearing debris from the pump house to surface and stand clear so that the DHRW pump out for maintenance can be restored.
HHL1	Routine	Frequency of leaving the decay heat removal system misaligned following test. Manual valves DH-V-12A and DH-V-12B are not restored to the normal system alignment.
HHL1A	Dynamic	Operator fails to remotely open the DHR drop line valves to go on DHR following a successful normal plant cooldown (1C-ESV MCC is available).
HHL1B	Dynamic	Operator fails to locally open the DHR drop line valves to go on DHR following a successful normal plant cooldown (used for HL-1 if 1C-ESV MCC is failed).
HHL2	Routine	Error rate of the independent verifier failing to detect the misalignment of DH-V-12A or DH-V-12B described by HHL1.

TABLE 1-1 (continued)

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Designator	Human Action Type	Description
HHP1	Dynamic	Operator fails to manually start makeup pump B following a loss of offsite power. One vital train of electric power and the opposite train of decay heat closed cooling water fail. Makeup pump B is stripped as a result of the loss of power and must be manually loaded onto the diesel generator.
HIC1	Dynamic	Operator fails to take manual control of the main feedwater valves, given auto-ICS control failure.
HIC2	Dynamic	Operator fails to manually trip the main feedwater valves to control flow.
HIC3	Dynamic	Operator fails to set the manual loader to zero, given that the manual loader was not initially set to zero.
HIC4	Dynamic	Operator fails to manually control the TBVs and ADVs using the hand/auto station, given failure of autopower from bus ATA. It is assumed that 5 minutes are available for action.
HIC5	Routine	Frequency of the atmospheric dump valve manual loader to inadvertently be left at the nonzero (or normal) position.
HIC6	Routine	Fraction of time that the backup manual loader would be left in the nonzero position if inadvertently mispositioned; i.e., frequency manual loader is used times the average duration until detection.
HID1	Dynamic	Operator fails to identify a steam generator tube rupture as such; failure assumes that the operator takes it for a very small LOCA.
HID2	Dynamic	Similar to HID1 except that offsite power is lost. Failure of the operator to identify a steam generator tube leak. Flow to the main condenser is now not available.
HINJ1	Dynamic	Operator fails to open MU-V14A and start the standby makeup pump to provide seal injection flow when no ESAS signal is present (used in INJ-1).

TABLE 1-1 (continued)

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Designator	Human Action Type	Description
HINJ2	Dynamic	Operator fails to locally open the makeup pump cross-connect valves (MU-V76A/B) and suction valve MU-V14B and to start makeup pump C after failure of makeup pumps A and B flow paths (used in INJ-2).
HINJ3	Dynamic	Operator fails to locally open the makeup pump cross-connect valves (MU-V76A/B) after failure of A and B makeup pump flow paths and an ESAS signal is present (used in INJ-4).
HINJ4	Dynamic	Operator failure to locally reopen MU-V20 after instrument air failure (Top Event AM failed) [used in INJ-1(AM), INJ-2(AM), INJ-3(AM), and INJ-4(AM)].
HLT1A	Dynamic	Operator fails to take actions to switch from the makeup tank to the BWST for makeup pump suction within 25 minutes during a normal cooldown.
HLT1B	Dynamic	Operator fails to take actions to provide makeup to the BWST from Unit 2 during cooldown within 24 hours.
HLT2	Dynamic	Similar to HLT1B except during a steam generator tube rupture after a failure to previously cool down and depressurize to go on DHR (used in LT-2). There are 8 hours available to make the transfer.
HMR1	Dynamic	Operator fails to reestablish makeup pump recirculation after ESAS closure of MU-V-36 and MU-V-37 and after successful manual throttling of HPI flow. Failure to establish recirculation may result in failure of one or more makeup pumps.
HNS1	Dynamic	Operator fails to isolate a leaking, ruptured nuclear services heat exchanger. All support is assumed available. It is assumed that 30 minutes are available for action between the time a surge tank low level alarm is received until a loss of system cooling capability.
HNS2	Dynamic	Operator fails to start an NSRW pump, given a loss of one train of AC power, and the remaining powered pump was not selected to engineered safeguards. Failure of power to 1C-ESV MCC would prevent the pump B discharge valve to open. High temperature motor alarms would be expected in 2 to 3 minutes.

TABLE 1-1 (continued)

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Designator	Human Action Type	Description
HNS3	Dynamic	Operator fails to start the standby auxiliary building ventilation train on failure of the running train, assuming the conditions for an engineered safeguards signal are present but only one train of actuation signals occurs.
HNS4	Dynamic	Same as HNS3 except that no engineered safeguards signal from either train is available.
HNS5	Dynamic	Same as HNS4 except this action is used for the loss of nuclear services cooling initiating event or for NS-1; i.e., all support available.
HNS6	Dynamic	Failure to isolate a leaking heat exchanger supplied cooling by NSCCW. It is assumed that 30 minutes are available for action between the time a surge tank low level alarm is received until a loss of system cooling capability. Initial surge tank level is assumed to be near the low level alarm setpoint.
HNS7A	Dynamic	Failure to locally isolate an NSCCW pump that has lost electric power and whose check valve suffers a gross reverse leakage.
HNS7B	Dynamic	Failure to locally isolate an idle NSCCW pump, which has failed mechanically earlier (i.e., power is available to it, but the valves are manual), and whose check valve suffers a gross reverse leakage.
HNS8A	Dynamic	Failure to locally isolate an idle NSRW pump whose check valve suffers a gross reverse leakage. Offsite power and the train of vital electric power to the pump and its discharge valve are failed.
HNS8B	Dynamic	Failure to remotely isolate an idle NSRW pump whose check valve suffers a gross reverse leakage. Power is available to the pump and to its discharge valve.
HP01	Dynamic	Operator fails to manually open the PORV for HPI cooling when the support systems needed for automatic control are not available. Makeup pumps have sufficient high pressure capacity if automatic pressure control is working.

TABLE 1-1 (continued)

Designator	Human Action Type	Description
HRC1	Dynamic	Operator fails to close the PORV block valve (used in RC-4, RC-5, RC-6, RC-7, RC-8, and RC-9) if the PORV fails to reseat properly.
HRC2	Dynamic	Operator fails to throttle HPI after the PORV or PSVs have passed water [used in RC-3, RC-6, RC-9, RC-6(1C), and RC-C9(1C)] to allow the PORV to reseat.
HRE1	Recovery	During a loss of all AC power, failure of the operators to recover HPI flow before RCP seal failure at 6 hours. Exhaustion of the batteries at 6 hours complicates subsequent efforts to restore electric power. EFW is assumed available (used in RE-1).
HRE2	Dynamic	Operator fails to restore river water before RCP seal failure after the operators were not able to earlier restore river water before turbine trip occurs. Success is achieved by the operators restoring river water or by successfully rotating service beween the three makeup pumps to provide seal injection without river water (used in RE-2).
HRE3	Recovery	During a loss of all AC power, failure of the operators to recover HPI flow before core uncovery at 1 hour. EFW is not available (used in RE-3).
HRE4	Dynamic	Operator failure to unplug the river water pump house screens before a loss of river water pump suction, which eventually results in a turbine trip. Used in the loss of river water initiating event frequency. It is assumed that only 6 hours are allowed for unplugging.
HRE5	Recovery	During a loss of offsite power sequence with onsite power available, failure of the operators to recover offsite power within 6 hours (used in steam generator tube rupture sequences).
HRE6A	Dynamic	Failure of the operators to recover river water from a plugging of the pumphouse screens prior to the time of core damage resulting from a seal loca. Emergency feedwater is assumed available. The time available for recovery is variable, depending on the number of river water pumps running and including approximately 6 hours from the time of plant trip, after which all three makeup pumps are assumed unavailable.

TABLE 1-1 (continued)

Designator	Human Action Type	Description
HRE6B	Dynamic	Similar to HRE6A except that EFW has also failed.
HRE6C	Dynamic	Similar to HRE6A except that control building ventilation has failed. The screens must be unplugged before either a seal LOCA leads to core damage or until the loss of control building ventilation results in an extended loss of all AC power.
HRE7	Recovery	During a loss of offsite power with one diesel generator unavailable, failure of the operators to recover HPI flow before RCP seal failure at 6 hours. Exhaustion of the batteries at 6 hours complicates subsequent efforts to restore electric power. EFW is assumed available.
HRE8	Recovery	During a loss of offsite power with one diesel generator unavailable. Failure of the operators to recover HPI flow before core uncovery at 1 hour. EFW is not available.
HRE9	Dynamic	Operator fails to recover DHRW by installing a temporary fire hose to an operable decay heat service cooler from the hose station in the heat exchanger vault to the DR-V-17A/B drain lines. This action is applicable when the DHRW pumps fail but a leak has developed in the RCS, which requires cooldown using the decay heat closed cooling water system.
HRE11	Dynamic	Operators fail to initiate repair of the DHR pumps or the DHCCW pumps, given that these pumps fail to start on an ESAS signal and both DHR pump trains are not available. This action models only the decision to attempt the repair. The likelihood of successful repair if repair is attempted is considered in actions HRE13 and HRE14.
HRE12A	Dynamic	Operators fail to locally actuate a DHR pump train, given DC power to that train is unavailable. The operators have 6 hours to accomplish the local start.
HRE12B	Dynamic	Similar to HRE12A except that the operators have 12 hours to accomplish the local start.

TABLE 1-1 (continued)

Sheet 13 of 15

Designator	Human Action Type	Description
HRE12C	Dynamic	Similar to HRE12A except that the operators have 24 hours to accomplish the local start before the DHR system is required.
HRE13A	Recovery	Operators fail to recover a failed DHR pump train by repairing a failed DHR or DHCCW pump within 6 hours. The decision to attempt the repair is covered by action HRE11.
HRE13B	Recovery	Operators fail to recover a failed DHR pump train by repairing a failed DHR or DHCCW pump within 12 hours. The decision to attempt the repair is covered by action HRE11.
HRE13C	Recovery	Operators fail to recover a failed DHR pump train by repairing a failed DHR or DHCCW pump within 24 hours. The decision to attempt the repair is covered by action HRE11.
HRE14A	Recovery	Operators fail to restore a DHR pump or DHCCW pump from maintenance within 6 hours. The decision to attempt the recovery is covered by action HRE11.
HRE14B	Recovery	Operators fail to restore a DHR pump or DHCCW pump from maintenance within 12 hours. The decision to attempt the recovery is covered by action HRE11.
HRE14A	Recovery	Operators fail to restore a DHR pump or DHCCW pump from maintenance within 24 hours. The decision to attempt the recovery is covered by action HRE11.
HRT1	Routine	Operator fails to remove the bypass from RPS after testing.
HRT2	Routine	Error rate of the independent verifier failing to detect the error of HRT1.
HRT3	Routine	Operator miscalibrates two or more RPS channels.
HRT4	Routine	Error rate of the independent verifier failing to detect the miscalibration of HRT3.
HRT5	Routine	Operator miscalibrates a single RPS channel.

TABLE 1-1 (continued)

Designator	Human Action Type	Description
HRT6	Routine	Error rate of the independent verifier failing to detect the miscalibration of HRT5.
HRT7	Dynamic	Operator fails to manually trip the reactor by pushing the scram button within 30 seconds following a loss of main feedwater and failure of the automatic trip function.
HRT8	Dynamic	Operator fails to interrupt power to the control rod drives from the control room within 30 seconds, given failure of the automatic reactor trip function, to prevent an ATWS condition.
HRV1	Dynamic	Operator fails to terminate feedwater to one or more steam generator to mitigate the occurrence of a stuck open MSSV or ADV following a plant trip given that the SLRDS fails to isolate feedwater automatically.
HSI1	Dynamic	Operator fails to isolate the main steam lines for a downstream steam line break.
HSI2	Dynamic	Operator fails to shut the MSIVs and stop EFW to the broken OTSG.
HSR1	Dynamic	Operator fails to switch over to sump recirculation following a large LOCA. Only a short response time is available (about 36 minutes after event initiation, but only about 1 minute after reaching the BWST low level alarm).
HSR2	Dynamic	Operator fails to switch over to sump recirculation and align for high pressure recirculation following a small LOCA. A long response time is available (about 10 minutes are available once the low BWST level is reached, but this would not be for about 12 hours after the initiator). Action includes opening the piggyback valves (DH-V-7A and DH-V-7B).
HSR3	Dynamic	Operator fails to switch over to sump recirculation following a medium LOCA. The response time available is shorter than that for a small LOCA but larger than that for a large LOCA.
HSV1	Dynamic	Operator manually closes the reactor building sump drain valves to prevent loss of recirculation inventory after a failure of automatic isolation (used in SV-2).

TABLE 1-1 (continued)

Designator	Human Action Type	Description
HTB1A	Dynamic	The operators fail to initiate turbine cooling of the RCS following a steam generator tube rupture or a very small break. The operators have successfully cooled down to DHR entry conditions, but, for some reason, neither DHR pump train is operable. Turbine cooling is then used to continue the cooldown to stop the leak.
HTB1B	Dynamic	Similar to HTB1A except that the operators have previously failed to achieve cooldown to DHR entry conditions.
HTC1	Dynamic	Operator fails to locally close, with a handwheel, the turbine-driven EFW pump steam supply valves (MS-V-13) and to isolate the affected steam generator after a steam generator tube rupture [used in TC-1 (SG), TC-2, and TC-2(AM)]. Failure assumes that long-term makeup to the BWST will be necessary to make up for the continuing loss of water.
HTC2	Dynamic	Operator fails to close the turbine-driven EFW pump steam supply valves and isolate the affected OTSG after an SGTR and failure of MF+ (used in TC-5). The overcooling transient is assumed to be caused by a stuck open ADV, which must be closed locally.
HTH1	Dynamic	Operator fails to throttle HPI by using MU-V217. (Operator earlier opened MU-V217 and started a second MUP on RT/TT). No ESAS signal was generated (used in TH-1). It is assumed 30 minutes are available.
HTH2	Dynamic	Operator fails to throttle HPI by using MU-V16A, MU-V16B, MU-V16C, and MU-V16D after engineered safeguards actuation (used in TH-2).
HTH3	Dynamic	Operator fails to throttle HPI after ESAS actuation followed by the loss of the A train of engineered safeguards electric power. The side A injection valves remain open and must be locally closed because makeup pump B must continue running for seal injection.
HVB1	Dynamic	Operator fails to transfer to inverter 1E in the event that the inverter supplying power to vital instrument bus VBB or VBD fails.

TABLE 1-2. QUANTIFICATION RESULTS FOR DYNAMIC AND RECOVERY HUMAN ACTIONS

Designator	Name of Distribution	Mean	Variance	5th Percentile	Median	95th Percentile
HAM1	HE*- Bypass Instrument Air Transfer Valve, OSP Available	1.27-03	7.46-06	4.14-05	4.06-04	3.88-03
HAM2	HE - Restart Instrument Air Compressors, OSP Lost	4.96-02	1.05-02	1.61-03	1.58-02	1.51-01
HBW1	HE - Initiate HPI Cooling	3.44-02	5.45-03	1.12-03	1.10-02	1.05-01
HBW2	HE - Initiate HPI; after Blackout, No EFW	7.07-02	7.31-03	7.84-03	3.91-02	1.88-01
HBW3	HE - Initiate HPI; after Loss of River Water, EFW Available	1.21-03	6.73-06	3.93-05	3.86-04	3.69-03
HC31	HE - Isolate Seal Return; Automatic Signal 30 Failed	1.84-02	1.56-03	5.99-04	5.88-03	5.62-02
HCA2	HE - Manual Containment Isolation; Reactor Building Initially Unisolated	2.95-01	8.27-02	3.26-02	1.63-01	9.91-01
HCD1	HE - Initiate Cooldown with ADVs and Pressurizer Spray	1.27-04	7.43-08	4.13-06	4.06-05	3.88-04
HCD2	HE - Initiate Slow Cooldown; RCP or Spray Not Available	6.34-03	1.86-04	2.06-0[illegible]	2.03-03	1.94-02
HCD3	HE - Initiate Cooldown without ATA, RCP, and Spray Available	1.09-04	5.48-08	3.55-06	3.48-05	3.33-04
HCD4	HE - Initiate Cooldown with ADVs and Pressurizer Spray, SGTR	1.09-04	5.48-08	3.55-06	3.48-05	3.33-04
HCD5	HE - Initiate Cooldown with PORV, SGTR, and LOSP	7.83-03	2.83-04	2.55-04	2.50-03	2.39-02
HCF1	HE - Establish Reactor Building Cooling after River Water Fails	4.08-01	1.61-02	2.25-01	3.75-01	6.12-01
HCF2	HE - Manual Regulation of RBEC Water Pressure	5.04-01	5.75-02	1.88-01	4.22-01	9.91-01
HCS5	HE - Manually Initiate Spray; Purge in Progress	4.53-01	1.42-02	2.75-01	4.24-01	6.43-01
HCV1	HE - Realign for Once-Through Flow (AH-D36, or NS fails)	5.07-02	3.76-03	5.61-03	2.80-02	1.35-01
HCV2	HE - Start Standby CBV Train after Operating Train Fails; OSP Available	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03
HCV3	HE - Outside Air too Warm for Alternate Ventilation	5.00-02	6.25-10	5.00-02	5.00-02	5.00-02
HCV4	HE - Establish Alternate CBV Cooling Following LOCV	1.28-03	7.52-06	4.16-05	4.08-04	3.90-03
HCV5	HE - Open Damper that Transferred Closed	4.91-02	3.52-03	5.45-03	2.72-02	1.31-01
HCV6	HE - Restart CBV after OSP Lost and One Diesel Generator Failed	1.29-04	7.65-08	4.19-06	4.11-05	3.93-04
HCV7	HE - Align CBV to Recirculation Mode; No ESAS Present	2.72-02	3.41-03	8.85-04	8.69-03	8.31-02
HCV8	HE - Establish Alternate Ventilation after Plant Trip	1.28-03	7.52-06	4.16-05	4.08-04	3.90-03
HCV9	HE - Establish Alternate Ventilation after Plant Trip, with 2-hour Delay	1.28-03	7.52-06	4.16-05	4.08-04	3.90-03

*HE = Human Error

NOTE: Exponential notation is indicated in abbreviated form; i.e., 1.27-03 = 1.27×10^{-3}.

TABLE 1-2 (continued)

Designator	Name of Distribution	Mean	Variance	5th Percentile	Median	95th Percentile
HDT1	HE*- Prevent Boron Concentration Effects Following LOCA	8.87-04	3.63-06	2.89-05	2.84-04	2.71-03
HEF1	HE - Replenish 2-hour Bottles or Control EF-V30S; LOSP	6.17-02	1.81-03	1.64-02	4.68-02	1.29-01
HEF2	HE - Manual EFW Flow Control; Automatic Control Fails	2.77-02	3.55-03	9.02-04	8.86-03	8.47-02
HEF3	HE - Replenish 2-hour Bottles; SLB Sequence	3.94-01	1.24-01	4.55-02	2.02-01	9.91-01
HEF4	HE - Control EFW Flow Following Loss of All AC	1.29-04	7.65-08	4.19-06	4.11-05	3.93-04
HEF5	HE - Manually Initiate EFW; Automatic Initiation Fails; 7 Minutes	1.76-02	1.43-03	5.74-04	5.63-03	5.38-02
HEF8	HE - Manual EFW Flow Control; EF-V 30 Fails; For EF+	2.96-02	4.04-03	9.63-04	9.46-03	9.04-02
HEF9	HE - Remote Manual EFW Flow Control; EF-V 30 FAILS; FOR EF+	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03
HEF10	HE - Remote Isolation of CST Draining into Hotwell	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03
HFW4	HE - Manually Control OTSG Level after Automatic Fails	2.61-02	3.15-03	8.50-04	8.35-03	7.98-02
HFW5	HE - Manually Control Main Steam Pressure after Automatic Fails	1.27-04	7.43-08	4.13-06	4.06-05	3.88-04
HGA1	HE - Conservative Estimate of OSP Nonrecovery in 6 Hours	1.00-02	2.50-11	9.99-03	9.99-03	1.00-02
HHA1	HE - Pull Divers from Pump House to Recirculation DHRW Pumps from Maintenance	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03
HHL1A	HE - Remotely Open Dropline Valves Go to On DHR	1.21-04	6.73-08	3.93-06	3.86-05	3.69-04
HHL1B	HE - Locally Open Dropline, Given 1C Failed	1.21-03	6.73-06	3.93-05	3.86-04	3.69-03
HHP1	HE - Restart Makeup B after Loop; One Diesel Generator and Top Events HA or HB Failed	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03
HIC1	HE - Manual Control of MFW Valves; ICS Failed	4.93-03	1.12-04	1.61-04	1.58-03	1.51-02
HIC2	HE - Manual Trip of MFW Pumps	1.11-01	1.76-02	1.23-02	6.16-02	2.96-01
HIC3	HE - Set ADVs Manual Loader to Zero if not Initially at Zero	3.54-02	5.80-03	1.15-03	1.13-02	1.08-01
HIC4	HE - Manual Control of TBV/ADV When ATA Fails	5.17-02	1.14-02	1.68-03	1.65-02	1.58-01
HID1	HE - Identify SGTR; Condenser Available	1.27-04	7.43-08	4.13-06	4.06-05	3.88-04
HID2	HE - Identify SGTR; Offsite Power Lost	1.51-04	1.05-07	4.92-06	4.83-05	4.62-04
HINJ1	HE - Start Standby Makeup Pump for Seal Injection; No ESAS	1.27-04	7.43-08	4.13-06	4.06-05	3.88-04
HINJ2	HE - Crossconnect Makeup Pump for Seal Injection; A and B Failed	1.27-03	7.43-06	4.13-06	4.06-04	3.88-03
HINJ3	HE - Crossconnect Makeup Pump C For Seal Injection; ESAS Present	9.43-03	4.11-04	3.07-04	3.02-03	2.88-02
HINJ4	HE - Open MU-V20 for Seal Injection; Loss of Air	8.86-02	1.81-03	3.52-02	7.55-02	1.58-01
HLT1A	HE - Switch from Makeup Tank to BWST; Normal Cooldown Failed	7.22-03	2.41-04	2.35-04	2.31-03	2.21-02

*HE = Human Error

NOTE: Exponential notation is indicated in abbreviated form; i.e., 8.87-04 = 8.87 x 10^{-4}.

TABLE 1-2 (continued)

Sheet 3 of 5

Designator	Name of Distribution	Mean	Variance	5th Percentile	Median	95th Percentile
HLT1B	HE*- Long-term Makeup to BWST; Normal Cooldown Fails	6.24-02	1.82-03	1.68-02	4.76-02	1.30-01
HLT2	HE - Long-term Makeup to BWST; SGTR Cooldown Fails	6.56-02	1.80-03	1.89-02	5.10-02	1.33-01
HMR1	HE - Establish Makeup Pump Recirculation after ESAS and TH	3.24-01	9.34-02	3.91-02	1.87-01	9.83-01
HNS1	HE - Failure to Isolate a Leaking Nuclear Service Heat Exchanger	7.14-02	1.77-02	2.33-03	2.28-02	2.24-01
HNS2	HE - Start NSRW Pump; Pump GB Failed; Not ESAS Selected	6.29-03	1.29-04	2.14-04	2.10-03	2.01-02
HNS3	HE - Start Standby Auxiliary Building Ventilation Train; Running Train Failed	1.00-01	2.10-11	1.00-01	1.00-01	1.00-01
HNS4	HE - Start Standby Auxiliary Building Ventilation Train; No ESAS Present	1.00-01	2.10-11	1.00-01	1.00-01	1.00-01
HNS5	HE - Start Standby Auxiliary Building Ventilation Train for LOCV Initiating Event	1.00-01	2.10-11	1.00-01	1.00-01	1.00-01
HNS6	HE - Failure to Isolate Leaking NSCCW Heat Exchanger	2.04-01	9.99-02	3.36-03	2.68-02	1.00+00
HNS7A	HE - Power to NSCCW Pump Lost and Check Valve Fails	3.99-01	7.68-02	8.80-02	2.85-01	9.91-01
HNS7B	HE - NSCCW Pump Fails and Check Valve Fails to Reseat	3.99-01	7.68-02	8.80-02	2.85-01	9.91-01
HNS8A	HE - NSRW Pump Idle and Check Valve Fails to Reseat; Power Not Available	9.36-02	1.27-02	1.04-02	5.18-02	2.49-01
HNS8B	HE - NSRW Pump Idle and Check Valve Fails to Reseat; OSP Available	1.56-02	1.13-03	5.09-04	5.00-03	4.78-02
HPO1	HE - Manually Open PORV for HPI Cooling; ATA Failed	1.09-03	5.46-06	3.54-05	3.48-04	3.32-03
HRC1	HE - Close PORV Block Valve after PORV Fails	8.87-03	3.63-04	2.89-04	2.84-03	2.71-02
HRC2	HE - Throttle HPI after PORV Passes Water	6.17-02	1.81-03	1.64-02	4.68-02	1.29-01
HRE1	HE - Recover Electric Power; Loss of All AC; EFW Available	4.94-05	1.23-08	1.45-06	1.50-05	1.52-04
HRE2	HE - Restore River Water with Fire Service Water or Rotate Makeup Pumps	7.43-02	1.81-03	2.47-02	6.03-02	1.43-01
HRE3	HE - Recover Electric Power; Loss of all AC; EFW Failed	8.36-04	3.76-06	2.26-05	2.44-04	2.57-03
HRE4	HE - Unplug River Water Screens before Turbine Trip	1.51-01	8.52-02	3.00-02	3.00-02	1.00+00
HRE5	HE - Loop with Onsite Power Available; Recover OSP for SGTR	3.94-02	9.53-04	8.84-03	2.83-02	8.74-02
HRE6A	HE - Unplug River Water Screens before Core Damage; EFW Available	1.90-03	1.68-05	6.20-05	6.09-04	5.82-03

*HE = Human Error

NOTE: Exponential notation is indicated in abbreviated form; i.e., 6.24-02 = 6.24 x 10^{-2}.

TABLE 1-2 (continued)

Sheet 4 of 5

Designator	Name of Distribution	Mean	Variance	5th Percentile	Median	95th Percentile
HRE6B	HE*- Unplug River Water Screens before Core Damage; EFW Failed	6.07-02	5.40-03	6.71-03	3.35-02	1.61-01
HRE6C	HE - Unplug River Water Screens Before Loss of AC or Seal Failure; CV F	6.98-02	1.79-03	2.18-02	5.56-02	1.38-01
HRE7	HE - Recovery Electric Power, One Diesel Generator Available, with EFW	5.01-02	1.18-02	1.42-03	1.50-02	1.54-01
HRE8	HE - Recovery Electric Power, One Diesel Generator Available, without EFW	3.82-01	7.14-02	8.58-02	2.75-01	9.06-01
HRE9	HE - Recover HA and HB if FXA Fails; All Support Available	1.90-03	1.68-05	6.20-05	6.09-04	5.82-03
HRE9A	HE - DCCW Pump Failures; No Recovery in 24 Hours	5.00-02	1.60-11	5.00-02	5.00-02	5.00-02
HRE11	HE - Initiate Repair of DHR/DHCW Pumps Given ESAS	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03
HRE12A	HE - Locally Start Decay Heat Pumps Given DC Fails, 6 Hours	1.78-03	1.47-05	5.81-05	5.71-04	5.46-03
HRE12B	HE - Locally Start Decay Heat Pumps Given DC Fails, 12 Hours	1.63-03	1.23-05	5.32-05	5.22-04	4.99-03
HRE12C	HE - Locally Start Decay Heat Pumps Given DC Fails, 24 Hours	1.63-03	[illegible]	5.32-05	5.22-04	4.99-03
HRE13A	HE - Nonrepair of DHR/DCCW Pumps in 6 Hours if Failed to Start	4.00-01	4.00-08	4.00-01	4.00-01	4.00-01
HRE13B	HE - Nonrepair of DHR/DCCW Pumps in 12 Hours if Failed to Start	2.80-01	1.60-09	2.80-01	2.80-01	2.80-01
HRE13C	HE - Nonrepair of DHR/DCCW Pumps in 24 Hours if Failed to Start	2.80-01	1.60-09	2.80-01	2.80-01	2.80-01
HRE14A	HE - Nonrecovery from Maintenance DHR/DCCW Pumps in 6 Hours	3.60-01	1.60-09	3.60-01	3.60-01	3.60-01
HRE14B	HE - Nonrecovery from Maintenance DHR/DCCW Pumps in 12 Hours	1.40-01	1.60-09	1.40-01	1.40-01	1.40-01
HRE14C	HE - Nonrecovery from Maintenance DHR/DCCW Pumps in 24 Hours	2.00-02	1.60-09	1.99-02	2.00-02	2.00-02
HRT7	HE - Manual Reactor Trip with Scram Button	1.55-02	1.10-03	5.03-04	4.94-03	4.72-02
HRT8	HE - Interrupt Power to CRD; Automatic Trip Fails	1.38-01	1.79-03	7.71-02	1.27-01	2.06-01
HRV1	HE - Isolate MFW Following Stuck Open MSSV in 30 Minutes	3.22-02	4.80-03	1.05-03	1.03-02	9.85-02
HSI1	HE - Isolate Main Steam Lines; Downstream Steam Line Break Upstream Breaks	7.43-02	8.07-03	8.23-03	4.11-02	1.98-01
HSI2	HE - Shut MSIVs and Stop EFW to Failed Steam Generator; Upstream Breaks	8.37-02	1.02-02	9.30-03	4.63-02	2.23-01
HSR1	HE - Switchover to Sump Following Large LOCA	4.74-02	9.77-03	1.54-03	1.52-02	1.45-01

*HE = Human Error

NOTE: Exponential notation is indicated in abbreviated form; i.e., 6.07-02 = 6.07 x 10^{-2}.

TABLE 1-2 (continued)

Sheet 5 of 5

Designator	Name of Distribution	Mean	Variance	5th Percentile	Median	95th Percentile
HSR2	HE*- Recirculation Switchover Following Small LOCA	1.27-04	7.43-08	4.13-06	4.06-05	3.88-04
HSR3	HE - Switchover to SUMP Following Medium LOCA	7.22-03	2.41-05	2.35-04	2.31-03	2.21-02
HSV1	HE - Close Sump Drain Valves; Automatic Fails	7.75-03	2.78-04	2.52-04	2.48-03	2.37-02
HTB1A	HE - Initiate Turbine Cooling, SGTR or VSB, CD Success	5.94-02	5.16-03	6.59-03	3.29-02	1.58-01
HTB1B	HE - Initiate Turbine Cooling, SGTR or VSB, CD Failure	2.06-01	2.49-02	4.65-02	1.48-01	4.58-01
HTC1	HE - Locally Isolate Steam Generator Following SGTR	1.09-04	5.48-08	3.55-06	3.48-05	3.33-04
HTC2	HE - Close to EFW Supply Valves; MF+ Failed	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03
HTH1	HE - Throttle HPI Using MUV 217; No ESAS	1.36-04	8.53-08	4.42-06	4.34-05	4.15-04
HTH2	HE - Throttle HPI Using MUV-16S after ESAS	3.86-02	6.89-03	1.26-03	1.24-02	1.18-01
HTH3	HE - Throttle HPI after ESAS and GA Fails	1.85-01	4.15-02	2.06-02	1.03-01	5.07-01
HVB1	HE - Transfer Instrument Bus to Inverter 1E	1.27-03	7.43-06	4.13-05	4.06-04	3.88-03

*HE = Human Error

NOTE: Exponential notation is indicated in abbreviated form; i.e., 1.27-04 = 1.27 x 10^{-4}.

TABLE 1-3. QUANTIFICATION RESULTS FOR BASIC HUMAN ERROR RATES

Designator	Name of Distribution	Mean	Variance	5th Percentile	Median	95th Percentile
HELD	HE*- Conditional Human Error Probability - Low Dependence	6.06-02	2.22-03	1.38-02	4.37-02	1.34-01
HEMD	HE - Conditional Human Error Probability - Medium Dependence	1.90-01	2.58-02	3.65-02	1.29-01	4.45-01
HEHD	HE - Conditional Human Error Probability - High Dependence	5.46-01	5.02-02	2.36-01	4.76-01	9.97-01
HECD	HE - Human Error - Complete Dependence	00+00	2.50-09	1.00+00	1.00+00	1.00+00
HEC1	HE - Changing or Tagging Wrong Valve	1.17-02	4.95-04	5.11-04	4.31-03	3.52-02
HEC2	HE - Changing or Restoring Wrong MOV Switch	7.03-03	1.79-04	3.06-04	2.58-03	2.11-02
HEC3	HE - General Error of Commission - Nonpassive Tasks	7.03-03	1.79-04	3.06-04	2.58-03	2.11-02
HEO1A	HE - Failure to Follow Short List - Less than 10 Items	2.34-03	1.99-05	1.02-04	8.60-04	7.05-03
HEO1B	HE - Failure to Follow Long List - More than 10 Items	7.03-03	1.79-04	3.06-04	2.58-03	2.11-02
HEO2A	HE - Failure to Detect Errors When Checking Each Item	1.61-02	3.81-04	1.79-03	8.93-03	4.30-02
HEO2B	HE - Failure to Detect Errors When Checking Routine Tasks	1.61-01	3.21-02	1.79-02	8.93-02	4.39-01
HEMH	HE - Error of Misdiagnosis - High	8.07-02	9.54-03	8.94-03	4.46-02	2.15-01
HEMM	HE - Error of Misdiagnosis - Medium	2.66-02	3.28-03	8.68-04	8.52-03	8.14-02
HEML	HE - Error of Misdiagnosis - Low	2.66-03	3.28-05	8.68-05	8.52-04	8.14-03
HNV1	HE - Nonviable Slip in Selecting Similar Controls	3.75-03	7.59-06	9.21-04	2.77-03	8.08-03
HDRT1	HE - Duration Until Detection to Remove RPS Bypass	2.84+01	2.22+03	4.00+00	8.00+00	1.68+02

*HE = Human Error

NOTE: Exponential notation is indicated in abbreviated form; i.e., 6.06-02 = 6.06 x 10^{-2}.

TABLE 1-4. ERROR QUANTIFICATION FOR ROUTINE HUMAN ACTIONS

Human Action Identifier	Error Rate	Comments
HCA3	HEC3*HEHD	High dependence between channels.
HCA4	HEMD	Verifier reviews action as it is performed.
HCS1	HE01B	-
HCS2	HE02A	-
HCS3	HE01B*HEHD	Complete dependence assumed between pressure switches.
HCS4	HE02A*HECD	Complete dependence assumed between pressure switches.
HDEA1	13,140 Hours/2	Assumed a conservative bound equal to one-half the time to the next refueling outage.
HDEA2	13,140 Hours/2	Assumed a conservative bound equal to one-half the time to the next refueling outage.
HDEF1	720/2	Assumed misalignment detected, on average, one-half the time period between tests.
HDEF2	720/2	Assumed misalignment detected, on average, one-half of the time period between tests.
HDH2	HE01B	Assumed it would remain misaligned until the next scheduled test.
HDH3	HE02A	Assumed it would remain misaligned until the next scheduled test.

Note: Distributions for the standard error rates are given in Table 1-3.

TABLE 1-4 (continued)

Sheet 2 of 3

Human Action Identifier	Error Rate	Comments
HDRT1	4 to 168 Hours	High probability of being detected by the beginning of the next shift; small chance of not being detected for up to 1 week.
HDRT2	13,140 Hours	Assumed a conservative bound equal to the time to the next refueling outage.
HDRT3	13,140 Hours	Assumed a conservative bound equal to the time to the next refueling outage.
HEA1	HEC3*HEHD	High dependence between channels.
HEA2	HE02A	-
HEA3	HEC3	-
HEA4	HEMD	Verifier reviews action as it is performed.
HEF6	HE01B	-
HEF7	HE02A	-
HHL1	HE01B	-
HHL2	HE02A	-
HIC5	HE01B	-
HIC6	1 day/183 Days	Assumed a conservative bound; 1 day to detection and repositioned every 6 months.
HRT1	HE01B	-
HRT2	HE02A	-

Note: Distributions for the standard error rates are given in Table 1-3.

TABLE 1-4 (continued)

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Human Action Identifier	Error Rate	Comments
HRT3	HEC3*HEHD	High dependence for miscalibrating second channel.
HRT4	HEMD	Verifier reviews action as it is performed.
HRT5	HEC3	-
HRT6	HEMD	Verifier reviews action as it is performed.

Note: Distributions for the standard error rates are given in Table 1-3.

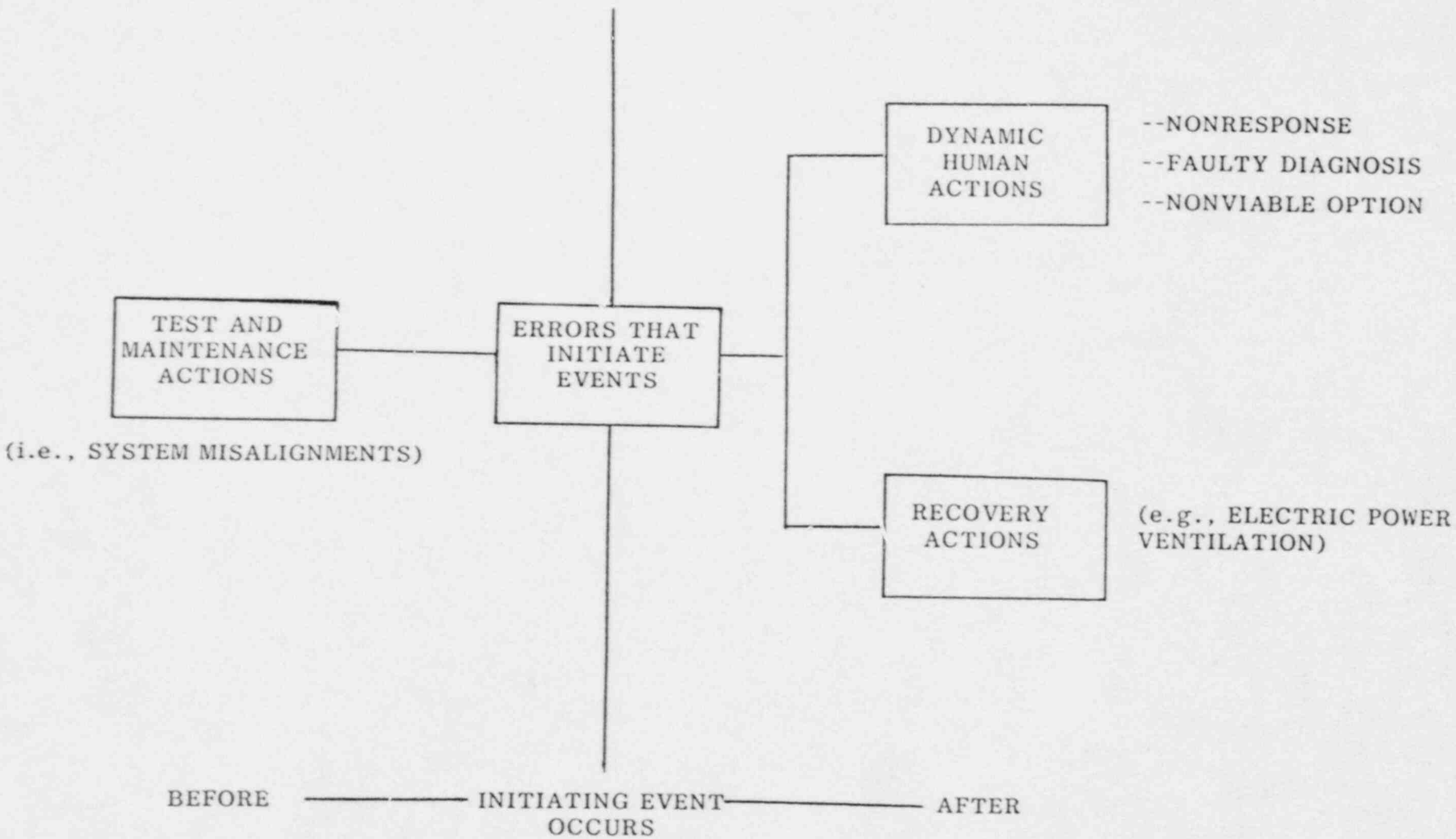

FIGURE 1-1. CLASSIFICATION OF HUMAN ACTIONS BY TYPE

2. OPERATOR RESPONSE METHODOLOGY

The methodology for the analysis and evaluation of operator actions is described in this section. Relative to the data available for equipment failure rates, maintenance frequencie and repair times, there is much less information available for evaluating the likelihood of human actions. Essentially, one must quantify the error rates for human actions based on one's state of knowledge by analyzing in detail each operator action, subject to practical constraints (e.g., budget and schedule), and by using what other analysts have derived for similar situations.

Although our engineering analysis may be satisfactory, subconscious biases could distort our probabilistic judgments. The potential for systematically distorting these judgments was pointed out previously in Reference 1-6. For example, it is well known that probability assessors tend to be overconfident and produce distributions that are narrower than justified (References 2-1 through 2-3). Such a situation was encountered in the context of specializing generic distributions for failure rates (Reference 2-4), and the tendency has been to use broader distributions in later work (References 2-5 through 2-7). Perhaps the best remedy for these potential biases is to be aware of them. Furthermore, the best measure (not the ultimate criteria) for the acceptability of a particular distribution, until adequate experience becomes available, is its reasonableness from the engineering standpoint, as judged by the study team and subsequent peer review.

Other practical limitations encountered in the analysis of human actions are documented in Section 6.6 of Reference 1-1. Such limitations are shared by the analytical approaches adopted in this study. These limitations in the methods for quantification of human action error frequencies are reflected in the relatively large uncertainties attributed to each event frequency assigned.

2.1 INITIAL REVIEW OF OPERATOR ACTIONS

As an initial step in the frequency evaluation of operator actions, a complete list of actions included in all of the systems models was compiled. The initial identification of the operator tasks of interest was primarily a collection process. Operator actions had been previously identified in the development of the event sequence diagrams and in the performance of the systems analysis for each top event in the event trees. Actions of interest, which take place prior to an accident initiator, were identified and their resultant impacts on the system evaluated as misalignment states of the system affected. Dynamic actions were identified when called out by the plant procedures (reviewed during the development of the event sequence diagrams); for example, those to control and coordinate plant systems or those judged to be the likely operator response should the automatic systems fail. No dynamic actions of commission (i.e., incorrect actions that, if performed, would make things worse) were initially identified for quantification.

The identification of operator tasks is also an iterative process. Specific operator actions to restore systems initially failed were identified as it became apparent that such system failure modes could dominate the system failure frequency unless credit for such obvious operator responses were to be taken. Complex recovery actions (e.g., recovery of offsite power) were not evaluated in the initial quantification of the plant model. In the final quantification, a select group of complex recovery actions was identified and a detailed evaluation performed. These recovery actions were chosen to address accident sequences found to be important in the earlier rounds of quantification.

Thus, the quantification of error rates for human actions was performed in a two-step process. In the first step, preliminary point estimates were developed for the error rates of the human actions identified up to that time. In the second step, a detailed evaluation of these and other human actions, identified in the initial quantification rounds as being important, was performed.

In the initial accident sequence quantification rounds, for actions that take place prior to the initiator, the basic human error rates used were derived from the human reliability handbook (Reference 2-8). Since the general approach used to evaluate these actions was later refined and applied again to the final list of routine actions considered, details of the preliminary assessment are not provided here. The final methodology used for quantifying all errors associated with routine human actions is documented in Section 2.2.

The initial list of dynamic actions listed were judgmentally assigned preliminary mean failure rates. The collective judgment of five study team members was used to assign the preliminary dynamic human error rates. The five-member study team, which assigned these preliminary values, had a diverse background. All five, however, had some hands-on operational experience. Four of the five are intimately familiar with the TMI-1 design. The developer of the plant model event trees and the systems analysis task leader were represented in the group. The GPU team members included a former operator of the sister plant, TMI-2, and a former supervisor in charge of operator training. The study team's judgments were, in part, based on experience in the development of human action error rates for previous studies and by comparisons with assessments made by others (Reference 1-1). Each of the dynamic human actions on the initial list was discussed extensively. Consideration was given to the human action description, including response time available, availability of indications, sequence initiating event, support system state, and likely accident scenario. Table 2-1 indicates the types of items discussed for the human action HSR2; i.e., opening of the containment sump valves for switchover to sump recirculation. After discussion of each dynamic human action, the five study team members expressed their opinions about the likely human error rate. Eventually, the group arrived at a consensus, as noted by the asterisk alongside the 5×10^{-3} value in Table 2-1. These realistic to somewhat conservative judgments were then used in the initial rounds of accident sequence quantification.

The intent was to thereby identify the most important human actions for subsequent detailed review and documentation. The importance of the failure of each human action was determined by its occurrence in the accident sequences contributing most to the core melt frequency or to particular plant damage states that are risk significant.

Important new human actions were then identified by examining results of the initial quantification. The complete list of human actions was later reevaluated using the methods presented in the following sections for the final round of accident sequence quantification.

2.2 ROUTINE HUMAN ACTIONS - TEST AND MAINTENANCE ACTIONS

2.2.1 OVERVIEW

Test and maintenance actions that may inadvertently leave a system in an unusual alignment (i.e., not the normal alignment called for by procedure) are modeled in the system analyses. This category of human actions includes errors, such as equipment miscalibration and failures to correctly restore a system from a prior test or maintenance alignment. Test and maintenance actions are usually all performed routinely and successfully as part of normal plant operation. Should such errors occur, however, they may leave the system in a degraded state until detected, either during a routine inspection or when next tested, which may not be for several months, depending on the procedures that apply. The likelihood of such errors is minimized, however, by the details provided in the written test and maintenance procedures, the equipment tagging procedures followed, and the independent checks made by plant personnel (other than those who originally performed the action) to verify that the system is properly aligned. In addition, system operability tests are generally performed before the system is declared operable following completion of the action (see Section 3.2). Such system tests are performed specifically to determine if a misalignment has occurred and to verify the proper functioning of equipment that has been restored.

The systems analysis activity includes the identification of system miscalibration or misalignment errors. Once identified, a judgment is made about whether the error is significant. The action may be dismissed from further evaluation by the criterion that the error does not materially alter the system alignment in a way that degrades the ability of the system to perform its intended function, or it may be neglected because the impact of the misalignment error is the same as some other equipment failure mode that is clearly more frequent, by an order of one magnitude or more. Using such criteria, the number of system misalignment configurations that must be analyzed is minimized, thereby reducing the number of test and maintenance human action errors that must be evaluated.

Once identified and judged to be significant, the likelihood of such test and maintenance errors are quantified using the results from the Nuclear Regulatory Commission human reliability handbook (Reference 2-8). The rates of such errors are developed on a generic basis rather than using plant specific data. The results are presented for certain basic actions that are used in the systems and plant analyses, either directly or after some modifications dictated by circumstances specific to each system or event.

The human reliability handbook is a substantial extension of the human reliability analysis contained in the Reactor Safety Study (Reference 2-9). It provides qualitative and quantitative information for assessing human errors in numerous situations and discusses extensively the various factors that influence human performance.

Despite the impressive amount of work the handbook contains, the quantitative information provided is essentially the judgment of its authors and is not based on actual data at nuclear power plants. It is necessary, therefore, to use judgment in using this information in the study.

For a specific human error rate, the handbook usually provides a best estimate and upper and lower bounds. The use of a lognormal distribution is suggested with the two given bounds to be used as its 95th and 5th percentiles. The handbook points out that these are merely suggestions and that the users may, in some situations, wish to assign a larger uncertainty band.

In most cases, the lognormal distribution is a satisfactory distribution to use because "the performance of skilled persons tends to bunch up toward the low human error probabilities" (Reference 2-10, page 16-6). Indeed, the distributions developed in this section are all assumed to be lognormal.

The lognormal distribution is determined by using the best estimate as the median and the upper bound as the 90th percentile, rather than the 95th percentile that the handbook recommends. This follows the approach discussed in Section 5.2.1.1.2 of the data report for evaluating expert opinions by expressing greater uncertainty about the error rates than the generic sources of data typically recommend; i.e., stretching out the original distributions.

Having made these decisions, the parameters, μ and σ, of the lognormal distribution are obtained from the following equations:

$$\exp(\mu) = BE \text{ (Best Estimate)} \tag{2.1}$$

$$\exp(\mu + 1.28\sigma) = UB \text{ (Upper Bound)} \tag{2.2}$$

The solution is

$$\mu = \ln(BE) \tag{2.3}$$

$$\sigma = \ln(UB) - \mu]/1.28 \tag{2.4}$$

Since publication of the draft NRC human reliability handbook in 1980 (Reference 2-10), the final report has also been published

(Reference 2-8). A few comments are now offered relative to the presentation in Chapter 20 of Reference 2-8 that describe how the analysis procedures were adopted for use in this study. Table 2-2 reflects a compilation of basic human error rates from Chapter 20 of Reference 2-8. For ease of comparison, the search scheme, Figure 20-1 in the handbook, is repeated here as Figure 2-1. The sources of the estimates used in this study are cross-referenced in Table 2-2 of this section to those presented in the handbook. The basic human error rates presented in Table 2-2 are for normal conditions, as judged to be appropriate for actions taking place prior to an accident initiator. The use of these distributions from the handbook, as followed in this study, is illustrated by the following example. Similar calculations led to the basic human error rate distributions presented in Table 1-3.

Example

For the rate of omission in nonpassive tasks (e.g., maintenance, test, etc.) when written procedures, consisting of more than 10 special instruction items with checkoff provisions, are used correctly, Table 20-7 of the handbook gives

Best Estimate (BE): 3×10^{-3}
Lower Bound (LB): 10^{-3}
Upper Bound (UB): 10^{-2}

From Equations (2.3) and (2.4)

$\mu = -5.81$ and $\sigma = 0.94$

Therefore,

Mean: $\alpha = \exp\left[\mu + \frac{\sigma^2}{2}\right] = 4.67 \times 10^{-3}$

Variance: $\alpha^2 [\exp(\sigma^2) - 1] = 3.08 \times 10^{-5}$

95th Percentile: $\exp(\mu + 1.645\sigma) = 1.41 \times 10^{-2}$

5th Percentile: $\exp(\mu - 1.645\sigma) = 6.40 \times 10^{-4}$

Observe that the numbers are not much different from those of the handbook.

2.2.2 ERRORS OF COMMISSION

The errors of commission that may result from routine human actions, as modeled in this study, are restricted to actions in failing to properly restore plant equipment from test or maintenance conditions or in miscalibration of sensors. Error estimates for selecting the wrong valve or control switch were taken from Tables 20-12 through 20-14 of Reference 2-8. The handbook estimate for general error of commission listed in Table 2-2 is used for sensor calibration errors. Specific estimates for the frequency of calibration errors are not provided in any of the tables of the handbook. Other errors of commission caused by misreading displays during routine tasks (i.e., Tables 20-9 through 20-11 in Reference 2-8) are not modeled in this study. It is assumed that such errors would be easily and readily recovered prior to any significant plant degradation or, at least, that they occur infrequently compared to the errors that are included for routine tasks.

2.2.3 ERRORS OF OMISSION

Estimates for errors of omission for routine activities reported in Table 2-2 are also taken from the handbook (Reference 2-8). Such estimates are used to describe such postulated actions as failing to restore or align valves following a maintenance activity or test. Other errors of omission identified in the handbook, such as in originally preparing the procedure used or in the administrative control of implementing the provisions of the procedure, are neglected. Errors in the original preparation of the procedures are believed negligible because the TMI-1 plant has been operated and maintained for several years now during which time such omissions would likely have been identified. Errors in implementing the procedure are not really appropriate for the actions modeled because those of interest are the system restoration errors after the procedure has already been at least partially implemented. Errors of omission involving routine human actions without procedures or written instructions were not identified or explicitly modeled in this study; i.e., Tables 20-6 and 20-8 of the handbook were not used.

Estimates for errors of omission involving the failure of a checker to detect an error made by someone else are adopted from the handbook; i.e., Table 20-22. Again, errors of an administrative control nature (i.e., Table 20-6 of Reference 2-8), such as failing to implement the checking procedures, were not modeled. The tagging and locking administrative control systems at TMI-1 are judged to be excellent, as described in Section 3.2. Referring to the description in Table 20-15 of Reference 2-8, TMI Unit 1 tagging and locking systems have many of the characteristics of a level 1 system. For conservatism, however, the nominal human error probabilities characteristic of a level 2 system are assumed. This avoids the detailed effort required to substantiate the level 1 values for all restoration tasks during all phases of plant operation. The handbook estimates for failure of basic walkaround inspections to detect system or equipment misalignments outside the control room (i.e., Table 20-27 of Reference 2-8) are not used. For the relevant events identified in the TMI-1 PRA, written procedures are used to perform the walkaround. Consequently, as suggested by the NRC handbook (see footnote to Table 20-27), the estimates for the errors of omission and commission in routine tasks, defined previously, are used instead of the estimates from Table 20-27.

2.2.4 DEPENDENCE AND UNCERTAINTY BOUNDS

2.2.4.1 Dependence between Human Errors

When two or more routine tasks are to be performed, the question of dependence must be addressed. This study adopts the suggested treatment in the NRC handbook for dependence, summarized in Tables 20-17, 20-18, 20-19, and 20-21 of Reference 2-8. Briefly stated, this approach uses five separate formulas that depend only on the degree of dependence judgmentally assigned by the analyst as appropriate for the task in question and for the preceding tasks. These five levels of dependence are: zero, low, moderate, high, and complete. The handbook (Chapter 10) defines five levels of dependence as:

- Zero Dependence (ZD): "The quality of performance, including nonperformance, of one activity has no effect on the performance of subsequent activities."
- Low Dependence (LD): "It is a convenient assumption to make when the dependence between actions is clearly greater than zero but not much greater."
- Moderate Dependence (MD): "...a level of dependence between LD and HD."
- High Dependence (HD): "It is a convenient assumption to make when the dependence between two actions is not complete but is definitely toward the higher end of the dependence continuum."
- Complete Dependence (CD): "Complete dependence between the actions of two people is rare, but not as rare as ZD. CD between two actions performed by the same person is more common."

The handbook formulas for conditional human error probabilities are provided in this report as Table 2-3, these formulas are judged to represent best estimates for the conditional human error rates.

2.2.4.2 Uncertainty Bounds

Uncertainty bounds for the basic human error probabilities suggested in the NRC handbook are used as input in this study. However, the suggested lognormal distributions, with the stated upper and lower bounds as the 5th and 95th percentiles and the best estimate as the 50th percentile, are stretched out for use in this study. The upper bounds are instead treated as the 90th percentiles of a lognormal distribution.

For conditional human error probabilities, the estimates offered by the handbook in assigning uncertainty bounds (i.e., Table 20-21 and Appendix A of Reference 2-8 and repeated as Table 2-4 in this section for convenience) are adopted as is in this study. No additional stretching of the suggested conditional human error probabilities is performed. The handbook-suggested values cover the uncertainty in the basic human error probability estimate, the uncertainty in estimating the degree of dependence between tasks, and the modeling uncertainties in the formulas that account for the degree of dependence assumed. The uncertainty ranges reported in Table 20-21 of Reference 2-8 are therefore used directly in this study for estimates of routine task error rates. These distributions for conditional human error probabilities are summarized in Table 1-3 in which it has been assumed that the underlying basic human error rate is less than 0.01.

2.3 DYNAMIC HUMAN ACTIONS

This section describes the approach taken for the evaluation of dynamic human actions that may be required by procedure or, at any rate, take place after the accident sequence has been initiated. First, an overview of the approach is provided, followed by sections that provide additional details about the evaluation of frequency estimates for nonresponse errors, errors of misdiagnosis, and the treatment of dependencies between tasks.

2.3.1 OVERVIEW

In this study, as in Reference 2-11 (Section 4.3.8 and Chapter 10 from which many of the ideas in this section were taken), it is judged that the major causes of errors related to dynamic human actions involve the diagnosis of the event. Both failure to perform a diagnosis and misdiagnosis are considered. In the classification scheme of Reference 2-12, mistakes, which are errors in the formation of an intention, dominate the likelihood of failure to perform the dynamic human action. Slips, which are errors in the execution of an intention, are judged of secondary importance. This key notion is fundamental to the approach described below.

Figure 2-2 illustrates how several categories of information are iteratively employed in the process of evaluating dynamic human actions. These categories of information include plant systems and human interaction information, human performance information, and information from the probabilistic plant model in the form of event sequence diagrams, top event definitions for each system analysis, and a list of initiating events. Each input to the process is briefly described below.

- Event sequence diagrams indicate human action events included in the framework of the plant systems model. The identification of the operator tasks of interest, the context in which they arise, and the relevant accident sequences are identified in the development of the ESDs (see the Plant Model Report). Sequences involving operator action (e.g., manual trip of the reactor) are identified on the basis that recovery by operator action is feasible should automatic systems fail or in the event operator action is required to control and coordinate the operation of plant systems. The definition of possible sequences involving operator action allows one to focus on the types of plant information required and the factors that affect the operators in their performance.

- Systems and human interaction information is developed by the review of plant-specific simulator training experience, station procedures, and the systems analysis used in the safety assessment. Sequences identified in a review of the ESDs are compared with operator training experience and actual plant operating experience in the TMI-1 plant to better appreciate such performance shaping factors as the presentation of information and the number and importance of alarms. The human action analysis team included GPUN personnel with substantial experience in plant operations and simulator training experience involving the TMI Unit 1 operators. Such information provides the basis for estimating allowable operator action response times and the response requirements.

- The TMI-1 PRA list of initiating events is used to describe the entries in the operator-plant status confusion matrix (the TMI Unit 1 specific confusion matrix is developed in Section 3.4), an extension of the confusion matrix developed by Potash, et al. (Reference 2-13), and used by Potash and Dougherty in the Oconee PRA (Reference 2-14). The confusion matrix documents the study team's judgments about whether the operators could misdiagnose one event as another and the effect of misdiagnosis on the operator's subsequent actions. The development of this matrix qualitatively aids in identifying possible operator mistakes, the results of these mistakes, and the possibility of recovery. The possibility that the symptoms of a particular initiating event are confused with another event are indicated as either a high (H), medium (M), or low (L) probability of misperception. The results of the misdiagnosis on subsequent operator actions for plant recovery are indicated either as having a negligible impact on recovery (N) or as requiring reanalysis by the operators for subsequent recovery (R). An illustrative example of this matrix is presented in Table 2-5. In this table, for example, it is judged that a reactor trip initiating event might be confused with a turbine trip and therefore may require operator rediagnosis. The subsequent impact of this misdiagnosis on the operator's actions, however, is judged to be negligible. The potential for misdiagnosis and the possible impact on the operator's actions varies, depending on the specific plant conditions for each specific initiating event and on the time period after the initiation of the event.

- The types of human performance information used in the analysis of dynamic human actions includes expert opinion summaries of human error estimates from previous PRA studies (Reference 2-14), the NRC handbook of human reliability analysis (Reference 2-8), the human cognitive reliability model for control room crew nonresponse probability (Reference 2-15), and a Bayesian treatment of one scenario (operators fail to stabilize high pressure injection) using historical evidence (Reference 2-11). The results of the Bayesian treatment, which examined historical evidence, is used to help calibrate and as a benchmark against which to compare expert opinion.

Each of the above categories of information is used in the evaluation of dynamic human actions. The tool used in this study to organize the quantification of dynamic human actions for each selected accident scenario is called an operator action event tree (References 2-15 and 2-16). A generalized operator action event tree representation, which has been modified to suit our needs, is presented in Figure 2-3. The generalized sequence of events shown is that once the event occurs, the operators check their indications, perform a diagnosis, then take action. Afterward, if sufficient time is available, additional plant cues or the arrival of additional support personnel may lead to a rediagnosis of the event sequence and a change in the course of action. The operator action tree is not a model of how operators think in that considerable iteration (i.e., among checking parameters, diagnosis, review of procedures, and discussion) takes place during this process. The operator action tree, however, is used to develop the probability of arriving at an end state in an operator sequence. Each end state with appreciable frequency in the operator action event tree representation is then mapped back into the plant model event trees to complete the evaluation of the overall plant sequence frequency. The judgment of which end states of the operator action event tree to include in the plant model is done on a case by case basis, taking into account the importance of the impact of the end state compared to the impacts of other events along the accident sequence and their frequencies. Each outcome that is mapped back to the plant event trees is modeled as either a top event by itself or in combination with the hardware necessary to perform the action.

For sequences through the operator action event tree, four different end states are possible (see Figure 2-3). Success indicates that the operator successfully contributes to the recovery of plant systems. The end states, "nonviable action" and "incorrect diagnosis" are ways in which an adverse operator action may degrade the response of plant systems or lead to other events that would not otherwise have occurred; e.g., failure to stabilize high pressure injection may result in the operation of the primary system power-operated relief valves.

A "nonviable action" end state (i.e., sequence A1*B4*C1 in Figure 2-3) is one in which the operator successfully diagnoses the event sequence, but either chooses a course of action that does not remedy the situation or is unable to accomplish the action chosen. Such nonviable courses of action may not affect the subsequent plant response or they may actually make things worse.

An "incorrect diagnosis" end state is one in which the operator incorrectly assesses the actual event sequence either because he does not detect the sequence of events correctly or he mistakenly interprets the available indications and, as a result, takes an action that fails to remedy the plant state or, again, may make things worse. There is also the possibility that, despite the incorrect diagnosis, a correct action may be taken anyway because the incorrect procedures that are then followed may still require that the correct action be taken; e.g., sequence A2*B5.

Finally, the "nonresponse" end state is one in which the operator fails to diagnose the event sequence and therefore takes no action. "Nonresponse" end state frequencies are evaluated by the methods described in Section 2.3.2. The methods for evaluating "incorrect diagnosis" end states are described in Section 2.3.3. In general, the operator action event tree sequences that result in a "nonviable action" end state are believed adequately accounted for by the evaluation of the other dynamic human action types.

The likelihood of the operator consciously selecting a nonviable action that worsens the plant status is very small, given that he has already correctly diagnosed the accident sequence, because of the written procedural guidance available to the operating crew. Such errors are believed bounded in frequency by operator action sequences that involve an incorrect diagnosis; e.g., sequence A2*B6*C2.

The likelihood of correctly diagnosed but nonviable actions that have essentially no effect on the plant status are assumed to be small relative to the error rate estimates developed for nonresponse end states. Since this class of nonviable actions also has the same effect as the nonresponse sequences, it is not analyzed separately.

Operator slips in executing the correct, intended course of action (e.g., inadvertent steam line rupture detection system actuation) might also lead to a nonviable action. Such slips are generally only important if they lead to a degradation in plant status that is not easily reversed. A complete assessment of such slips is not performed in this study. When specific slips are identified and judged to be important, they are included, however.

A nonviable action may also effectively result in a nonresponse if there is insufficient time to carry out the selected action. Dynamic human actions for which the adequacy of the allowable recovery time is questionable, even if a successful diagnosis is performed quickly and the course of action is clear, are evaluated in a detailed recovery analysis if repair of failed equipment is involved or if the recovery actions are complex. Methods for such recovery analysis are described in Section 2.4. Otherwise, if the time available or the time required to perform the correct action is uncertain, these time periods are treated as variables, probability distributions are assigned, and the methods of Section 2.3 again used. If the allowable recovery time is clearly insufficient, no credit is given for such operator actions.

2.3.2 NONRESPONSE FREQUENCY ESTIMATION

2.3.2.1 Overview

This section describes the methods used in this study to estimate the frequency of nonresponse operator action sequences that result from a failure of the control room team to diagnose the accident sequence and take the appropriate action. The quantitative model adopted for this purpose is the human cognitive reliability model developed by Hannaman, et al., for EPRI (Reference 2-15), but with some modifications. This model basically assumes that there are three key factors in the assessment of the nonresponse frequency for a control room crew; the dominant cognitive processing type, the median response time to perform the task, and the allowable time to perform the task before a change in plant status occurs. The effect of other performance-shaping factors, such as stress level, operator experience level, and the quality of the plant operator interface, are also accounted for in the model by modification of the estimated median time to perform the task. The type of dominant cognitive processing is assumed to be unaffected by the other performance-shaping factors.

The HCR model provides time-dependent error rate estimates for nonresponse operator action sequences. With increasing time, the mathematical correlation indicates a continually decreasing error rate. It was judged by the TMI-1 PRA study team that, in the absence of new, radically different stimuli, a lower limit to the control room team error rate should be reached that would then be time independent. Lower limits to the error rates were judgmentally assigned. These lower limits are adjusted to reflect the quality of the plant interface, changes in plant status indications, or in the makeup of the diagnosis team. A poor or very poor plant interface is assumed to have a negative influence on the time independent nonresponse error rate. Therefore, the time-independent rates are adjusted up accordingly. The arrival of additional control room crew personnel or the establishment of the emergency response team onsite, if applicable, is assumed to have a beneficial influence on the nonresponse error rate. Also, if indications of the plant status change radically, this may prompt a rediagnosis of the accident sequence by the control room crew. The time-independent nonresponse error rates are then adjusted to account for this rediagnosis.

2.3.2.2 Implementation

The HCR model is used to describe the time-dependent portion of the nonresponse error rates. The mathematical correlation is given by (Reference 2-15)

$$F(t) = \exp - \left\{ \frac{t/[T*(1 + K_1)*(1 + K_2)*(1 + K_3)] - C1i}{C2i} \right\}^{C3i}$$

C1i, C2i, C3i = dependent on the type of cognitive processing involved (skill (i=1), rule (i=2), or knowledge-based (i=3).

t = allowable response time.

T = median or best estimate of the actual response time.

$F(t) = 1$, if $t/[T*(1 + K_1)*(1 + K_2)*(1 + K_3)] < C1i$

Performance Shaping Factors

K_1 = Operator Experience

K_2 = Stress Level

K_3 = Quality of Plant Interface

where F(t) is the time-dependent frequency estimate for a nonresponse by the control room crew. The values of the correlation parameters of the HCR model are those identified as interim values after limited benchmarking in Reference 2-15. These assumed values are repeated here as Tables 2-6 and 2-7.

To use the HCR model, the particular dynamic operator action being considered must first be defined and the applicable performance-shaping factors characterized in terms that can be reflected in the model. This requirement is common to all such human action response models. Engineering judgment plays a major role in the assignment of the performance-shaping factors. A dynamic human action questionnaire was developed to allow the study team to codify pertinent information collected about each dynamic action and to document the judgments made in characterizing the performance-shaping factors.

Table 2-8 lists the questions asked for each dynamic human action considered. In part A of the questionnaire, the analyst is asked to describe, in general terms, the action being considered and to relate the action back to the plant model by identifying the split fractions in which the action is considered. The third part of Section A indicates the particulars of the accident scenario; i.e., the support system state, the initiating event, and the status of other plant systems. The status of plant instrumentation might also be an important consideration in the assignment of dynamic human error rates. The current state of the art, however, is not sufficient to discriminate error rates based on the status of instrumentation. Consequently, a systematic review of the status of the instrumentation on which the operator relies to diagnose each scenario was not performed in this study.

The support model does identify whether the power supplies to vital instrument buses VBA, VBB, VBC, and VBD are available or not. None of the support system states in which dynamic human actions are quantified have both power trains A and B of vital instrumentation unavailable. At least one power train to two vital instrument buses is available in each support state. The instruments on which the operators key to make their diagnosis are redundant. In particular, the subcooling margin monitors have redundant power supplies. Loss of one or more instrument buses may lead to additional confusion, but the operators are trained to recognize the loss of power position for such instruments. The scenario descriptions in the completed questionnaires do not, therefore, include a discussion of the status of power to such instrumentation.

Individual instruments may fail for a variety of reasons other than loss of power; i.e., see Section 3.6. A systematic review of such failures is not included in the current scenario descriptions. In part, such failures are implicitly accounted for in Section C of the questionnaire, which documents the quality of the operator/plant interface.

In part B, a set of questions is provided to help the analyst decide what type of cognitive processing is involved in making the diagnosis. Similarly, parts C, D, and E are designed to help the analyst qualitatively determine the most appropriate description for each of the performance-shaping factors identified as parameters of the HCR model: operator and plant interface, stress level, and the experience level of the operating team. Part F assesses the remaining parameters that must be defined to use the HCR model: the median response time and the allowable response time.

Part G of the questionnaire inquires about the potential for rediagnosis of an event following a nonresponse diagnosis if sufficient time is available. Results from this part of the questionnaire are used to account for correctly rediagnosing the event following an initial failure to diagnose; i.e., quantify branch C3 in the generalized operator action event tree representation, Figure 2-3.

One key element of dynamic human actions analysis is the dependence between two separate human actions in the same event sequence. The dependencies considered between human actions are documented in part H of the questionnaire. Of particular concern is the possibility of simultaneous, or nearly simultaneous, demands on the people who must perform the actions. If the diagnosis and the response times are relatively short compared to the time available, the concerns about competing demands on the operator's time are generally neglected. An operator time line is developed to assist the analyst in qualitatively evaluating the potential dependence between human actions if the demands on the control room crew are particularly heavy. An operator time line is simply a graph portraying the time available to accomplish each human action and the earliest indication for action so that the potential overlap is well displayed.

Parts I and J of the questionnaire address dynamic human action types other than the nonresponse errors; i.e., misdiagnosis and selections of nonviable options. Methods for modeling misdiagnosis errors are discussed separately in Section 2.3.3. As first noted in Section 2.3.1, dynamic actions resulting in the selection of a nonviable action, given that a correct diagnosis of the the event has already been performed, are believed adequately accounted for numerically by the nonresponse error estimates. A systematic identification of significant operator slips that might effectively lead to the selection of a nonviable action, is not performed. Part J of the questionnaire, nevertheless, provides the analyst with a place to document any particular concerns that arise even without a more complete evaluation. Engineering judgment is used to assign error rates to any nonviable actions deemed important enough to include in the plant model.

Part K of the questionnaire summarizes the conclusions reached about the characterization of the dynamic human actions cognitive processing type and the appropriate performance-shaping factors. The HCR model is then evaluated by using the corresponding correlation parameters from Tables 2-6 and 2-7 to determine estimates for the human action nonresponse probabilities.

The HCR model results are for human actions in which the time available for diagnosis is an important consideration in the human error estimate. It is judged by the TMI-1 PRA study team that, for actions in which the time available is very long relative to the time required to diagnose and complete the action, a time-independent human error rate governs. Such time-independent error rates effectively set lower limits to the total human error rates. Use of such time-independent error rates also implicitly recognizes that the data on which the HCR model correlation parameters are based are currently limited, especially in the lower range of human error estimates. Qualitatively, one expects that an incorrect diagnosis that leads the control room crew to believe no response is justified would likely still be believed if no other stimuli indicate the need for a rediagnosis. In such cases, a time-independent error rate particularly seems appropriate. Consequently, extrapolation, using the HCR model, to very low error rates may be inappropriate since the HCR correlation predicts a fairly rapid falloff in the human nonresponse error rate with increasing time, especially at low error frequencies. See, for example, Figure 2-4, which illustrates typical calculated values from the HCR model.

In response to the above observations, judgment was used to assign time-independent nonresponse frequencies. These frequencies are listed in Table 2-9. Different values are assigned to each of five classes of dynamic actions. In selecting these values, an attempt was made to be consistent with the judgments made by analysts in other PRA studies when assigning error rates to dynamic actions for which a substantial amount of time is available. The sum of the time-independent error frequency and the HCR model output is chosen as the total nonresponse error rate.

Referring back to the operator action event tree (Figure 2-3), if no detection or diagnosis of the event occurs (i.e., nonresponse), it is still possible for a successful outcome. The operating team may be prompted to rediagnose the event and redirect their efforts to take the proper action. The time-independent nonresponse error rates may be modified to account for a rediagnosis. Influence factors are applied to the values in Table 2-9 to account for rediagnosis if applicable. A rediagnosis may occur if additional staff become available (judged to have high dependence on the previous diagnosis) or if changes in the plant status prior to the allowable recovery time result in significantly different plant indications (medium dependence with the previous diagnosis). Table 2-10 lists the influence factors assumed. These factors are assumed to be applicable to each of the five human action types identified in Table 2-9. Since these factors are applied only to the time-independent error probabilities, adequate time for the second diagnosis, and subsequent action, is assumed. No factors to account for rediagnosis are assumed for the time-dependent error rate estimates.

A second consideration for modifying the time-independent nonresponse error rates is the quality of the plant-operator interface. Qualitatively, if the plant indications are poor or very poor, one would expect a greater potential for the operating crew not to respond. This negative influence of a poor plant-operator interface for a specific situation is accounted for by influence factor R3, as indicated in Table 2-10. These factors were again assigned using engineering judgment.

The models described in this section for assessment of nonresponse error rates were computerized. A list of the resulting program is provided in the Appendix (Table A-1). The treatment of dependencies between dynamic human actions and the procedures for estimating uncertainties (discussed in Sections 2.3.6 and 2.3.2) were also included in the program.

2.3.3 ASSESSMENT OF ERRORS OF MISDIAGNOSIS

Misdiagnosis is broadly defined as a misperception in the actual status of a plant safety state; i.e., reactor shutdown, cooled core, sufficient inventory. For example, operators may confuse a small LOCA with a steam generator tube rupture event because both result in a reduction in reactor coolant system inventory. This section describes the methods used to identify and quantify the likelihood of an "incorrect diagnosis"; i.e., sequence A2.B6.C2 in the generalized operator action event tree Figure 2-3, which is caused by a misdiagnosis.

Basically, the approach taken is to first identify the relative likelihood of entering the wrong procedure for each initiating event modeled. The list of initiating events is used as an initial screen of events since it represents a spectrum of plant transients or events during the first few minutes of an accident sequence. Ideally, a very extensive list of accident sequences would be compared to each other to assess the potential for misdiagnosis. However, such a formulation of the problem is open-ended and could never be construed as complete. The list of initiating events, with no other plant failures, is considered to be a manageable number of accident sequences that may still provide many of the insights to be learned from such an investigation.

Initiating events identified as having a nonnegligible probability of the operator selecting the wrong procedure are then evaluated further. An assessment is made of the impact of selecting the wrong procedure. Those actions called for in the incorrect procedure that might make it difficult to later recover from the incorrect diagnosis are identified. It is the potential for a misdiagnosis that leads to an action that complicates the situation that is of most interest.

The results of this review are documented in an operator-plant status confusion matrix, as described in Section 2.3.1. An example confusion matrix is provided as Table 2-5. The operator-plant status confusion matrix lists plant events in which event symptoms may be confused. The possibility that the symptoms of a particular event are confused with another event is indicated as having a high (H), medium (M), or low (L) probability of misperception. The results of the misdiagnosis on subsequent operator actions are indicated either as having a negligible impact on recovery (N) or as requiring reanalysis by the operators for recovery (R). A reactor trip, for example, may be confused with a turbine trip. The operators' immediate actions, verification that the reactor and turbine have tripped, are very similar and are almost automatic. Therefore, the effect of possible confusion between these two events, even if one is mistaken for the other, is judged to be negligible.

The entries in the confusion matrix are often symmetric. If one sequence of events is likely to be confused with another; generally, the reverse is also true. In the example above, a reactor trip was the initiating event. The matrix can, but does not in this case, distinguish any difference between the two symmetric cases in operator perception: that is, the same confusion level (medium in this case) and effect on the plant (a negligible impact in this case) is considered to exist if the turbine trip is the initiating event and the operators think a reactor trip had occurred or vice versa.

An individual performing an analysis of the possibility of confusion might argue that a higher state of confusion may exist for events that occur at lower frequencies or for events that may never occur during the lifetime of the plant. These events would be beyond the normal experience for the typical operator except in training. Actual operators handling a transient, it can be argued, may discount an event with a lower frequency of occurrence and may be more apt to assume that the similar initiating event with a higher occurrence frequency has actually occurred. For this reason, not all symmetric entries in the confusion matrix must be judged to have an equal chance of being confused with the other.

The impact of misdiagnosis on the operators' actions may vary considerably, depending on the specific plant conditions for each event and the time period after the event. For example, an initiating event, such as a steam generator tube rupture, may appear to be a small LOCA early in the transient before condenser or steam generator blowdown radiation alarms are annunciated or if the alarms fail to operate. However, the operators may still take proper initial corrective actions without knowing the cause of the small LOCA. Such considerations are therefore important when assessing the impact of identified potential areas for misdiagnosis.

Possible errors of misdiagnosis are difficult to identify. This type of dynamic error has not been studied as extensively as errors under routine conditions and are considered to be influenced more by operator perception of status and less by the position of controls. This subjective analysis of the potential for misdiagnosis, however, does consider possible ergonomical deficiencies when a deficiency may clearly contribute. Part I of the dynamic human actions questionnaire (i.e., Table 2-8) allows the analyst to document those situations in which the available indications differ only slightly between two similar events or, if the indications differ, only on parameters not normally keyed on by the operator .

The availability of electric power supplies for the instrumentation to monitor and track plant status is included in the support model event tree structure. The plant hardware (e.g., systems instrumentation, electric power availability) required to successfully carry out an operator action is analyzed explicitly and separately from the human response if it is believed to be important relative to the human error. Details on the use of specific plant instrumentation, especially its power supplies, were not reviewed in this study. A detailed, sequence-by-sequence review of the instrumentation available as a function of support system status is judged to not currently be warranted by the state of the art in human factors analysis.

The following describes the steps taken to develop the operator-plant status confusion matrix for TMI-Unit 1. The matrix is developed by first preparing some preliminary tables, then reviewing these preliminary tables as the assignment of the qualitative entries in the confusion matrix is made.

Three preliminary tables are used to summarize the information used by the operator to select the appropriate procedure. One table describes the physical status of the plant for each initiator in the early stages of an accident sequence. The physical status is described in terms of the expected response of a selected, short list of plant indications available to the operator and on which he is trained to initially focus his attention. Obviously, the response of every indication in the control room cannot be documented so simply. This table is just a summary of the important indications available to the operating crew for each initiator.

A second table is then prepared to relate the entry conditions for each procedure in terms of the same short list of plant indications. The entries in this table are determined by the layout of the procedures and not by the plant response to any particular initiator.

A third table is developed to identify the correct procedure or procedures to be followed for each initiating event. More than one procedure may be appropriate, or even necessary, to follow the correct response. This third table therefore also identifies the expected order in which the procedures should be implemented for each initiator.

The three tables together form a partial basis for judging the potential for confusion between each pair of initiating events. (See Section 3.4 for the TMI-1 specific tables). The expected plant response for the first initiator in the first preliminary table is contrasted with the entry conditions (in the second table) for the appropriate procedure for the second initiator in the pair (as identified in the third table). Depending on the similarity of plant indications, the potential for confusion is then judged as high, medium, low, or insignificant. The timing of the plant indications, the stress on the operators, and the available time for diagnosis of the plant status are, of course, not delineated in the three preliminary tables. These factors are considered judgmentally, however, in the assignment of confusion matrix entries and documented accordingly.

The second part of filling out the confusion matrix is concerned with the potential for a misdiagnosis, should it occur, leading to a situation that would complicate the operating team's ability to recover from it. A fourth preliminary table is prepared to document this judgmental process. The system functions of interest in the plant model are defined by the top events in the event trees. This preliminary table identifies which procedures call for manual action to initiate the systems that perform the actions defined by the top events, or to back up their automatic initiation. For example, Emergency Procedure 1210-7, large break LOCA cooldown, calls for manual switchover to achieve sump recirculation; i.e., Top Events SA and SB.

Thus, for the row in the fourth preliminary table corresponding to Top Events SA/SB, an "X" is placed in the column for Procedure 1210-7. In the same table, an "O" is placed in the appropriate place if the actions called for by a particular procedure are directly opposite to or otherwise complicate the system functions defined by a particular top event. For example, if a procedure says to turn the reactor coolant pumps off, this is a complicating action for both Top Events RP, reactor coolant pumps continue to run, and CD, cooldown and depressurization of the reactor coolant system using pressurizer spray and the reactor coolant pumps. It is possible that the wrong procedure could be selected and, yet, the correct operator response still be asked for. On the other hand, one or more top events may be adversely complicated by the error in selecting the wrong procedure; i.e., misdiagnosing the accident sequence. The degree of complication caused by the misdiagnosis is assigned judgmentally to the confusion matrix but only for those entries for which the potential for misdiagnosis was judged to be nonnegligible.

The entries in the final confusion matrix (presented in Section 3.4) can therefore take on a range of qualitative assessments, ranging from a negligible potential for misdiagnosis to a high potential for misdiagnosis that also has a strong potential for complicating the operator's ability to recover. The range of possibilities is identified in Table 2-11. The median point estimates shown in Table 2-11 are subjectively assigned. The values assigned are in the same range as those chosen in the Oconee PRA for similar events (Reference 2-14, page C-7).

Events of misdiagnosis enter into the generalized operator action event tree (see Figure 2-3) with branch A2; i.e., faulty detection diagnosis. In the event of a misdiagnosis, it is assumed that the operating crew initially follows the actions delineated in the incorrectly chosen procedure; i.e., follows branch B6 with frequency 1.0. As indicated in the generalized operator action event tree representation following the misdiagnosis, it is still possible, and actually likely, for there to eventually be a successful rediagnosis and subsequent redirection of the operating crew's actions; i.e., with time, the frequency of branch C2 in Figure 2-3 becomes very small.

The TMI-1 PRA study team is unaware of a suitable method for estimating the likelihood of failure to successfully rediagnose the plant status after an initial misdiagnosis. Therefore, it is assumed that all such initial misdiagnoses are eventually successful and the accident sequence correctly rediagnosed. The timing of the rediagnosis is implicitly modeled by judgmentally identifying which of the top events that are judged to be adversely affected by the initial misdiagnosis should be quantified as such; i.e., the misdirected action causing the complication is judged to occur prior to a successful rediagnosis. For example, using the reactor coolant pump example mentioned previously, the successful rediagnosis may be judged to occur after the RCPs were incorrectly tripped (i.e., Top Event RP), but before the time that cooldown and depressurization using pressurizer spray (i.e., Top Event CD) must be initiated. In this case, the impact of the misdiagnosis event would be modeled as affecting Top Event RP, but not CD, when including this misdiagnosis event in the plant model.

Each misdiagnosis event judged to have a nonnegligible frequency is accounted for in the plant model on a case-by-case basis. If the misdiagnosed event is judged to affect only one top event, the frequency of the event is included as just another failure mode for that top event. If the misdiagnosed event is judged to affect multiple top events, a new top event is then added to the appropriate event tree to account for this new dependency. In this way, a misdiagnosis leading to an entirely different sequence may be quantified.

2.3.4 NONVIABLE HUMAN ACTIONS

In the generalized operator action event tree representation (Figure 3-2), sequence A1*B4*C1 results in a nonviable action end state. As first discussed in Section 2.3.1, operator errors resulting in nonviable actions, which have essentially no impact on the status of the plant, are assumed to have relatively small error frequencies compared to the nonresponse error estimate assigned to nonresponse states. Similarly, the likelihood of the operator consciously selecting a nonviable action that worsens the status of the plant following a correct diagnosis of the situation is also believed to be very small.

The most likely cause of the operating crew performing a nonviable action, after a correct diagnosis has already been made, is believed to be the result of an inadvertent slip in attempting to perform the correct action. The operating crew member may inadvertently select the wrong control. In evaluating the frequency of such nonviable actions, use is made of error rate estimates presented in Table 20-12 of the NRC human reliability handbook (Reference 2-8). The potential for such slips is documented in the dynamic human actions questionnaire, part J. Only potential slips that may be caused by similar controls being located in close proximity are judged to have a significant frequency of occurrence. The NRC handbook suggests a best estimate error rate of 3×10^{-3} with an error factor of 3 (Reference 2-8, Table 20-12, item 2) for such errors. The probability distribution for this error rate is given the name HNV1. The mean, 5th, median, and 95th percentiles for it are provided in Table 1-3. The error rates recommended in the handbook for potential slips involving less similar controls were not used. A systematic and complete evaluation of such errors was not attempted in this study.

2.3.5 TREATMENT OF DEPENDENCIES AMONG TASKS

The likelihood of failure of a second human action in an accident sequence is generally greater if the first human action was not successfully completed. Dependencies among tasks exist because the decision to perform each task may be based on the same diagnosis, the actions may be directed at the same immediate goal, and, at any rate, these actions are to be accomplished by the same control room crew.

The NRC handbook (Reference 2-8) classifies dependencies between tasks according to the perceived strength of the dependency. Five levels of dependence are used. Equations are offered (i.e., Table 20-17 of Reference 2-8) for computing the conditional failure probability of a second action, given the success or failure of the immediately preceding action, These equations are repeated here as Table 2-3. This treatment of dependencies among tasks has been widely used in prior PRA studies; e.g., References 2-11 and 2-14. Since the HCR model formulation currently offers no guidance for use of the model in the treatment of dependence among tasks, the NRC handbook approach is also adopted here for all dynamic human actions.

The key aspect in applying the NRC handbook approach for dependencies among tasks lies in the qualitative assignment of the strength of the dependencies. Part H of the dynamic human actions questionnaire (Table 2-8) documents the judgments made in the assignment. If two actions are both directed at the same immediate goal (e.g., remote start of a pump or local start of the same pump) complete dependence is assumed. If both actions rely on the same event sequence diagnosis, complete dependence is again assumed. Operator time lines may be developed to document dependencies that may result from the need to perform a number of tasks simultaneously with a limited control room crew.

2.3.6 ASSIGNMENT OF UNCERTAINTIES

Uncertainty distributions are assigned to each of the human error rates developed for dynamic human actions. These assignments are based on judgment since there are few or no data on which to base such distributions. Both the NRC handbook (Reference 2-8) and the Oconee PRA authors (Reference 2-14) suggest an approach that divides the range of point estimate, dynamic human error probabilities into two regimes.

The Oconee PRA authors chose a dividing line at 0.1 (Section 6.4 of Reference 2-14). The NRC handbook (Reference 2-8) suggests that the dividing line between the two regimes be made at 0.001. For error rates greater that 0.001, an error factor of 5 is suggested; i.e., Table 20-20 of Reference 2-8. For error probabilities less than 0.001, an error factor of 10 is suggested. These error factors are in the same range as those derived by Apostolakis, et al., using a Bayesian approach and the available historical evidence to investigate the failure frequency of the operators to stabilize high pressure injection when necessary (Section 10, Reference 2-11). This event was assigned a mean error rate of about 0.02.

For this study, the dividing line between the two regimes is chosen to be at 0.03. Above this value, error factors of 5 (the ratio of the 95th to the 50th percentile) are used. For dynamic actions with point estimates below 0.03, error factors of 10 are assigned. In each case, lognormal distributions are assumed to apply. For "nonrare event" human error estimates (i.e., greater than about 0.1), use of a lognormal distribution may lead to error estimates that are not possible; i.e., values greater than 1.0. In such cases, discrete distributions are judgmentally developed that give roughly the same spread between the 5th and 95th percentiles, do preserve the mean, but that do not go above 1.0.

The above guidelines can be applied in a straightforward manner if the human action under consideration is not dependent on previous tasks. The formulas provided in Table 2-3 for dependent tasks introduce an added complication for treating uncertainties.

The NRC handbook suggests uncertainty ranges that can be used for conditional human error probabilities. These suggested ranges are repeated in Table 2-4 as a function of both the level of dependence among actions and the independent human error probability. The handbook approach, described in Appendix A of Reference 2-8, was adopted in this study for assigning uncertainty distributions to conditional human error rates.

If the first action fails and the second action is dependent on it, the methodology outlined in the NRC handbook was used directly. If the first actions succeed, however, following the same approach then leads to unusually narrow ranges for the error rate distribution of the second action. Therefore, if the preceding action on which the second depends is successful, the uncertainty range factor assigned to the error rate of the dependent action is then the same as if it were not dependent on the preceding action; i.e., factor of 5 if greater than 0.03; factor of 10 if less than 0.03. These methods for computing the uncertainty ranges of dynamic human action error rates were also included in the program for computing nonresponse error rates. The program listing is provided in Appendix A.

Study constraints precluded a detailed recovery analysis of every dynamic human action in which it was suspected that the uncertainties in the assumed allowable length of time for recovery and the time required to perform the indicated action could be very important. To treat such uncertainties without using the detailed recovery analysis methods described in Section 2.4, the program that computes nonresponse human error rates was augmented to treat uncertainties in such times. Discrete probability distributions for the allowable length of time and for the length of time estimated to be required to perform the indicated action can be input. The program then computes the human action error frequency for each discrete combination of the two distributions. These results are then displayed in the program output, so the range of estimates can be compared to the general human action range factors; i.e., factor of 5 if error frequency is greater than .03, and range factor is 10 if the error frequency is less than 0.03. If the range of error frequencies due to the variability of allowable length of time and length of response times is less than the general range factors, the general range factors are then used with a median value equal to the average of the computed error frequency distribution. If the time distributions lead to a greater range of error frequencies than the general range factors, the larger, computed error frequency distribution is then used directly.

Estimated upper and lower bounds and best estimate error frequencies for dynamic human actions are reported in Table 4-1. These estimates were fitted to 20-bin histograms to form probability of frequency distributions for each error rate. The final results, including the mean values for these frequency distributions, are reported in Table 1-2.

2.4 DETAILED RECOVERY ANALYSIS

2.4.1 OVERVIEW

A detailed recovery analysis requires careful evaluation of human response during abnormal and unfamiliar circumstances. The actions of operating, maintenance, supervisory, and support personnel must be coordinated in a team effort to restore normal plant conditions. Depending on the event scenario, the failed equipment, and the causes for failure, several competing recovery options may be available. These options must be evaluated considering the available personnel, the difficulty of each action, actual and perceived urgency, procedural guidance, training, and experience. Very often, these decisions must be made under conditions of high stress with little time for detailed planning. For these reasons, it is important to apply recovery models for specific event scenarios or for groups of event sequences exhibiting similar system and plant performance characteristics and requiring similar human responses.

The likelihood of core damage during a recovery scenario is a function of the time required to recover, T_R, and the time to core damage if recovery does not occur, T_{CD}. Damage occurs if T_R is greater than T_{CD}; i.e.,

$$Fr\{\text{core damage}\} = Fr\{T_R > T_{CD}\}$$

Note that the allowable recovery time may be chosen to be other than the time of core damage if appropriate.

This competing process model has been used in the analysis of other time-dependent scenarios (Reference 2-17). Its usefulness stems from its translation of models for physical variables (T_R and T_{CD}) into models for event frequencies that are needed in a PRA.

One method of determining T_R is the use of a simulation model. In simulation modeling, a complex time-dependent process can be treated in a relatively simple manner without sacrificing the essential details of the process. This method was used for the detailed recovery analyses performed on TMI-1.

2.4.2 THE RECOVERY MODEL

A realistic recovery model must account for the causes and timing of specific events, the sequencing of actions, and the time available for successful recovery. The purpose of the simulation model is to predict the distribution for the recovery time, T_R, given those various pieces of information. The model essentially consists of two parts: (1) a set of "rules" for system behavior that dictates when the system components fail, or are repaired, as a function of the current system configuration and (2) a Monte-Carlo sampling mechanism for establishing the occurrence times of key random events. As an example of the system behavior rules, in the model for electric power recovery, battery 1 is required to begin draining when diesel 1 fails. Another rule is that if battery 1 drains before either offsite power or diesel 1 is recovered, diesel 1 cannot be started for the duration of the scenario.

The advantage of a simulation is that rules of arbitrary complexity can be used to realistically treat the operational characteristics of the system being modeled. In the detailed recovery analysis, the simulation model is in the form of a small computer program written by using the SIMSCRIPT II.5 simulation language (Reference 2-18).

The program contains three basic sections. These sections are the PREAMBLE, the MAIN program, and the PROCESS and EVENT routines.

The PREAMBLE introduces the processes, events, and variables to be used in the simulation. It can be thought of as the cast of characters for the program. It also defines all variables and lists the items to be tracked in a TALLY statement.

The MAIN program reads the input data and starts the simulation. The PROCESS/EVENT routines define the actions associated with each simulated entry. These routines incorporate the system's rules of behavior mentioned above.

The disadvantage of a simulation approach when modeling rare events is that only a relatively small number of trials result in system failure. Therefore, estimates based on these trials may be subject to significant statistical variability. To reduce the scope of this problem, various importance sampling techniques may be used. In this case, a relatively simple approach is adopted. First, a set of system boundary conditions is developed, based on postulated failure or success on demand of the system components. Next, a simulation analysis is performed, conditioned on these boundary conditions. Using this technique, the equipment demand failure rates are incorporated when combining the conditional distributions for T_R. rather than during the sampling process.

The results of the simulation model program are in the form of a frequency of recovery given a particular set of boundary conditions; i.e., a recovery scenario. These results are combined using the following equation

$$F(T_{CD}) = \sum_{i=1}^{n} C_i F_i(T_{CD})$$

where

$F(T_{CD})$ = the unconditional frequency of recovery within the allotted time window T_{CD}.

T_{CD} = allotted time window; i.e., time to core damage.

C_i = frequency of the conditions imposed on scenario i.

$F_i(T_{CD})$ = the conditional frequency of recovery at time T_{CD} for scenario i.

n = the number of scenarios (sets of conditions) examined.

The frequency of core damage can now be determined by subtracting the frequency of recovery from 1; i.e.,

$$Fr(\text{core damage}) = 1 - F(T_{CD})$$

The specific rules and programs for each detailed recovery analysis are described in Section 4.3.

2.5 REFERENCES

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TABLE 2-1. SAMPLE WORKSHEET FOR INITIAL QUANTIFICATION OF OPERATOR ACTIONS

SPLIT FRACTION: SA/SB-1 HUMAN ACTION NAME: HSR2

DESCRIPTION: Must do within 10 minutes after getting BWST low-level alarm (about 6 to 12 hours into the scenario) to protect the LPI pumps. BWST low-level alarm at 3 feet in BWST. Operator opens sump isolation valves DH-V6A and DH-V6B, assuming there is water in the sump. Operator should also close BWST suction valves to the LPI pumps (DH-V5A and DH-V5B), but if he does not, check valves prevent backflow into BWST.

INITIATING EVENT: Transient, very small LOCA.

SUPPORT SYSTEM STATE: One train down, or all support systems available.

SCENARIO: Transient either fails to reclose PORV and RCS relief valves or perform HPI cooling (closed loop RHR and makeup is not an alternative). The BWST is exhausted, and at least one train of HPI and LPI pumps is available.

VALUE: 5×10^{-3}(MBS)

* 5×10^{-3}(CA)

10^{-3}(CH)

10^{-3}(TMc)

5×10^{-3}(FRH)

TABLE 2-2. SOURCE OF BASIC HUMAN ERROR RATES (Per Demand) FROM THE NRC HANDBOOK

Task	NRC Final Handbook Distribution* (Reference 2-8)	Source of Estimate in The NRC Final Handbook (Tables in Reference 2-8)
ERRORS OF COMMISSION		
1. Changing or tagging wrong valve when the desired valve is one of two or more adjacent, similar-appearing manual valves and at least one other valve is in the same state as the desired valves, or when the valves are MOVs of such a type that valve status cannot be determined at the valve itself.	5×10^{-3} EF = 3	Table 20-13, Item 2 and Table 20-14, Item 3
2. Changing or restoring wrong MOV switch or circuit breaker in a group of similar-appearing items identified by labels only.	3×10^{-3} EF = 3	Table 20-12, Item 2
3. General error of commission in nonpassive tasks, such as maintenance, test, or calibration, when written procedures are used; e.g., misreading label and therefore selecting wrong switch.	3×10^{-3} EF = 3	Table III 6-1, Item 3 of Reference 2-10
ERRORS OF OMISSION		
1. Failure to use procedures with checkoff provisions.		
a. Short list (< 10 items).	10^{-3} EF = 3	Table 20-7, Item 1
b. Long list (> 10 special instruction items).	3×10^{-3} EF = 3	Table 20-7, Item 2
2. Failure of checker to detect errors made by others.		
a. Failure to recognize an incorrect status when checking each item; failure to involve active participation.	10^{-2} EF = 5	Table 20-22, Item 4
b. Failure to recognize an incorrect status when checking routine tasks; failure of checker to use written materials.	10^{-1} EF = 5	Table 20-22, Item 1

*Best estimate; EF = error factor.

TABLE 2-3. EQUATIONS FOR CONDITIONAL PROBABILITIES OF SUCCESS AND FAILURE ON TASK "N," GIVEN SUCCESS OR FAILURE ON PREVIOUS TASK "N-1," FOR DIFFERENT LEVELS OF DEPENDENCE (From Reference 2-8, Table 10-2)

Level of Dependence	Success Equations	Equation Number*	Failure Equations	Equation Number*
ZD	$Pr[S_{"N"} \mid S_{"N-1"} \mid ZD] = n$	(10-9)	$Pr[F_{"N"} \mid F_{"N-1"} \mid ZD] = N$	(10-14)
LD	$Pr[S_{"N"} \mid S_{"N-1"} \mid LD] = \frac{1 + 19n}{20}$	(10-10)	$Pr[F_{"N"} \mid F_{"N-1"} \mid LD] = \frac{1 + 19n}{20}$	(10-15)
MD	$Pr[S_{"N"} \mid S_{"N-1"} \mid MD] = \frac{1 + 6n}{7}$	(10-11)	$Pr[F_{"N"} \mid F_{"N-1"} \mid MD] = \frac{1 + 6n}{7}$	(10-16)
HD	$Pr[S_{"N"} \mid S_{"N-1"} \mid HD] = \frac{1 + n}{2}$	(10-12)	$Pr[F_{"N"} \mid F_{"N-1"} \mid HD] = \frac{1 + n}{2}$	(10-17)
CD	$Pr[S_{"N"} \mid S_{"N-1"} \mid CD] = 1.0$	(10-13)	$Pr[F_{"N"} \mid F_{"N-1"} \mid CD] = 1.0$	(10-18)

*In Reference 2-8.

TABLE 2-4. APPROXIMATE CHEPs AND THEIR UCBs FOR DEPENDENCE LEVELS,* GIVEN FAILURE ON THE PRECEDING TASK (From Reference 2-8, Table 7-3)

Item	Levels of Dependence	BHEPs		
		(a)	(b)	(c)
1	ZD**	< .01	.05 (EF = 5)	.1 (EF = 5)
		(d)	(e)	(f)
		.15 (EF = 5)	.2 (EF = 5)	.25 (EF = 5)
Item	Levels of Dependence	Nominal CHEPs and (lower to upper UCBs)†		
		(a)	(b)	(c)
2	LD	.05 (.015 to .15)	.1 (.04 to .25)	.15 (.05 to .5)
3	MD	.15 (.04 to .5)	.19 (.07 to .53)	.23 (.1 to .55)
4	HD	.5 (.25 to 1.0)	.53 (.28 to 1.0)	.55 (.3 to 1.0)
5	CD	1.0 (.5 to 1.0)	1.0 (.53 to 1.0)	1.0 (.55 to 1.0)
		(d)	(e)	(f)
2	LD	.19 (.05 to .75)	.24 (.06 to 1.0)	.29 (.08 to 1.0)
3	MD	.27 (.1 to .75)	.31 (.1 to 1.0)	.36 (.13 to 1.0)
4	HD	.58 (.34 to 1.0)	.6 (.36 to 1.0)	.63 (.4 to 1.0)
5	CD	1.0 (.58 to 1.0)	1.0 (.6 to 1.0)	1.0 (.63 to 1.0)

*Values are rounded off from calculations based on Appendix A in Reference 2-8. All values are based on skilled personnel; i.e., those with more than 6 months experience on the tasks being analysed.

**ZD = BHEP. EFs for BHEPs should be based on Table 20-20 in Reference 2-8.

†Linear interpolation between stated CHEPs (and UCBs) for values of BHEPs between those listed is adequate for most PRA studies.

TABLE 2-5. OPERATOR PLANT STATUS CONFUSION MATRIX

Plant Event (illustrative example)	1 (RT)	2 (TT)	3 (IL)	4 (SL)	5 (ML)	6 (LL)
1 Reactor Trip (RT)	--	M/N				
2 Turbine Trip (TT)	M/N	--				
3 Isolable LOCA (IL)			--	M/N	L/N	
4 Small LOCA (SL)				--		
5 Medium LOCA (ML)					--	M/N
6 Large LOCA (LL)						--

NOTES:

1. Abbreviations (L = low probability of misperception; M = medium probability of misperception; H = high probability of misperception; N = negligible impact on recovery; and R = rediagnosis required to minimize impact of misperception.
2. For matrix intersections with no entry, the confusion probability is negligible.

TABLE 2-6. INTERIM HCR
CORRELATION PARAMETERS*

Cognitive Processing Type	C1i	C2i**	C3i
Skill (i=1)	0.7	0.407	1.2
Rule (i=2)	0.6	0.601	0.9
Knowledge (i=3)	0.5	0.791	0.8

*From Reference 2-15
**Decimals carried on C2 to ensure that
F(t) = 1 at t = 0.

TABLE 2-7. HCR MODEL PERFORMANCE-SHAPING FACTORS AND RELATED COEFFICIENTS*

	Coefficients
OPERATOR EXPERIENCE (K_1)	
1. Expert, well trained.	-0.22
2. Knowledge, average training.	0.00
3. Novice, minimum training.	0.44
STRESS LEVEL (K_2)	
1. Situation of grave emergency.	0.44
2. Situation of potential emergency.	0.28
3. Active, no emergency.	0.00
4. Low activity, low vigilance.	0.28
QUALITY OF OPERATOR/PLANT INTERFACE (K_3)	
1. Excellent.	-0.22
2. Good.	0.00
3. Fair.	0.44
4. Poor.	0.78
5. Extremely poor.	0.92

*From Reference 2-15.

TABLE 2-8. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Sheet 1 of 13

Human Action Identifier:______________________________

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) ________
   Rank on scale of 1 to 5, with 3 being average and 5 most familiar. _____

2. If yes, by what means? (procedures, training, frequent performance, or walk-throughs) ____________________
   Give procedure number if applicable ______________.

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) ________

4. Is this action included in simulator training? (yes, no) ________

5. How frequently are these actions reviewed by the operators? _________

Check descriptions that apply to this action:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) ________.

Knowledge-Based

☐ Not routine, action ambiguous.

☐ Not routine, procedure does not cover.

☐ Not routine, procedure not well understood.

☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ______________

TABLE 2-8 (continued)

Sheet 4 of 13

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   Are displays directly visible? __________

2. Alarms (name, location, audible, visual):

   Will there be many other alarms to distract the operator? (Describe.)

3. From where will action first be attempted? (control room, other--specify) ____________________

4. Is special coordination between operators required? (yes, no) ________

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)

   ____

6. How specific is the guidance for action? (component numbers, timing) ____________________

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human-engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human-engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) ________

2. Why is this action needed? (backup to an automatic action, planned manual action, recovery of failed system, defeat ESAS response) _______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) _______ (Explain if yes.)

4. Are there any system failures that complicate this action? (none, one, multiple) ____________________

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

- ☐ Vigilance Problem. Unexpected transient with no precursors.
- ☐ Optimal Condition/Normal. Crew carrying out small load adjustments.
- ☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- ☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, well trained. Licensed with more than 5 years experience.

☐ Average knowledge, training. Licensed with more than 6 months experience.

☐ Novice, minimum training. Licensed with less than 6 months experience.

F. Response Time Available

1. What is the timing of the first indications for the operator action? (in time since initiating event) ________________

2. When may the operator first act? (in time from initiating event) ________________

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event, ________
   or as time since first indications ________?

4. Estimate the median time to carry out the action, once decided to pursue. ________________

   Best estimate of the time it will take to diagnose ________?

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ________________

Assess timing for each scenar group.

Scenario Group	Time Allowed Best Estimate	Time Available Conservative Estimate	Time to Diagnose Best Estimate	Time to Perform Conservative/ Best Estimates
A.				
B.				
C.				
D.				

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ____________

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ________

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., none, shift technical advisor (STA), remote emergency response team] ________

   At what point would the following events be declared?

   - Alert (onsite response team called) ____________
   - Site Area Emergency (offsite response team called ________
   - General Emergency (potential evacuation) ____________

5. Should additional credit be given because of additional plant feedback? (yes, no)________

6. Should additional credit be given because of newly arriving crew members? (yes, no) ________

TABLE 2-8 (continued)

Sheet 9 of 13

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

2. How much influence do previous human errors have on this action? (significant, some, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

4. Are there enough personnel available to carry out the necessary actions? __________

5. Must a specific dependence with another human action be accounted for?

	Scenario Group	Yes/No	Comments
A.			
B.			
C.			
D.			

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number __________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) ________

3. Which initiating events may lead to a need for this action?

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) ________ If no, identify by initiator ____________________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ______________.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) ________ If yes, identify ____________________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ____________________

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

   Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low? ____________________

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) __________ Identify by number ______________.

10. If the incorrect procedure is entered, does it direct the operator to:

    - [ ] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify ____________________.
    - [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______________________

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) _______

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) _______

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) _______ Identify:

4. Is more than one option pursued in parallel? (yes, no) _______

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) _______ Identify _____
____

   If the correct action were taken prematurely, would the action still be successful?_______

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) _______
   Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes/no)_____ Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low? _____________

Human Action Identifier: ______________________________

K. Summary Sheet

From B. What type of behavior is required? ____________________

From C. Description of plant interface? ______________________

From D. Expected stress level for each scenario group?

Group A ______________________________
Group B ______________________________
Group C ______________________________
Group D ______________________________
Group E ______________________________

From E. Experience level of operating team ____________________.

From F. Time available to perform correct action ______________.
Best estimate of time to diagnose______________________.

From G. Additional credit for rediagnosis due to plant feedback?
______________ Arriving crew members? _______________

From H. Need to account for dependence with other actions for each scenario group? Degree of dependence?

Group A ______________________________
Group B ______________________________
Group C ______________________________
Group D ______________________________

From I. Potential for incorrect diagnosis leading to failure? ____
____

From J. Potential for selection of nonviable option? ____________

Type of human action

- [ ] Backup to an automatic action
- [ ] Detract from an ESAS response
- [ ] Recovery of a failed system via realignment
- [ ] Planned manual action
- [ ] Action may lead to an extended outage; e.g., due to contamination.

TABLE 2-9. ASSUMED TIME-INDEPENDENT NONRESPONSE FREQUENCIES

Task Type	Best Estimate Human Error Value
1. Manual Backup to Automatic Plant Response (e.g., manual reactor trip, HPI startup)	10^{-3}
2. Change/Detract from ESAS Plant Response (e.g., turn off HPI)	3×10^{-2}
3. Recovery of Failed System (e.g., isolate leaking heat exchanger)	10^{-2}
4. Planned Manual Action (e.g., recirculation switchover)	10^{-3}
5. Action that Will Contaminate the Plant or Otherwise Lead to an Extended Outage (e.g., HPI cooling)	10^{-2}

TABLE 2-10. INFLUENCE FACTORS ON
TIME-INDEPENDENT NONRESPONSE FREQUENCIES

Benefits from Rediagnosis

Condition	R_1 Factor
Skill or Rule-Based Process and Shift Technical Advisor Arrives	1/3
Knowledge-Based Process and Offsite Emergency Response Team Arrives	1/2

Condition	R_2 Factor
New Plant Indications Causes Control Room Crew To Reassess Diagnosis (e.g., reactor vessel level drops, radiation alarms go off)	1/7

Negative Influence of Poor Plant Interface

Condition	R_3 Factor
Poor Plant Interface with Operating Crew	3
Very Poor Plant Interface with Operating Crew	7
Fair or Better than Average Plant Interface with Operating Crew	1

TABLE 2-11. BEST ESTIMATE ERROR RATES FOR MISDIAGNOSIS EVENTS IDENTIFIED IN THE OPERATOR-PLANT STATUS CONFUSION MATRIX

Potential for Initial Misdiagnosis*	Degree of Complication of Recovery Actions	
	Negligible	Some Impact on Subsequent Operator Actions
High	0	0.05
Medium	0	0.01
Low	0	0.001
Negligible (blank)	0	0

*That is, selection of the wrong procedure.

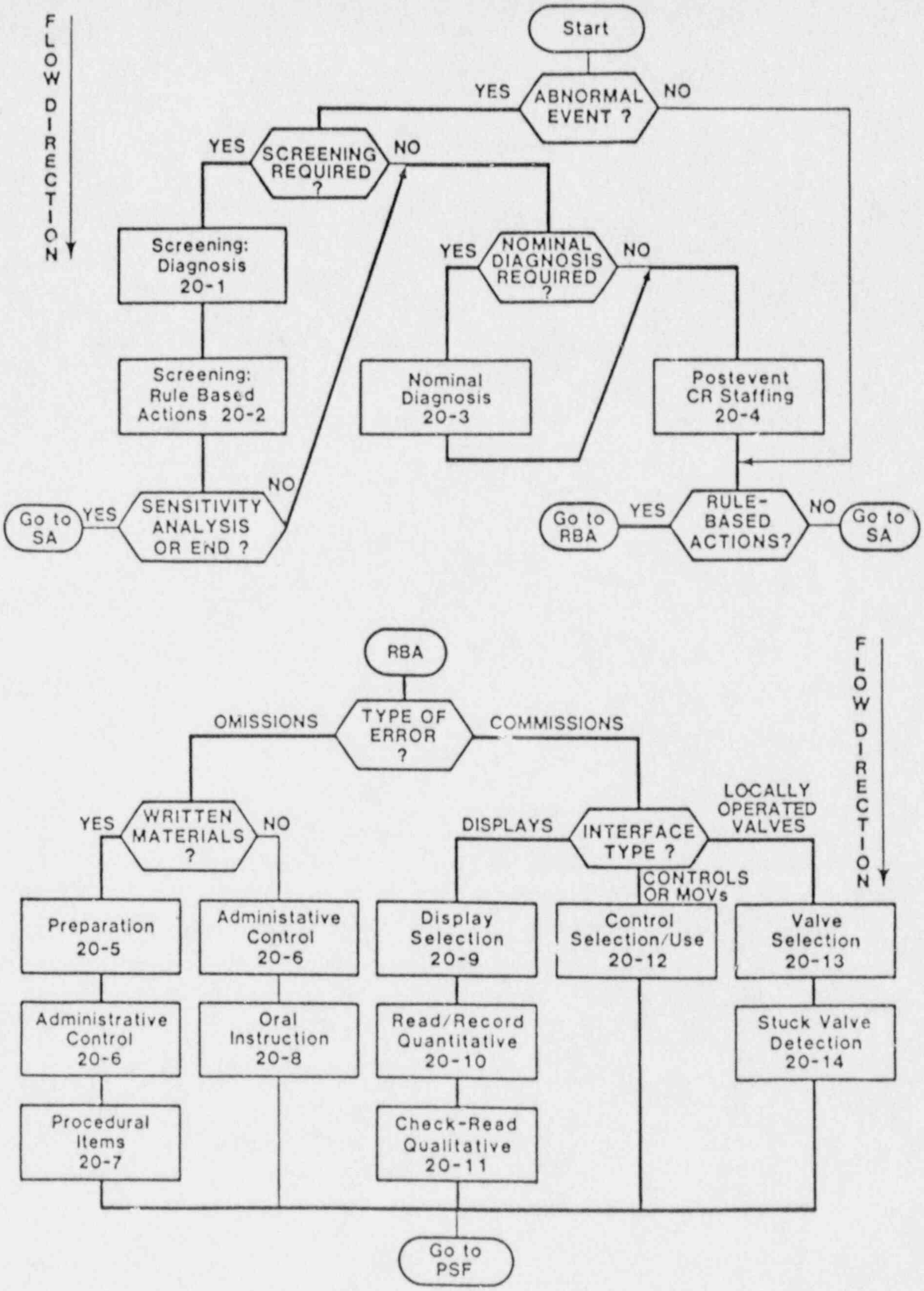


FIGURE 2-1. SEARCH SCHEME (Figure 20-1 from Reference 2-8)
(Sheet 1 of 3)

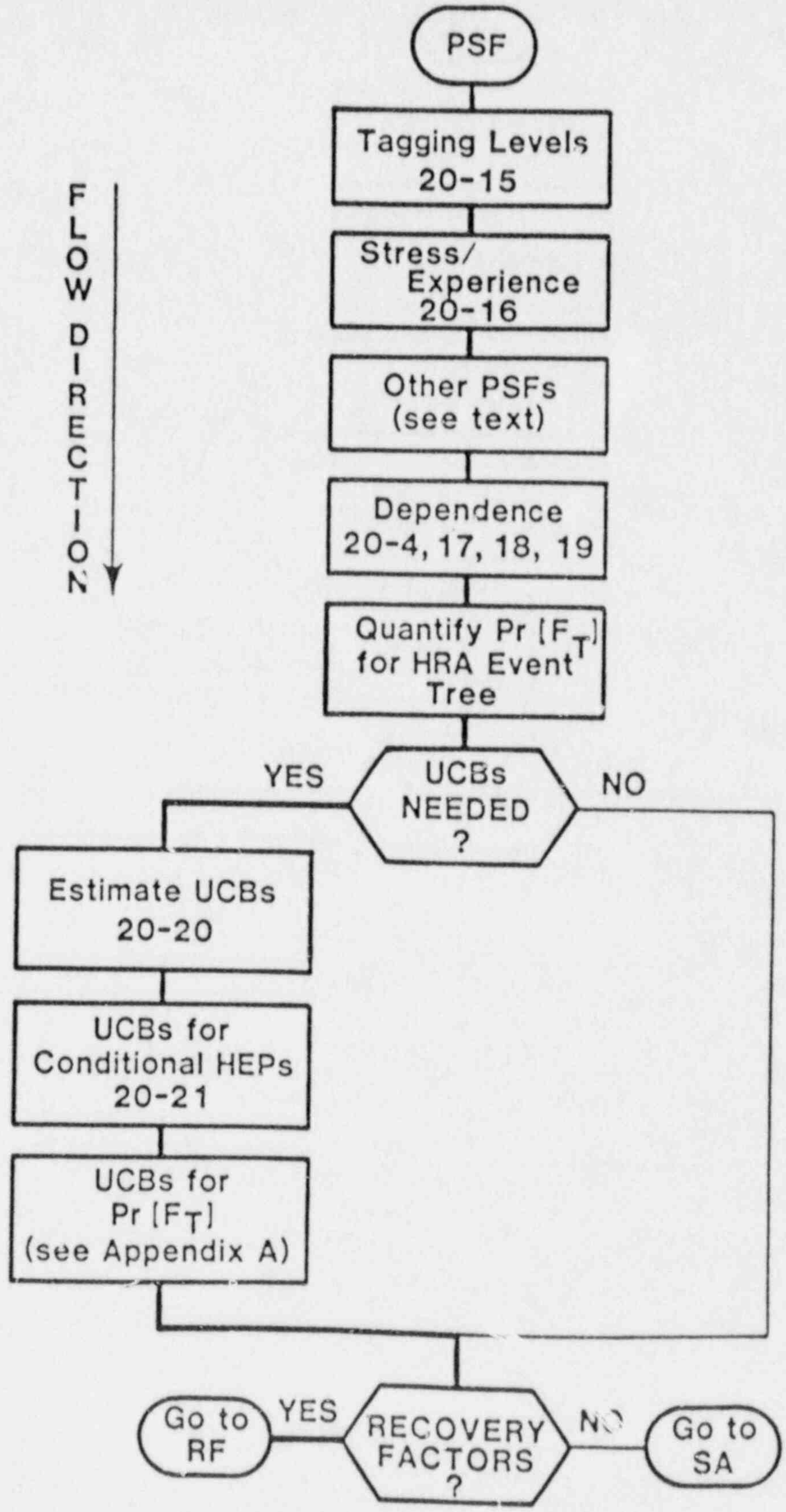


FIGURE 2-1 (Sheet 2 of 3)

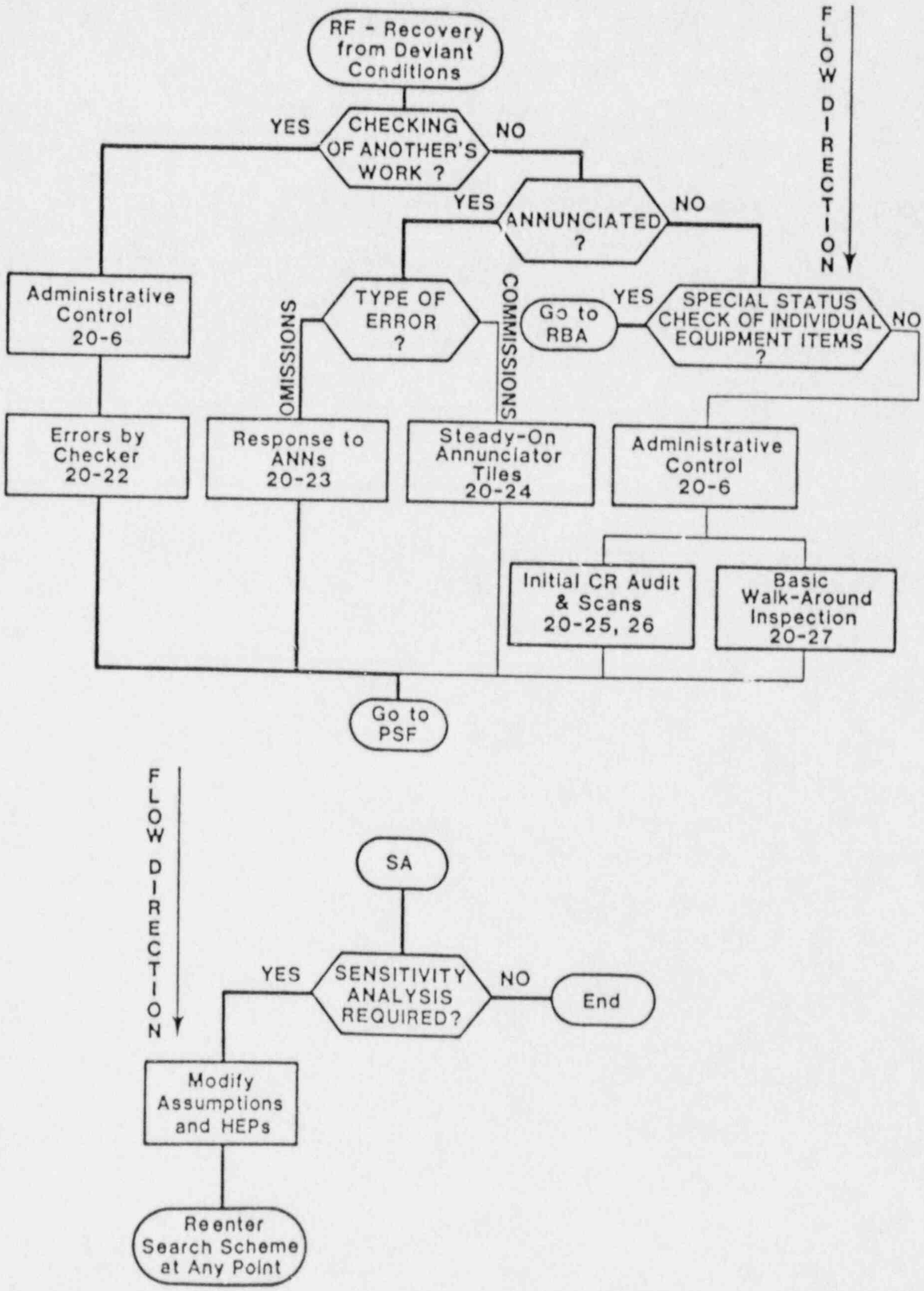


FIGURE 2-1 (Sheet 3 of 3)

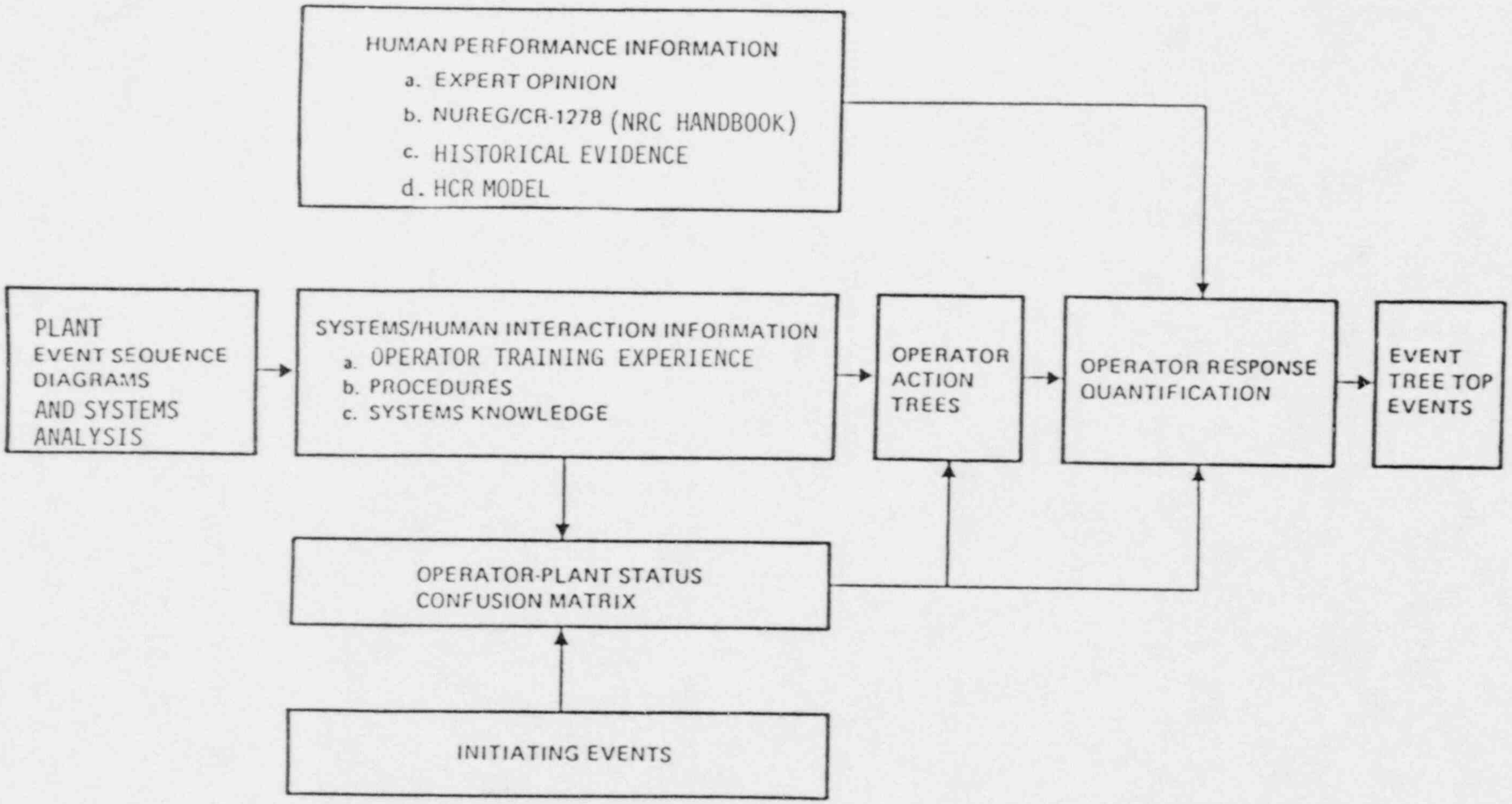
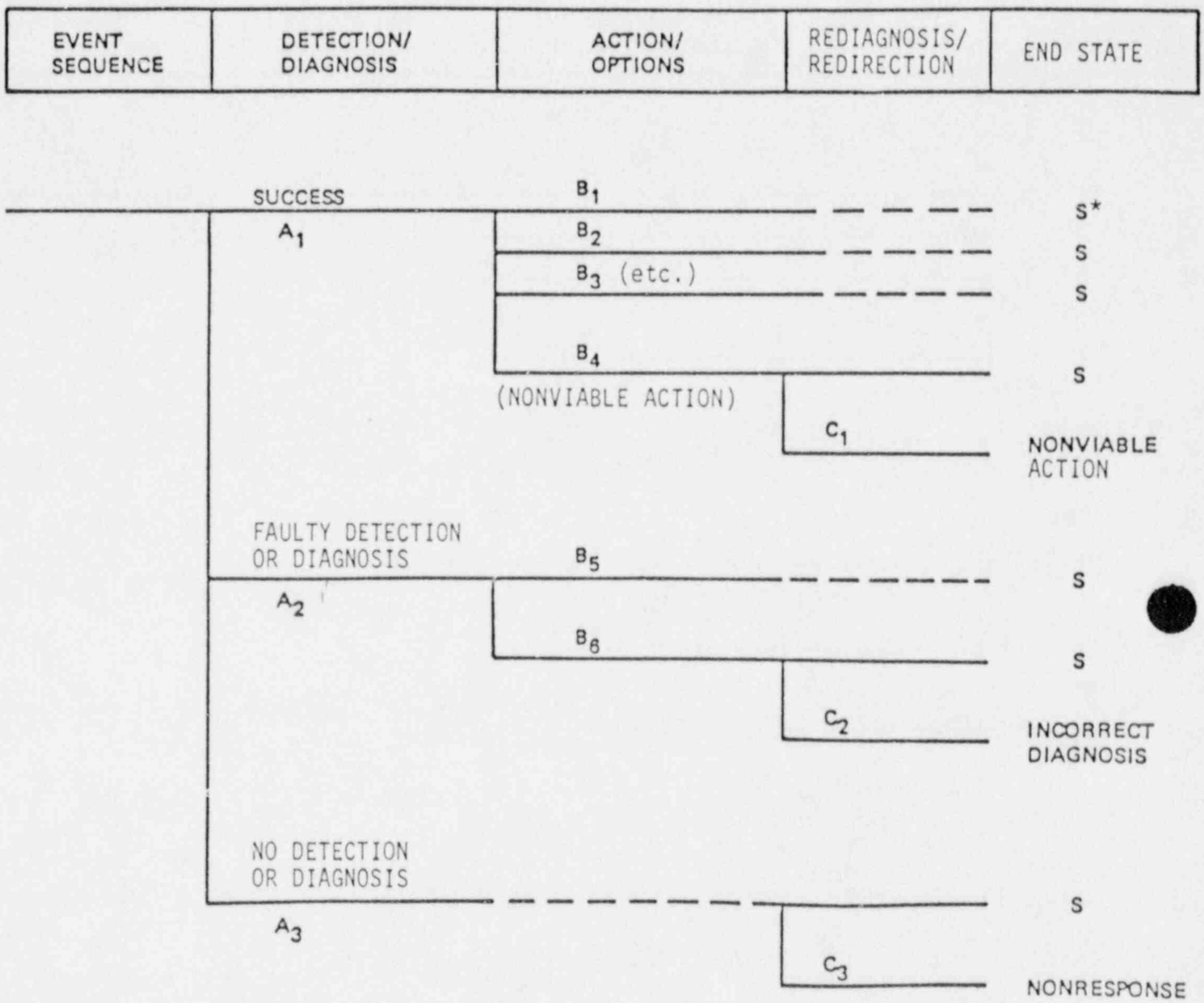


FIGURE 2-2. DYNAMIC HUMAN ACTIONS INFORMATION FLOW



*S = SUCCESSFUL OPERATOR RESPONSE.

FIGURE 2-3. GENERALIZED OPERATOR ACTION EVENT TREE REPRESENTATION

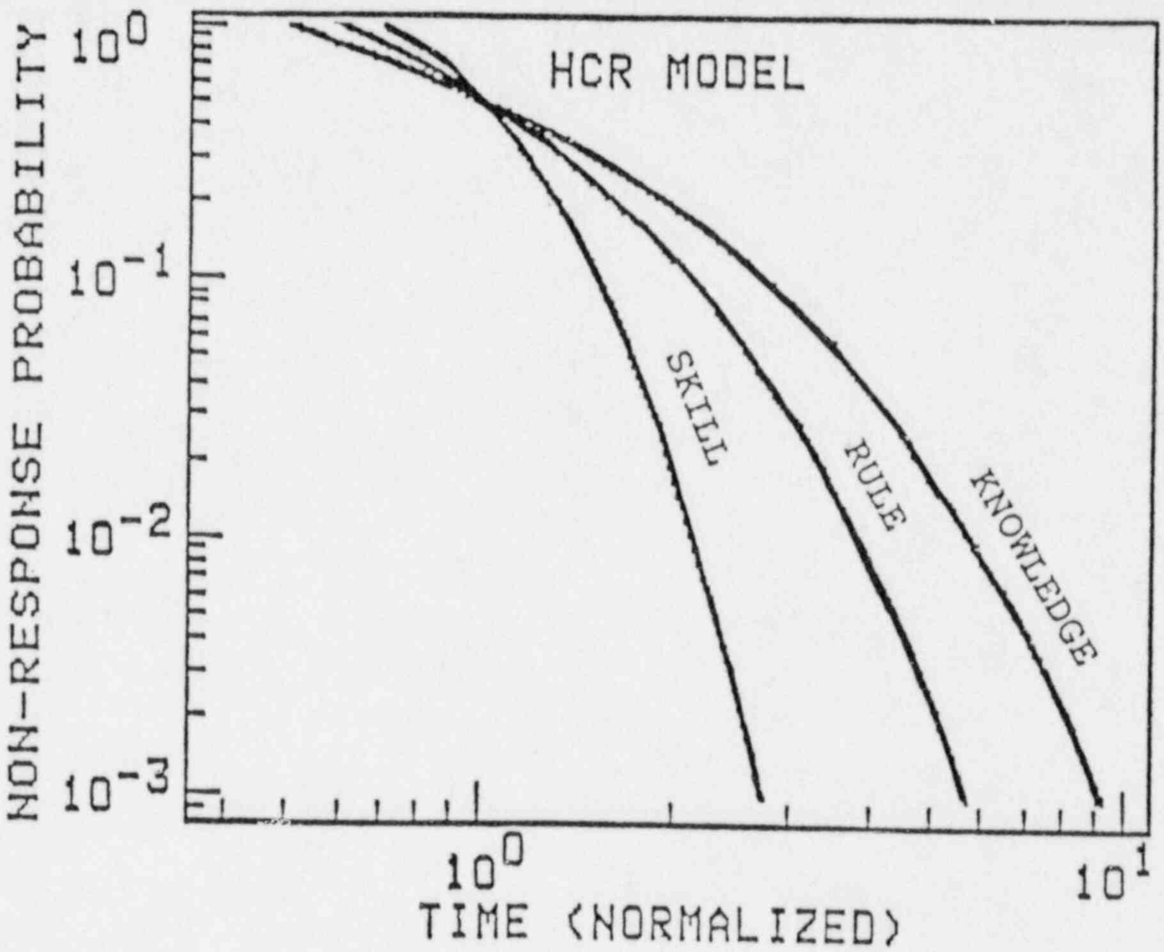


FIGURE 2-4. NORMALIZED CREW NONRESPONSE CURVES FOR SKILL, RULE, AND KNOWLEDGE BASED COGNITIVE PROCESSING
(Figure 2-2 from Reference 2-18)

PROCEDURES \ TOP EVENTS	AA	AM	BA	BB	BW	CA	CB	CD	CF	CP	CS	CV	C1	C2	C3	DA	DB	DH	DT	EA	EB	E+	E-	GA	GB	HA	HB	HI	HL	HPA	HPB	ID	INJ	LP	LT	MF+	MF-	MR
1210-1 REACTOR/TURBINE TRIP			X	X	X	X	X	X	X		X		X	X	X			X		X	X	X	X	X	X	X	X	X		X	X	X				X	O	
1210-2 LOSS OF SCM					X			X															X			X	X	X		X	X	X						
1210-3 EXCESSIVE COOLING					X			X															X			X	X	X		X	X	X				X	O	
1210-4 LACK OF PSHX					X			X															X			X	X	X		X	X	X					X	
1210-5 SGTR			X	X				X										X								X	X		X			X						
1210-6 SMALL BREAK LOCA COOLDOWN			X	X	X	X	X	X	X				X	X				X	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X			
1210-7 LARGE BREAK LOCA COOLDOWN			X	X	X	X	X	X	X		X		X	X	X				X	X	X		O	X	X	X	X	X	X	X	X			X				
1210-8 RCS SUPERHEATED			X	X	X	X	X	X	X				X	X				X						X	X	X	X		X	X	X			X				
1210-9 HPI COOLING					X			X																		X	X	X		X	X	X						
1210-10 ATOG RULES					X																	X	X			X	X	X		X	X							X
1202-2 LOSS OF OFFSITE		X			X			X	X			X												X	X								X				X	
1202-2A BLACKOUT		X			X			X	X			X	X	X									X	X	X	X	X	X		X	X		X				X	
1202-9A LOSS OF "A" DC								X								X							X															
1202-17 LOSS OF ICCW																																						
1202-26 PARTIAL LOFW								X															X													X	X	
1202-29 PRESSURIZER SYSTEM FAIL					X			X												X	X					X	X	X		X	X							
1202-30 EARTHQUAKE								X																														
1202-31 FIRE										X																												
1202-35 LOSS OF DHR			X	X	X			X										X								X	X	X	X	X	X		X	X				O
1202-36 LOSS OF INSTRUMENT AIR		X						X	X														X										X					
1202-37 COOLDOWN OUTSIDE CONTROL ROOM					X			X										X		O	O		X			X	X		X	X	X					X	O	
1202-38 NSRW FAIL								X																		X												
1202-40 ICS POWER FAIL	X							X															X										X			X	O	
1203-19 RIVER WATER SYSTEM FAIL								X										X					X			X	X											
1203-20 NSCCS FAIL																										X				X								
1203-21 SSCCS FAIL																																					X	
1203-24 STEAM LEAK								X	X																													
1203-34 CONTAINMENT BUILDING VENTILATION FAIL												X																										
1102-11 COOLDOWN								X			O							X		O	O		O			X	X	O	X	O	O		X				X	
1102-16 NATURAL CIRCULATION COOLDOWN								X															X						X									

LEGEND:

X – INDICATES THAT THE PROCEDURE CALLS FOR PERFORMANCE OR VERIFICAT

O – INDICATES THAT THE PROCEDURE CALLS FOR AN ACTION THAT DEGRADES C

NS	OP	PO	PV	PW	RC	RE	RP	RT	RV	SA	SB	SD	SE	SI	SL	SV	TC	TH	TH	TT	VA	VB	1C
							O	X							X	X	X			X			
					X		O											X					
									X					X	X		X						
		X			X		X											X					
		X					X	X						X	X		X	X		X			
		X					O		X	X	X		X			X	X	X					
										X	X			X		X	X	X					
		X			O		X			X	X						O						
		X			X		X		X									X					
							O	X	X									X					
X	X					X	X	X					X							X			
X	X					X	X	X					X							X			
								X												X	X		
X								X					X							X			
								X												X			
		O			X			X												X			X
								X												X			
								X												X			
							X			X	X							X					
X							O	X					X										
							O	X												X			
X							O	X												X			
								X												X			
X																							
																				X			
								X						X	X	O				X			
		X							X	O	O				O		X						
							O		X														

ON OF THE TOP EVENT FUNCTION.

R IS OPPOSITE TO THE TOP EVENT FUNCTION.

TABLE 3-11. OPERATOR ACTIONS CALLED FOR IN EACH PROCEDURE

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TABLE 3-12. TRANSFERS CALLED OUT IN EACH PROCEDURE

INITIAL PROCEDURE \ PROCEDURE TRANSFERRED TO	1210-1 REACTOR/TURBINE TRIP	1210-2 LOSS OF SCM	1210-3 EXCESSIVE COOLING	1210-4 LACK OF PSHX	1210-5 SGTR	1210-6 SMALL BREAK LOCA COOLDOWN	1210-7 LARGE BREAK LOCA COOLDOWN	1210-8 RCS SUPERHEATED	1210-9 HPI COOLING	1210-10 ATOG RULES	1202-2 LOSS OF OFFSITE POWER	1202-2A BLACKOUT	1202-9A LOSS OF "A" DC	1202-17 LOSS OF ICCW	1202-26 PARTIAL LOFW	1202-29 PRESSURIZER SYSTEM FAIL	1202-30 EARTHQUAKE	1202-31 FIRE	1202-35 LOSS OF DHR	1202-36 LOSS OF INSTRUMENT AIR	1202-37 COOLDOWN OUTSIDE CONTROL ROOM	1202-38 NSRW FAIL	1202-40 ICS POWER FAIL	1203-19 RIVER WATER SYSTEM FAIL	1203-20 NSCCS FAIL	1203-21 SSCCS FAIL	1203-24 STEAM LEAK	1203-34 CONTAINMENT BUILDING VENTILATION FAIL	1102-11 COOLDOWN	1102-16 NATURAL CIRCULATION COOLDOWN
1210-1 REACTOR/TURBINE TRIP			x	x	x																									
1210-2 LOSS OF SCM	x		x	x	x	x	x	x	x	x																				
1210-3 EXCESSIVE COOLING	x	x		x	x				x	x																				
1210-4 LACK OF PSHX	x				x	x	x		x	x																				
1210-5 SGTR	x								x																				x	
1210-6 SMALL BREAK LOCA COOLDOWN					x			x	x	x																				
1201-7 LARGE BREAK LOCA COOLDOWN						x		x		x																				
1210-8 RCS SUPERHEATED		x				x																								
1210-9 HPI COOLING				x	x	x			x	x																			x	
1210-10 ATOG RULES																														
1202-2 LOSS OF OFFSITE POWER	x																													x
1202-2A BLACKOUT	x										x																			
1202-9A LOSS OF "A" DC																														
1202-17 LOSS OF ICCW																														
1202-26 PARTIAL LOFW										x																				
1202-29 PRESSURIZER SYSTEM FAIL																													x	
1202-30 EARTHQUAKE	x																												x	
1202-31 FIRE																					x									
1202-35 LOSS OF DHR																														x
1202-36 LOSS OF INSTRUMENT AIR																														
1202-37 COOLDOWN OUTSIDE CONTROL ROOM																x													x	
1202-38 NSRW FAIL																														x
1202-40 ICS POWER FAIL																													x	
1203-19 RIVER WATER SYSTEM FAIL																			x							x				
1203-20 NSCCS FAIL																														
1203-21 SSCCS FAIL																														
1203-24 STEAM LEAK	x																												x	
1203-34 CONTAINMENT BUILDING VENTILATION FAIL																														
1102-11 COOLDOWN																														
1102-16 NATURAL CIRCULATION COOLDOWN																													x	

TABLE 3-13. "MISALIGNMENT ERRORS" AT TMI UNITS 1 AND 2 INVOLVING SAFETY SYSTEMS

	Date	TMI Unit	System Involved	Following Test or Maintenance*	Number of Trains Affected	Comments	Detection/Recovery Time
1.	January 1974	1	HPI	M	One	Failed pumps by leaving suction valves closed; valves opened but pump remained disabled.	Next pump test (quarterly).
2.	May 1974	1	Diesel Generator	M	One	Lube oil switches left disconnected.	48 hours.
3.	June 1974	1	HPI	M	One	Switch valve left closed.	Operability test before placed in service.
3A.	November 1974	1	Sampling Line	M	One	Primary sampling containment line valve left open.	4 months.
3B.	September 1974	1	Containment Isolation	M	Two	Two normally open valves left in closed position. Part of emergency access hatch mechanism involving automatic pressurization of door seals.	8 days.

*T = Test; M = Maintenance.

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TABLE 3-13 (continued)

Sheet 2 of 4

	Date	TMI Unit	System Involved	Following Test or Maintenance*	Number of Trains Affected	Comments	Detection/Recovery Time
3C.	December 1975	1	Containment Isolation	M	One	Outside containment isolation valve for steam generator sample sample line failed to close; valve operator left in wrong position and would not close automatically.	2 weeks.
4.	February 1976	1	HPI	T	One	Incorrect valve lineup during test.	Discovered during same test.
5.	June 1978	2	Diesel Generator	M	One**	Failed to close breaker following switchgear cleaning.	14 hours.
6.	August 1978	1	NSRW	?	Two	Two of three pumps (running) not selected to engineered safeguards.	33 hours and 20 minutes.
7.	March 1979	2	EFW	(T)?	Three	EFW discharge valves left closed. Not noticed in the control room.	Accident revealed (2 weeks?).

*T = Test; M = Maintenance.

**While maintenance continued on the second train, both trains were out of service.

TABLE 3-13 (continued)

Sheet 3 of 4

	Date	TMI Unit	System Involved	Following Test or Maintenance*	Number of Trains Affected	Comments	Detection/Recovery Time
8.	March 1979	1	EFW	M	One	MS-V6, steam-regulating valve left closed.	Routine surveillance during heatup.
9.	-/1980	2	NSRW and Diesel Generator	M	One	Service water valve alignment error rendered one diesel generator inoperable; other diesel generator still operable.	Completion of service water maintenance (8 hours).
10.	January 1981	2	NSRW	-	One	Pump stopped, but left in pull-to-lock rather than in automatic mode.	Less than 1 day.
10A.	June 1981	2	Control Building Ventilation	M	-	Left control building ventilation interlock in defeat preventing the automatic signal to go to the recirculation position.	Quickly when alarmed (?).

*T = Test; M = Maintenance.

TABLE 3-13 (continued)

Sheet 4 of 4

	Date	TMI Unit	System Involved	Following Test or Maintenance*	Number of Trains Affected	Comments	Detection/Recovery Time
11.	August 1981	2	Diesel Generator	M	One**	With one service water pump in maintenance, failed to restore second diesel generator after performing operability test.	7 hours (during maintenance).
12.	August 1983	1	Waste Storage Tank	M	One	Maintenance failed to close sampling line valve after sampling MWST. Hydrogen cover gas over makeup tank leaked into MWST because of this open line.	1 day.

*T = Test; M = Maintenance.

**While maintenance continued on the second train, both trains were out of service

TABLE 3-14. INSTRUMENT PROBLEMS AT TMI UNITS 1 AND 2

Date	TMI Unit	System/ Instrument Involved	Number of Trains Affected	Comments	Type of Problem*	Detection/ Recovery Time
August 1974	1	Waste/pH Monitor	One	pH readings too low.	MI,EF	4 Days
September 1974	1	Waste Gas/ Radiation Monitor	-	Radiation monitor taken out of service while release in progress.	NR	<1 Day
April 1975	1	CRD	-	Equivalent full-days curve not updated; reactivity excess.	NR	4 Days
February 1975	1	CRD	-	CRD position indication had been reading faulty. Operators disbelieved it when eventually it correctly indicated a problem. Discrepancy not investigated.	MI,EF	10 Days
December 1976	1	Reactor Building Radiation Monitoring	One	Design error of radiation monitor resulted in excess moisture.	ED	-

*See Sheet 6 of 6 for definitions.

TABLE 3-14 (continued)

Date	TMI Unit	System/ Instrument Involved	Number of Trains Affected	Comments	Type of Problem*	Detection/ Recovery Time
January 1976	1	Coolant Leak Detection/ Radiation Monitor		Valve not restored on RM-A2 after quarterly surveillance.	NR	Two days (although daily surveillance)
February 1976	1	Particulate Monitoring	One	Cover plate ajar after inspection of reactor building atmosphere monitor.	NR,MI	22 hours.
June 1976	1	Containment Isolation/ Radiation Monitor	One	Following maintenance, radiation monitor left disabled, so purge valves would not close on an ESAS signal.	NR	Discovered while in Test
July 1977	1	Reactor Building Particulate Monitor	One	Improper reassembly of radiation monitor following test allowed in leakage of outside air.	NR,MI	-
March 1979	2	Pressurizer Level	One	During TMI-2 accident, pressurizer level misled operators.	MI,ED	1 Hour plus 40 Minutes

*See Sheet 6 of 6 for definitions.

TABLE 3-14 (continued)

Sheet 3 of 6

Date	TMI Unit	System/ Instrument Involved	Number of Trains Affected	Comments	Type of Problem*	Detection/ Recovery Time
March 1980	1 and 2	RPS	Multiple	Narrow-range RCS pressure transmitters. When off scale, sometimes go back to on scale.	MI,EF	-
June 1980	2	Remote Shutdown	One	RCS inlet temperature on remote shutdown panel failed.	EF	-
December 1980	2	Core Flood Tanks	Two	CFT level indicators stuck in position although level dropped.	MI,EF	-
January 1981	1	HPI	One	Flow indication line MU-36-FF leaked due to corrosion and makeup startup.	EF	-
November 1981	2	OTSG Level (ICS)	One	125V DC power to level transmitter.	EF,MI	Quickly Noted Failure
November 1982	2	Sump Level	One	Level in sump reads too high because of sludge.	MI,ED	-

*See Sheet 6 of 6 for definitions.

TABLE 3-14 (continued)

Sheet 4 of 6

Date	TMI Unit	System/ Instrument Involved	Number of Trains Affected	Comments	Type of Problem*	Detection/ Recovery Time
January 1982	2	Chlorine Monitor	-	Monitor failed; set off alarm; operator silenced; placed in safe position.	EF	As Alarm Sounded
April 1982	1	Radiation Monitor for River Water	One	Mud blocked flow to radiation monitor.	ED,MI	-
October 1982	2	Level in OTSG	Two	Level instruments on two steam generators failed because of two different causes.	EF	Quickly Noted Failure
June 1982	2	Chlorine Monitor	One	Alarmed high on failure.	EF,MI	Noticed on Alarm
February 1982	1 and 2	Radio Masks	-	False detection of hydrogen due to face mask radios.	MI,ED	-
May 1983	2	Containment Sump/Level	-	Level indication did not change although water added due to valve leaking beside instrument.	MI,--	Detected in 1 Week

*See Sheet 6 of 6 for definitions.

TABLE 3-14 (continued)

Sheet 5 of 6

Date	TMI Unit	System/ Instrument Involved	Number of Trains Affected	Comments	Type of Problem*	Detection/ Recovery Time
July 1983	2	Level In Tank	One	Standby pressure control system tank level failed low.	EF,MI	<1 Day
July 1983	1	Radiation Monitor	One	Radiation monitor read a high count at condenser.	EF,MI	-
August 1983	1	Radiation Monitor	One	No flow to radiation monitor at condenser due to moisture condensation.	EF,MI	-
August 1983	1	Radiation Monitor	One	Maintenance closed valve, isolating radiation monitor from condenser.	NR	40 Minutes
April 1983	1	DHR/Oil Level	Two	Labeled low oil level incorrectly, then removed alternate oil control mechanism. One pump failed, the other had some problem, but was not run until first pump pump failed.	NR	At Equipment Failure

*See Sheet 6 of 6 for definitions.

TABLE 3-14 (continued)

Sheet 6 of 6

Abbreviations for Types of Problems NR - instrument not properly restored. MI - misleading indications. EF - equipment failure. ED - environmental design.

TABLE 3-15. INSTRUMENT CALIBRATION PROBLEMS AT TMI 1 AND 2

Date	TMI Unit	System Involved	Number of Trains Affected	Comments	Detection/ Recovery Time
April 1975	1	RPS	Four	Only one individual calibrated high power trip points set at 109.5% whereas specified at 105.5%.	Routine Testing 4 Days
May 1977	1	ICS/RPS	Four	Steam generator pressure transmitter failed; consequently, all four nuclear detectors miscalibrated reading power 10% too low.	Several Calibration Periods Possible
September 1978	1	CVSCS(?)	One(?)	NaOH concentration miscalibrated because of calibration drift due to seal failure of pressure transmitter.	At Next Calibration
December 1981	2	Core T_{AVE}	One	Thermocouple leads polarity reversed and left reversed after calibration.	15 Hours

TABLE 3-16. TMI EXPERIENCE CONCERNING DYNAMIC HUMAN ACTIONS

Sheet 1 of 2

	Date	TMI Unit	Systems Involved	Comment	Recovery/ Detection Time
1.	July 1974	1	River Water	Operators fail to monitor ΔT to river when monitor plus its backup was out of service. Discharge water temperature slightly exceeded environmental limits.	3 Days
2.	April 1977	1	Circulating Water	Middletown fire department arrived quickly in response to pump house flood.	1 Day
3.	April 1978	2	MFW	Operator, following reactor trip, cut MFW demand, but did not initially realize that MFW was in manual.	80 Seconds
4.	March 1978	2	CRD	Operator misinterpreted procedures; proceeded to higher power level with control rods out of position.	?
5.	October 1978	2	RPS	CRD trip breakers closed with only one source range detector in service technical specification violation. Power source out on other detector.	?
6.	March 1978	2	PORV	Vital power lost caused PORV to fail to open position and lose indication. Operator could not determine the source of depressurization.	4 Minutes
7.	March 1979	2	PORV, EFW, and HPI	TMI-2 accident. Recovered EFW by opening valves (noted level too low).	8 Minutes
				Closed block valve in PORV.	1 Hour, 42 Minutes
				Attempted cooldown and depressurization for sequence with possible steam generator tube rupture.	7 Hours
				Operator isolated containment well after (20 minutes) RCD tank blew.	30 Minutes
				Operator started HPI manually and isolated letdown.	13 Seconds
8.	July 1980	2	Ventilation	Failed to reset four fans from control room following fire alarm. Indicator overlooked on back panel.	5 Hours

TABLE 3-16 (continued)

Sheet 2 of 2

	Date	TMI Unit	Systems Involved	Comment	Recovery/ Detection Time
9.	October 1981	2	Auxiliary Building Ventilation	Did not recognize significance of reduced flow in auxiliary building due to previous damper problems. Indications had been faulty.	2 Days
10.	May 1976	1	Waste Evaporator	Operator verified alarm, found that alarm had failed to automatically close valve to terminate release. Operator manually terminated the release by closing the valve from control room.	90 Minutes after the Alarm

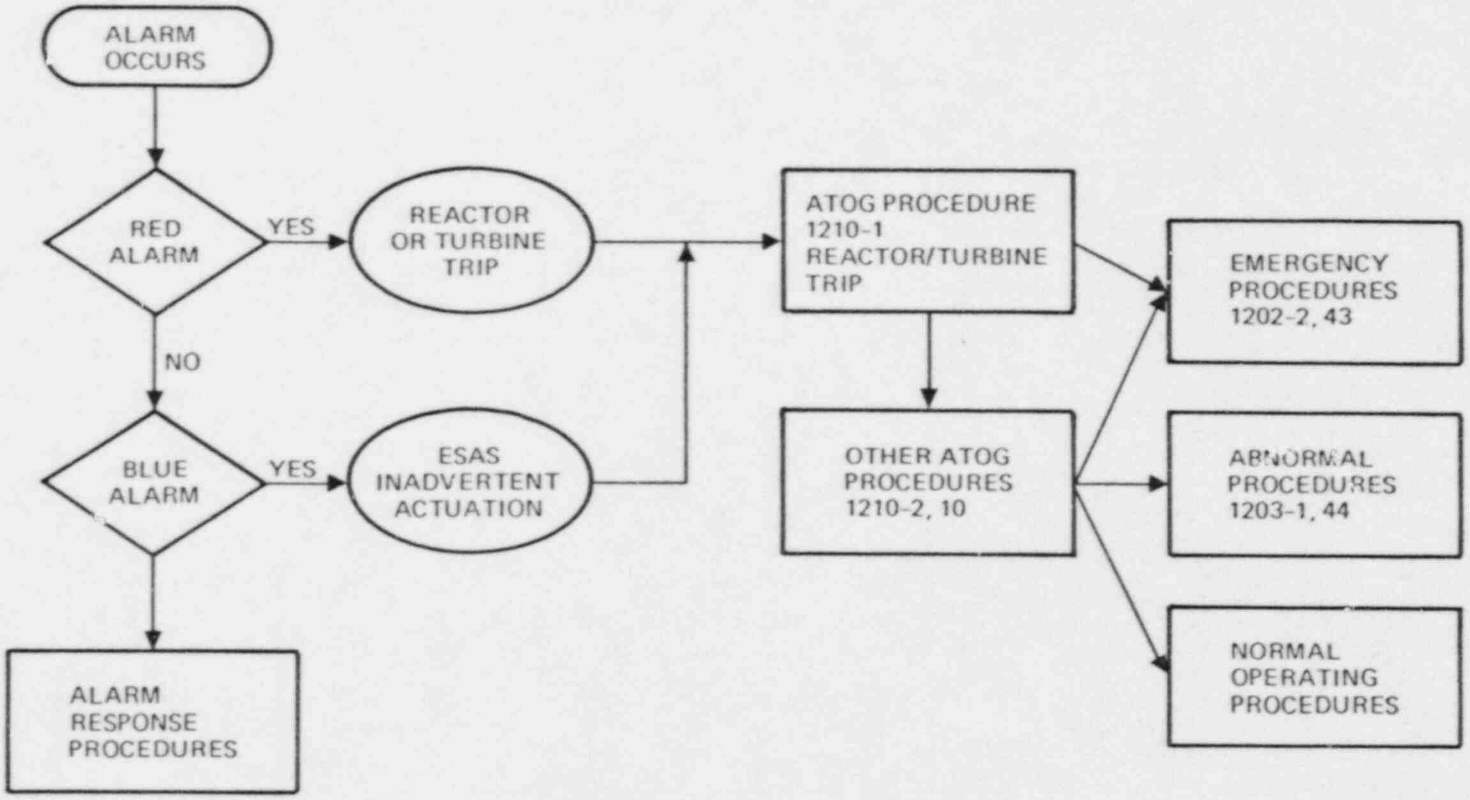

FIGURE 3-1. PROCEDURES UTILIZED BY THE CONTROL ROOM CREW

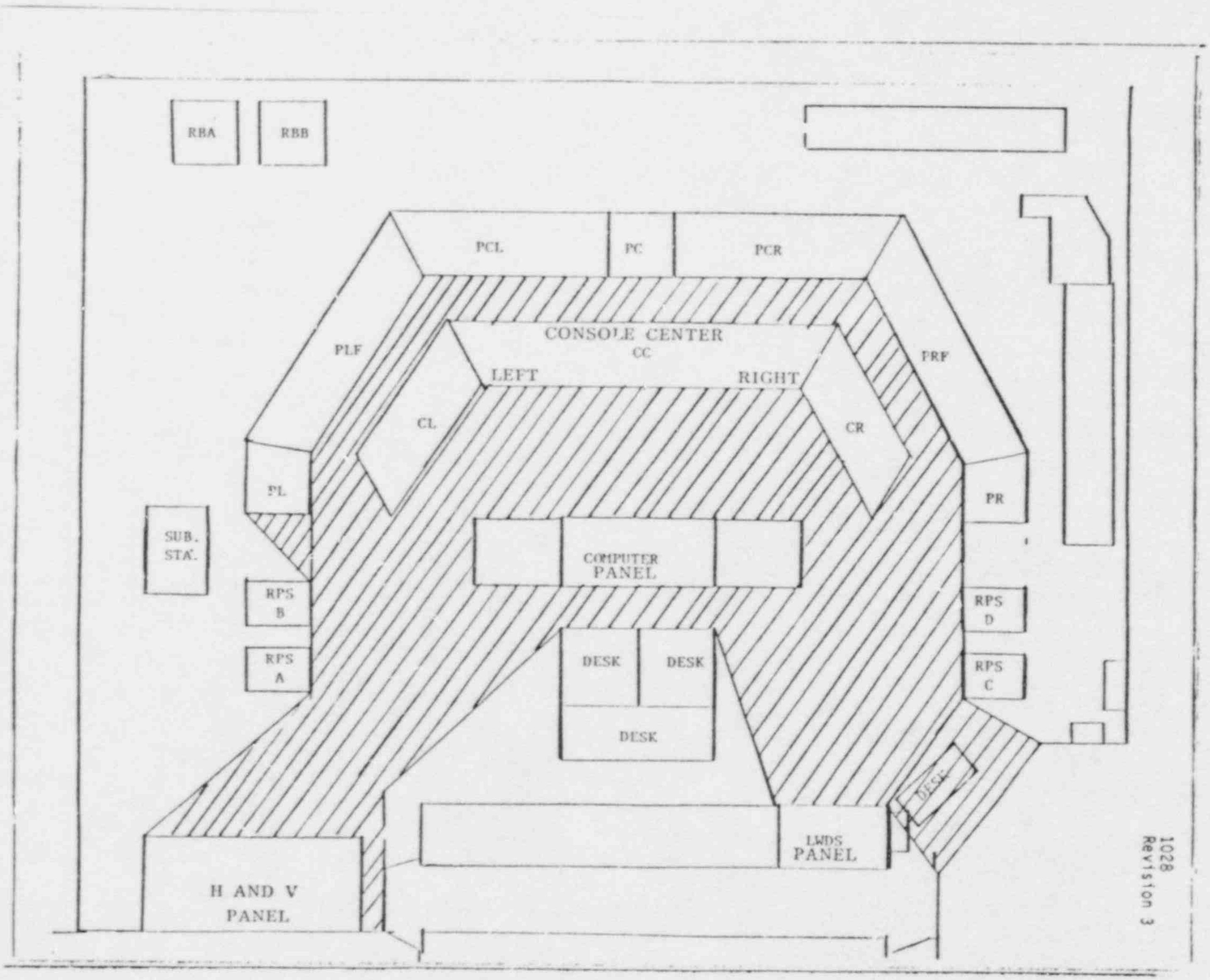

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FIGURE 3-2. TMI-1 CONTROL ROOM LAYOUT

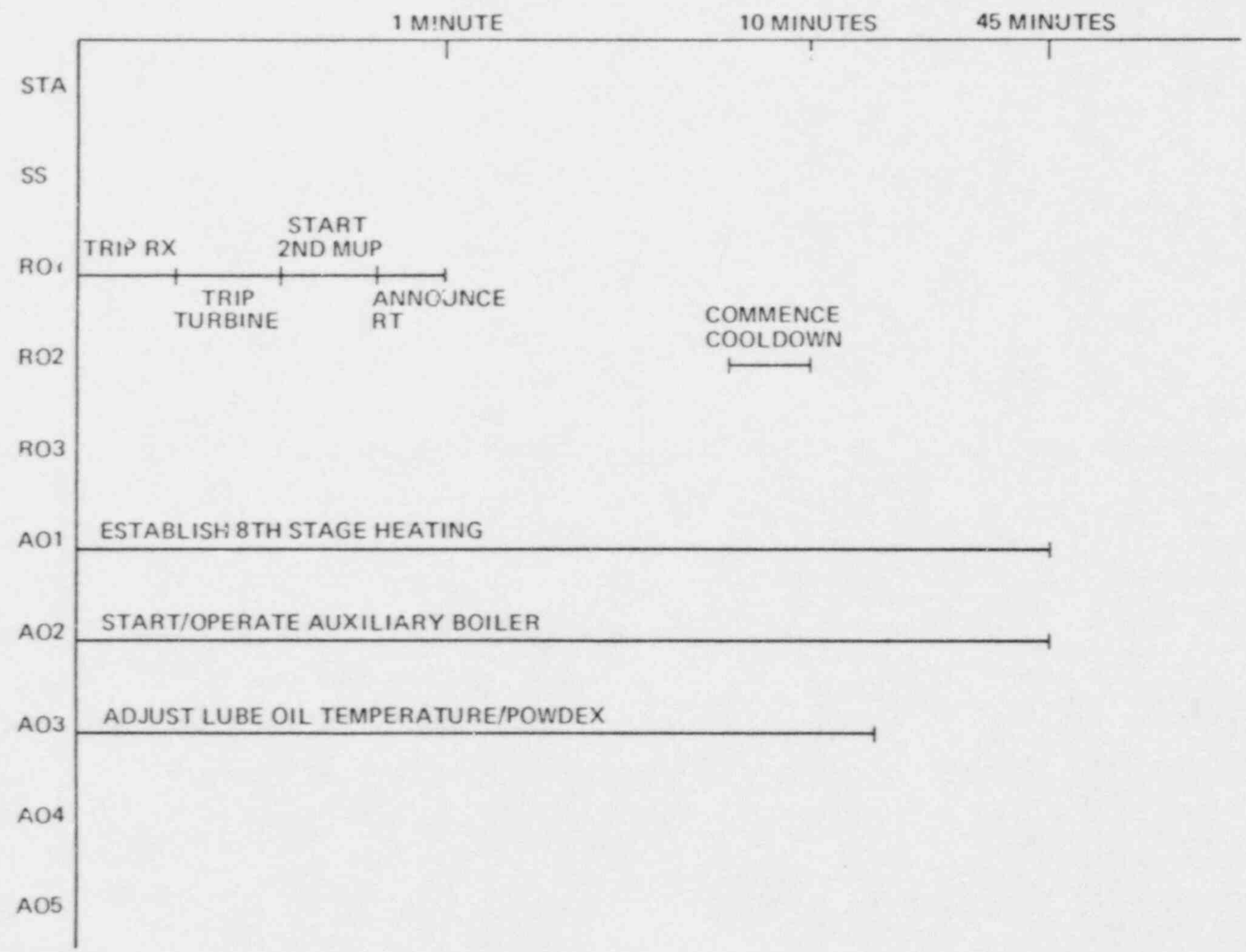

FIGURE 3-3. OPERATOR RESPONSE TIME LINE FOR GENERAL TRANSIENTS

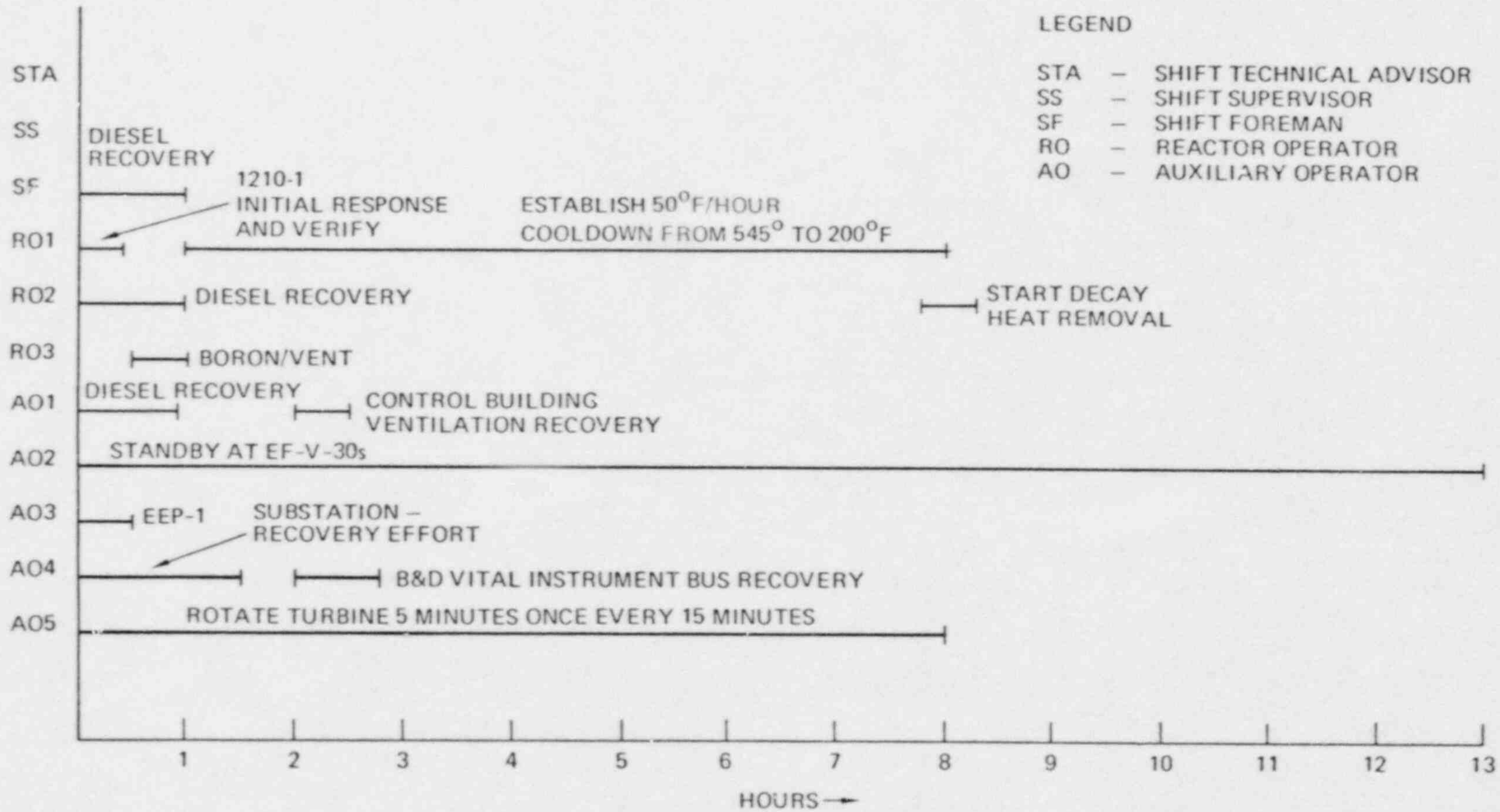

FIGURE 3-4. OPERATOR RESPONSE TIME LINE FOR LOSS OF OFFSITE POWER WITH THE 1B DIESEL FAILED

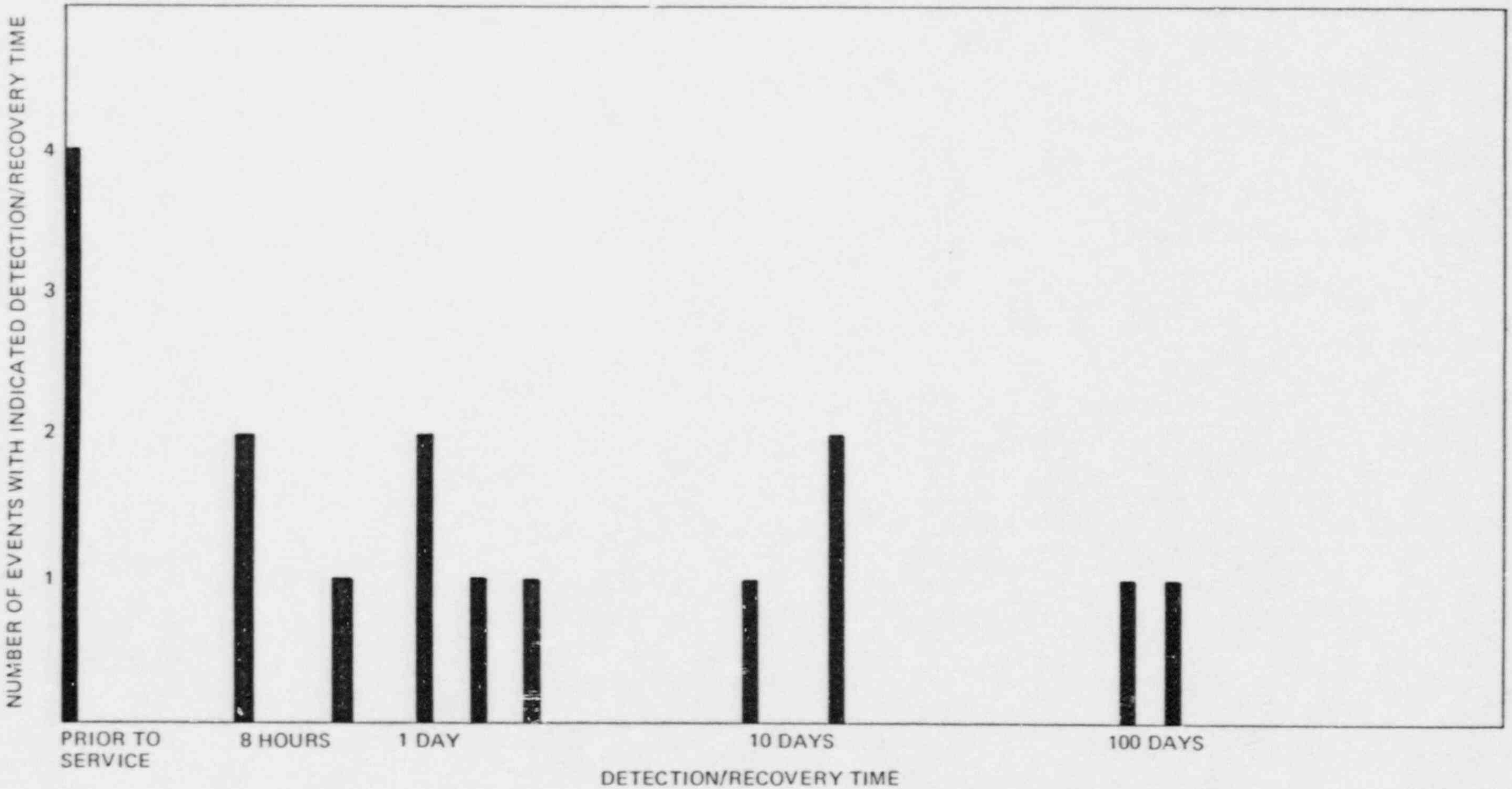

FIGURE 3-5. HISTOGRAM OF DETECTION/RECOVERY TIMES FOR MISALIGNMENT ERRORS AT TMI STATION

4. DESCRIPTION AND QUANTIFICATION OF HUMAN ACTIONS

This section documents the quantification of each human action identified. All of the human actions listed in Table 1-1 are considered. This section is divided into three parts corresponding to the three separate methodologies for evaluating the frequencies of the different human action types; i.e., routine, dynamic, and recovery actions.

4.1 ROUTINE HUMAN ACTIONS

Results from the evaluation of routine human actions are summarized in Table 1-4. The distributions for the referenced human action rates are provided in Table 1-3. The human action identifiers are listed in alphabetical order.

The human error rates assigned to each of the human action identifiers are defined in Section 2.2. The methodology for estimating these error rates, the special numerical results obtained, and the basis for the use of these error rates are also described in Section 2.2.

A discussion of the specific application of these error rates for the specific routine actions evaluated is provided in the following paragraphs.

In the paragraphs that follow, the term, operator, is not meant to be restricted to just those personnel manipulating plant controls in the control room. Here, operator is meant to include all plant operations personnel who may impact the status of plant equipment, including maintenance crews and instrument technicians.

The list of routine human actions listed in Table 1-4 is not exhaustive. First, the only errors of commission associated with routine actions are those involving miscalibration of RPS and ESAS channels. Inadvertent valve manipulations that result in system misalignments, but that are not tied to either test or maintenance procedures, are not modeled explicitly. Isolated errors of this type are not believed to contribute significantly to risk. Errors of omission in restoring systems to normal status following test or maintenance actions are included. However, in some cases, frequency arguments employing comparisons with system hardware failure rates have been used to limit the number of routine human actions considered in this section. Such frequency arguments are provided in the individual systems analysis.

Finally, routine human actions that lead to the misalignment or failure of redundant system trains are not all modeled explicitly. The miscalibration of multiple RPS and ESAS channels is modeled explicitly. However, the common cause failure parameters for pumps, valves, and other mechanical components are believed to adequately account for the misalignment of multiple mechanical system trains.

4.1.1 HCA3

HCA3 is the human error rate of miscalibrating two or more ESAS channels that provide the 4-psig containment high pressure signal during the scheduled refueling outage calibration. The error rate assigned is made up of two parts. Miscalibration of one channel is assigned an error rate of HEC3; i.e., a general error of commission. The likelihood of a failure of miscalibration of a second channel, given miscalibration of a first, is assumed to be highly dependent. Therefore, the overall error rate assigned to HEA1 is HEC3*HEHD, where HEHD is the conditional human error rate, assuming a high level of dependence. No credit is given for the fact that not all miscalibrations are sufficient to result in failure of the system. Also, miscalibrations of sensors should be easier to detect than miscalibrations of bistable trip setpoints. The error rate assigned to HCA3 is assumed to apply the miscalibration of the bistable trip setpoints.

4.1.2 HCA4

HCA4 is the error rate of the independent verifier failing to detect the miscalibration of two or more ESAS channels, as represented by HEA1. Two persons perform the ESAS channel calibration together. One reads the procedure and verifies that the other performs the calibration correctly. Medium dependence with the first action is assumed. HCA4 is therefore assigned an error rate of HEMD.

4.1.3 HCS1

HCS1 is the frequency of the operator leaving the reactor building spray valves in the recirculation line to the BWST in the test alignment after testing. These are manual valves that must be restored to the normal alignment following the test. Failure to restore these valves would require the omission of a step in the procedure.

Therefore, the human error rate assigned to this action is HE01B; i.e., failure to use a procedure with a long list of checkoff provisions. Only single spray pump train errors are considered explicitly in the evaluation. Multiple train errors of restoration are accounted for in the common cause failure parameters.

4.1.4 HCS2

HCS2 is the error rate of the independent verifier failing to detect the misalignment of the manual valves noted in the discussion for HCS1. Since the verifier is required by procedure to verify the restoration of these valves, the human error rate assigned to HCS2 is HE02A; i.e., failure of the checker to recognize an incorrect status when checking each item.

4.1.5 HCS3

HCS3 is the frequency of the operator failing to restore the reactor building spray pressure switch manual isolation valves following the reactor building spray 30-psig pressure channel tests. There are three pressure switches per pump train, and only two of the three are needed for system success. Two or more pressure switches must therefore be left in the test position to fail one train of reactor building spray. Failures affecting both spray trains are not modeled explicitly as human errors. Such human errors are instead accounted for in the evaluation of common cause failure parameters for the pumps. The error frequency assigned to HCS3 for one train of spray only is HE01B*HEHD; i.e., failure to follow procedures with a long list of checkoff provisions times the conditional high dependence of repeating the error for a second pressure switch.

4.1.6 HCS4

HCS4 is the error rate for an independent verifier failing to detect the failure in the action to restore the valves, represented by HCS3, involving the reactor building spray pressure switch isolation valves. An error rate of HE02A is assigned; i.e., failing to recognize an incorrect status when checking each item. Complete dependence (HECD) is assigned for the verifier when considering multiple pressure switches.

4.1.7 HDEA1

HDEA1 is the duration (in hours) until more than one miscalibrated ESAS channel is detected that the independent verifier failed to detect immediately following the calibration. It is assumed that the miscalibration would not then be detected until about one-half into the time to the next calibration performed during the next refueling outage. The ESAS channels (including the bistable trip points) are actually tested monthly although the calibration is performed only once each refueling. Several such tests are conservatively assumed to pass before the miscalibrated channels are detected. The detection time is assumed to be in 0.75 years, or 13,142 hours.

4.1.8 HDEA2

HDEA2 is the duration (in hours) until detection of a single, miscalibrated ESAS channel that the independent verifier failed to detect immediately following the calibration. Similar to HDEA1, HDEA2 is assigned a duration of 0.75 years, or 13,142/2 hours.

4.1.9 HDEF1

HDEF1 is the average duration until a valve misalignment is detected following testing of a pump in the EFW system. The pumps are tested once a month, but such misalignments are often detected prior to the next test. HDEF1 is therefore assigned a duration of 720/2 hours.

4.1.10 HDEF2

HDEF2 is the average duration until an error in the calibration of the EFW sensor channels is detected. HDEF2 is assigned a duration of one-half the test period for the system or 720/2 hours.

4.1.11 HDH2

HDH2 is the error rate for the operator failing to realign the DHR system following pump testing. The error would require an omission in following the test procedure to restore the manual valves to the normal alignment. Human errors in restoration of these valves affecting both DHR trains are not modeled explicitly with human error rates. Such errors are instead accounted for in the common cause failure parameters for the pumps. The error rate assigned to HDH2 for misalignment of a single DHR train is then HE01B; i.e., failure to follow procedures with a long list of checkoff provisions.

4.1.12 HDH3

HDH3 is the error rate of the independent verifier failing to detect the failure to realign the DHR system following pump testing. This error would be an omission to follow the test procedure that requires independent verification of the restoration to the normal system lineup. The error rate assigned is then HE02A; i.e., failure to recognize an incorrect status when checking each item. If the verifier also fails to detect the error, it is conservatively assumed by the analysis that the system would remain in the misaligned configuration until the next scheduled test.

4.1.13 HDRT1

HDRT1 is the average duration until detection of an operator error in failing to remove an RPS channel from bypass after testing, given that the independent verifier also failed to detect the error. When an RPS channel is in bypass, the corresponding RPS cabinet in the control room has a light on top that is lit. At the shift change, the oncoming crew is required to take numerous control room readings and, in particular, to check the log that identifies when an RPS channel bypass is both implemented and terminated. Therefore, it is assumed that, if an RPS channel is left in bypass, it is very likely to be detected by the beginning of the next shift. HDRT1 is assigned a small chance of being detected in the same shift (a .1 probability for 4 hours), a good chance of being detected at the beginning of the next shift (a .5 probability for 8 hours) and less chance of being detected during later shifts (a 0.3 probability at 24 hours and a 0.1 probability at 1 week).

4.1.14 HDRT2

HDRT2 is the average duration to detection of a miscalibration of multiple RPS channels. The miscalibration is assumed to go undetected until the next scheduled calibration at the next refueling outage. HDRT2 is assigned a duration of 1.5 years, or 13,140 hours.

4.1.15 HDRT3

HDRT3 is the average duration to detection of a miscalibration of a single RPS channel. Similar to HDRT2, HDRT3 is assigned a duration of 1.5 years, or 13,140 hours.

4.1.16 HEA1

HEA1 is the human error rate of miscalibrating two or more ESAS channels during the scheduled refueling outage calibration. The error rate assigned is made up of two parts. Miscalibration of one channel is assigned an error rate of HEC3; i.e., a general error of commission. The likelihood of a failure of miscalibration of a second channel, given miscalibration of a first, is assumed to be highly dependent. Therefore, the overall error rate assigned to HEA1 is HEC3*HEHD, where HEHD is the conditional human error rate, assuming a high level of dependence. No credit is given for the fact that not all miscalibration errors are sufficient to result in failure of the system. Also, miscalibrations of sensors are more easily detected than miscalibrations of bistable trip setpoints. The error rate assigned is assumed to apply to the miscalibration of the bistable trip setpoints.

4.1.17 HEA2

HEA2 is the error rate of the independent verifier failing to detect the miscalibration of two or more ESAS channels, as represented by HEA1. Two persons perform the ESAS channel calibration together. One reads the procedure and verifies that the other performs the calibration correctly. However, if a channel is outside the tolerance limits, the persons performing the calibration must submit an Exception and Deficiency sheet documenting the finding that they are out of tolerance. This report would then be reviewed by the shift supervisor and the preventive maintenance supervisor. Consequently, the verification action is assumed to be independent of the initial miscalibration. An error rate of HE02A is therefore assigned to HEA2.

4.1.18 HEA3

HEA3 is the error rate for miscalibrating one ESAS channel during the scheduled refueling outage calibration. Similar to that for HEA1, the error rate assigned to HEA3 is HEC3; i.e., a general error of commission.

4.1.19 HEA4

HEA4 is the error rate for the independent verifier failing to detect a single ESAS channel miscalibration, as represented by HEA3. Medium dependence is assumed between the two actions. HEA4 is assigned an error rate of HEMD.

4.1.20 HEF6

HEF6 is the frequency of the operator failing to restore one train of the emergency feedwater system to the normal alignment following a system test or maintenance action. Failure to restore the system would require the omission of a step in the procedure. Therefore, the human error rate assigned to this action is HE01B; i.e., failure to use a procedure with a long list of checkoff provisions. Only single train errors are considered explicitly in the evaluation. Multiple train errors of restoration are accounted for implicitly in the common cause failure parameters for the failure modes of the system pumps.

4.1.21 HEF7

HEF7 is the error rate of the independent verifier failing to detect the misalignment noted in the discussion for HEF7. Since the verifier is required by procedure to verify the restoration of these valves, the human error rate assigned to HEF7 is HE02A; i.e., failure of the checker to recognize an incorrect status when checking each item.

4.1.22 HHL1

HHL1 is the error rate for leaving one train of the decay heat removal system misaligned following test. Manual valves DH-V-12A or DH-V-12B may not be restored to the normal system alignment. The error rate assigned to HHL1 is then HE01B, failure to follow procedures with a long list for checkoff provisions.

4.1.23 HHL2

HHL2 is the error rate for the independent verifier failing to detect the decay heat removal system misalignment error represented by HHL1. Since the verifier is required by procedure to verify the restoration of these valves, the human error rate assigned to HHL2 is HE02A; i.e., failure of the checker to recognize an incorrect status when checking each item.

4.1.24 HIC5

HIC5 is the error rate of the atmospheric dump valve manual loader being inadvertently left at the nonzero position. The position of this manual loader is checked during plant heatup from shutdown conditions and verified every shift. HIC5 is assigned an error rate of HE01B; i.e., failure to follow a procedure with a long checkoff list, given that the manual loader was used for cooldown.

4.1.25 HIC6

HIC6 is the fraction of time that the backup manual loader for the atmospheric dump valves is not correctly set at the zero (i.e., valves closed) position as a result of the mispositioning represented by HIC5. The position of the manual loader is verified as part of a routine check of tasks by each shift according to the CRO reading sheet.

A conservative estimate of the time that the manual loader might be mispositioned is used in this evaluation. It is conservatively assumed that, if left in the nonzero position, the error would, on average, be detected within 24 hours. This corresponds to three shift changes. It is also assumed that the ADVs would be repositioned with the manual loader once every 6 months (OPS-232, surveillance test). This gives an estimate of 5.5×10^{-3} for the fraction of time that the manual loader may be misaligned, given that the operator initially failed to restore it to the zero position.

4.1.26 HRT1

HRT1 is the error rate for the operator failing to remove the bypass from an RPS channel after testing, which is performed monthly. Only one RPS channel can be left in bypass at a time. This error would be an omission of a step in the testing procedure. The error rate assigned to HRT1 is therefore HE01B; i.e., failure to follow procedures with a long checkoff list.

4.1.27 HRT2

HRT2 is the error rate for the independent verifier failing to detect that an RPS channel was left in bypass after RPS testing. By procedure, the independent verifier checks to ensure that the system is restored to the normal alignment following the test. The error rate assigned to HRT2 is therefore HE02A; i.e., failure to recognize an incorrect status when checking each item. If the independent verifier fails to detect the misalignment, the average duration until detection is given by HDRT1.

4.1.28 HRT3

HRT3 is the error rate for the operator miscalibrating two or more RPS channels during the refueling outage calibration. The error rate consists of two parts. First is the error rate for miscalibration of one channel, HEC3; i.e., a general error of commission. High dependence is assumed for the likelihood of miscalibrating a second channel, given miscalibration of one. Therefore, the overall error rate is assigned HEC3*HEHD where HEHD is the conditional human error rate, assuming a high level of dependence.

4.1.29 HRT4

HRT4 is the error rate for the independent verifier failing to detect the miscalibration of multiple RPS channels, as represented by HRT3. Two persons perform the RPS channel calibrations together. The independent verifier reads the procedure aloud and verifies that the action is being performed correctly, while the two work through the procedure. Medium dependence between the two actions is assumed. HRT4 is assigned an error rate of HEMD.

4.1.30 HRT5

HRT5 is the error rate for the operator failing to properly calibrate a single RPS channel. Similar to the first part of HRT3, an error rate of HEC3, general error of commission, is assigned.

4.1.31 HRT6

HRT6 is the error rate for the independent verifier failing to detect the miscalibration of a single RPS channel, as represented by HRT5. Similar to that for HRT4, medium dependence is assumed between the performance of the action and the independent verification. HRT6 is assigned an error rate of HEMD.

4.2 DYNAMIC HUMAN ACTIONS

This section presents the results for the dynamic human actions that were evaluated using the methods described in Section 2.3. Section 4.2.1 presents the results of the nonresponse human error frequency estimates. Section 4.2.2 presents the results for the errors of misdiagnosis, and Section 4.2.3 presents the results for the evaluation of potential nonviable human actions. Detailed recovery analyses performed for a select few dynamic human actions are described in Section 4.3.

4.2.1 NONRESPONSE DYNAMIC HUMAN ERRORS

The final distributions for the nonresponse human error frequencies are summarized in Table 1-2. Dynamic human action questionnaires were completed for nearly all of the dynamic human actions identified. The input to the computer program that was prepared for quantification of the dynamic actions and the results are listed in Table 4-1. A separate page of results is provided for each action.

In Table 4-1, the input echoes are self-explanatory. These are the qualitative judgments that are used in the dynamic, nonresponse human error frequency models described in Section 2.3.2. For most actions listed, point values are estimated for both the median estimate of the length of time it takes to diagnose and the medium estimate of the length of time available for diagnosis. For those actions for which the length of time available to diagnose is very uncertain because either the amount of allowable time, the amount of time required to respond (once diagnosed), or both are uncertain, variable time distributions are used, then provided in the input echo. If variable time distributions are used, the error frequency results for each discrete combination of the length of time available and the length of time to respond are provided as intermediate results. The final error frequency distribution results are then provided in the form of a lower bound (5%), a best estimate or median, and an upper bound (95%). Discrete distributions are then developed to represent the range of results for use in quantifying each split fraction. The mean values of these discrete distributions are provided in Table 1-2. At the bottom of the program output for each dynamic human action, the contributions of the time-dependent and time-independent error frequencies are provided prior to accounting for assumed dependencies among actions. The failure frequency range provided above these results does account for the dependencies among actions, as specified in the input echo.

The full, completed questionnaires are provided in Appendix B. Questionnaires were not completed for the following human actions; HCV3, HGA1, HNS3, HNS4, and HNS5.

HCV3 represents the fraction of time that the outside air temperature at TMI is too warm to permit effective cooling of the control building in the once-through cooling mode without operable chillers. The allowable upper limit to this outside air temperature is assumed to be 84°F, allowing 20°F for the rise in temperature through the hotter rooms and a limiting equipment failure temperature in terms of a bulk room air temperature of 104°F (Reference 4-1). According to meteorological records at the site during the last 5 years, the fraction of time the outside air temperature has exceeded 84°F varied between 1.5% and 4.5% (Reference 4-1). A conservative estimate of 5% exceedance was therefore assumed for this analysis. This means that, for 5% of the time, extended loss of the chillers is assumed in the plant model to result in eventual failure of some equipment serviced by the control building ventilation system even if the system fans function properly. However, if the loss of control building ventilation procedure is followed, and portable ventilation fans installed, the maximum allowable outside air temperature is increased from 84°F to 95°F. The average year exceeds 95°F only 0.2% of the year (Reference 4-2) and, generally, for only 2 to 3 consecutive hours. Therefore, if portable ventilation is established in the control building, only 0.2% of the time is the outside air temperature assumed too hot for effective cooling. Then, the conditional frequency of exceeding 95°F, given 85°F is exceeded, is given by .002/.05 = .04.

Dynamic human actions HNS3, HNS4, and HNS5 are currently not used in the quantification of the plant model. In the evaluation of Top Event NS, (nuclear services cooling), it has been assumed that loss of the Class I, auxiliary building ventilation system would not lead to overheating of the closed cooling water pumps it services. However, the equations have been written in a way that permits this dependency to be considered at a later time, if desired. The three dynamic actions listed above would then be used. They are each concerned with manually starting the standby ventilation train in the event the normally operating train fails or loses power. For the quantification of accident sequences in this study, they are not used. Consequently, the dynamic human action questionnaires were not completed for these actions. Instead, conservative, screening values of 0.1 are assigned to the error frequencies for these actions for now.

Human action identifier, HGA1, represents a conservative estimate of the error frequency for failing to recover offsite power within 6 hours following an initial loss of all vital AC. The detailed recovery analysis documented in Section 4.3 supersedes this estimate in the final results, by suitably adjusting the split fractions for Top Event RE. Use of HGA1 is therefore a calculational convenience to conservatively account for offsite power recovery in most sequences involving degraded electric power states. For those sequences still found to be important, the results from the detailed electric power recovery analyses described in Section 4.3 are then used to refine the frequency estimates.

Questionnaires were completed for all the other dynamic human actions listed in Table 1-1. For presentation purposes, these events are divided into two groups; those that are dependent on the performance of other human actions and those that are assumed to be independent.

4.2.1.1 Dependent Actions

A list of the accident scenarios examined in which dependent dynamic human actions are evaluated is provided in Table 4-2. Each of these accident scenarios is described in the following paragraphs.

The first accident scenario listed in Table 4-2 is initiated by a loss of river water, assumed to be caused by a plugging of the pump house screens, possibly by leaves or other river debris. Initially, the operators would sense the screen problems via a trouble alarm. HRE4 represents the action to attempt to clear the screen prior to the time that the plant trips. HRE6 represents the action to subsequently clear the screens if the operators failed to do so earlier. Three different variations of HRE6 are used to represent three key scenario groups: (1) control building ventilation and emergency feedwater succeeds (HRE6A); (2) control building ventilation succeeds, but emergency feedwater fails (HRE6B); and (3) control building ventilation fails, but emergency feedwater succeeds. The status of the control building ventilation system and the emergency feedwater system are important in determining the time available to clear the pump house screens. If emergency feedwater fails, the time available is 1 hour from the loss of river water pump suction. If emergency feedwater and control building ventilation succeed, the time before core damage is governed by the timing and rate of RCP seal leakage. From the time the river water pumps lose suction, 9 hours are assumed to be available. The conditional failure frequency of control building ventilation is increased, given a loss of river water, because the ultimate heat sink for the chilled water system is then lost. The loss of control building ventilation also affects the allowable time to unplug the screens. Without control building ventilation, all vital AC power may be lost as the switchgear rooms overheat. The allowable recovery time is then determined by which takes the shorter length of time, the control building room heatup or the RCP seal leakage that leads to core damage.

HRE2 represents the action to prevent an RCP seal LOCA from developing by maintaining seal injection without river water. At low injection flow rates, the makeup pumps can continue to operate for a few hours without cooling. HRE2 represents the action to rotate between the makeup pumps to sufficiently extend the time available to unplug the river water screens to ensure eventual success. A low dependence is assumed between HRE2 and HRE6A. This action is not viable if control building ventilation fails because AC power is assumed to be eventually lost or, if EFW fails, because the required makeup pump injection rates would then be too high; i.e., the pumps would quickly overheat without cooling.

Each of the different sequences involving recovery from a loss of river water are illustrated in the event tree shown in Figure 4-1. The split fractions involving the human actions identified in this section are indicated at the corresponding branch points in the tree. Note that action HCF1 does not have a bearing on whether core damage occurs or not. HCF1 only helps define the plant damage state. Clearly, these actions are interrelated since they are directed, in part, at the same goal, cleaning the screens. If the operator is unsuccessful at both actions HRE2 and HRE6, a core melt sequence is assumed to result after the loss of inventory via the seal LOCA.

HCF1 represents the action to establish reactor building cooling without river water by realigning the industrial coolers to the fan coolers. A substantial dependence between this action and failure of both HRE2 and HRE6 is assumed because the operating crew may fixate on the initial recovery response even though they are unsuccessful. Finally, if the screens are successfully cleared and river water restored (i.e., HRE6 success), the operators must start the makeup pumps to reestablish normal seal cooling. Since both actions HRE6 and HBW3 are directed toward the same goal (i.e., providing RCP seal cooling), the evaluation of HBW3 assumes a dependence on the success of action HRE6.

Two dynamic human actions are considered for accident scenarios involving failure of reactor trip. Both human actions HRT7 and HRT8 are required, in the initial steps of Abnormal Transient Procedure 1210-1, Reactor/Turbine Trip. HRT7 represents the first action, which is to manually trip the reactor by pushing the scram button. HRT8 represents the subsequent action to interrupt power to the control rod drives. In the systems analysis of the reactor trip function, human action HRT8 is only asked if the rods failed to go in and action HRT7 does not cause the rods to go in. HRT7 may be unsuccessful because the operator fails to perform the action or, more likely, because the reactor trip breakers failed to function; therefore, pushing the scram button has no effect. In evaluating the error frequency for HRT8, a low dependence on the failure of HRT7 is assumed. Although these two actions are directed at the same goal, this approach is still believed to be conservative. Failure of HRT7 probably does imply failure of HRT8. However, the demand for HRT8 is much more likely to be due to failure of the trip breakers, regardless of the success or failure of HRT7. Thus, always assuming a low dependence on the failure of HRT7 should be conservative.

A third accident scenario involves the need to initiate HPI cooling following a loss of all secondary cooling. Two human actions are considered; HBW1 and HPO1. HBW1 represents the actions to decide to initiate HPI cooling, open the BWST suction valves, and start the HPI pumps. If the support systems needed for automatic pressure control of the PORV are available, the model assumes that manual action to hold the PORV open is not needed for success of HPI cooling. This is because of the very high pressure capacities of the makeup pumps. If automatic control power is lost to the PORV (i.e., instrument bus ATA is failed), the operator can still manually hold open the PORV, as needed, to allow successful HPI cooling; i.e., action HPO1. The action, HPO1, is therefore assumed dependent on successful performance of HBW1.

Following initiation of HPI cooling, the rate of makeup to the RCS should eventually exceed the rate of inventory loss. This then requires that HPI flow be throttled to prevent overfilling and challenging the PORV. After a normal plant trip, HPI is initiated manually and a flow path is provided by opening MU-V217 to maintain pressurizer level. This action is not modeled explicitly in the plant model event trees since it is not essential to plant safety. HTH1 represents the operator action to throttle the HPI flow before the PORV is challenged. The evaluation of HTH1 therefore assumes a dependency on the successful completion of the earlier operator action to manually increase HPI flow. If HTH1 fails, the operator may still throttle HPI after the PORV is challenged to allow the PORV and/or PSVs to reseat; i.e., action HRC2. Since the operator has already failed once to throttle HPI, the evaluation of HRC2 assumes a dependency on the failure to perform HTH1. Although both HTH1 and HRC2 are directed toward the same goal, complete dependence is not assumed because the plant PORV has in the meantime been challenged, which is judged likely to cause the operator to rediagnose the situation.

Following an ESAS initiation of HPI, the throttling action, HTH2, is again evaluated. In this case, however, the manual action to open MU-V217 did not take place, so no dependence is assumed. The subsequent action to throttle HPI after a PORV challenge is again assumed to have a medium dependence on failure of HTH2 since both actions are directed at the same goal; namely, maintaining RCS inventory. In case the operator succeeds in throttling after an ESAS initiation of HPI, care must be taken to ensure that makeup pump recirculation flow is established; i.e., action HMR1. Medium dependence on the success of HTH2 or HTH3 is assumed in evaluating the failure frequency for HMR1.

If a purge of the reactor building is in progress at the time of an accident, such as a LOCA, having the reactor building purge line open would prevent any appreciable buildup of pressure in the containment. This would preclude any automatic containment isolation signal. If the operator fails to manually isolate the reactor building (i.e., action HCA2), he is also unlikely to initiate reactor building spray. Therefore, a medium dependence on the failure of HCA2 is assumed in evaluating the failure frequency of HCS5; i.e., manual building spray initiation.

If instrument air is lost, one recovery action is to bypass the instrument air dryer transfer valve should a transfer operation sequence fail, blocking both flow paths. This failure mode is in fact expected to dominate the failure frequency for loss of instrument air. HAM1 represents the failure frequency for the operator action to locally bypass the air dryers. In the event HAM1 fails and an extended loss of instrument air results, HINJ4 represents the local operator action to open the air-operated seal injection valve; i.e., MU-V20. Evaluation of the failure frequency for this action is assumed to have a low dependence on the failure of HAM1.

Two general accident scenarios relate to cooldown and depressurization of the reactor coolant system following a plant trip. The cooldown and depressurization actions are assumed only required if there is an RCS leak; i.e., following a steam generator tube rupture or following a plant transient with a very small leak, not large enough to be called a small LOCA (and therefore included in the reactor trip initiating event frequency). Without a steam generator tube rupture, if the cooldown and depressurization are unsuccessful, this is assumed to be caused by failure of the corresponding human action; i.e., HCD1 or HCD2. If the RCS is not depressurized, the RCS leak would continue, albeit at a very low rate, and eventually require long-term makeup to the BWST; i.e., action HLT1B. Since, in this scenario, cooldown and depressurization were not initiated in time to preclude the need for BWST makeup, a low dependence is assumed in the evaluation of HLT1B on the failure of HCD1 or HCD2. On the other hand, if the cooldown and depressurization are successful, the operators would then open the dropline to go on DHR cooling. Therefore, the evaluation of actions HHL1A and HHL1B (i.e., actions to open the dropline) assumes that the operators have already successfully initiated the cooldown.

Following a steam generator tube rupture, the operator's first task is to diagnose the accident and identify which steam generator has failed; i.e., HID1 or HID2. The plant model assumes that this action must be successful to prevent core damage. Therefore, all subsequent actions in this scenario are evaluated assuming a successful diagnosis. The evaluation of the actions to isolate the affected steam generator (ITC1), initiate cooldown and depressurization (HCD3, HCD4, or HCD5), and open the DHR dropline (HHL1A) all assume successful diagnosis of the event. In addition, evaluation of the action to open the dropline (HHL1A) also assumes that cooldown and depressurization are successful. Should cooldown and depressurization not be successful, long-term makeup to the BWST would eventually be required; i.e., action HLT2. Therefore, evaluation assumes a low dependence on the failure of the actions to achieve the cooldown; i.e., HCD3, HCD4, and HCD5. The dependence is judged to be low because the actions are well separated in time.

The next three accident scenario groups listed in Table 4-2 all involve degraded states of electric power. If offsite power is lost, but both diesel generators function properly so that both vital buses are available, the operator actions that involve dependencies are the actions to ensure seal injection, EFW control, and cooldown and depressurization of the RCS. There are other actions that are required, such as restarting the control building ventilation system fans after the loss of offsite power (i.e., action HCV6), but these actions are assumed to be independent of other actions during the scenario. In the event of a loss of offsite power, the instrument air compressors would not be loaded onto the diesels if an ESAS signal is present. The plant model conservatively assumes that an ESAS signal has occurred so that manual action to reload the compressors is required; i.e., action HAM2. If the action is successful, instrument air is assumed available throughout the remainder of the scenario. If HAM2 fails and instrument air is lost, operator action is needed to locally open the RCP seal injection valve, MU-V-20, and to control EFW flow. Both the action to open the seal injection valve (action HINJ4) and the action to control EFW flow (action HEF1) are assumed to be dependent on the failure of HAM2. Low dependence is assumed because these actions are separated in time, with different indications to perform each action. For example, the action to control EFW flow would not be necessary until the 2-hour air bottles are exhausted. EFW control could then be achieved by either replenishing the bottles or by taking local manual control of the EF-V30s that otherwise require instrument air to remain open. Once a decision to initiate a cooldown is made, the loss of offsite power requires additional considerations because the RCPs would not be available. The action to initiate a slow cooldown (HCD2) is evaluated by assuming a high dependence on the success of HCD1.

The dependencies between actions to ensure seal injection and control EFW flow and to initiate a slow cooldown also apply to the accident scenario involving loss of offsite power with one vital bus failed. In addition, the loss of one vital bus greatly increases the chances of losing MCC 1C-ESV. In fact, the initial plant model conservatively assumes that if Top Event GB fails, power to MCC 1C-ESV is lost. No credit is taken for the transfer of MCC 1C-ESV to the opposite vital electric power train, which would be possible if no ESAS signal were present. The loss of MCC 1C-ESV precludes remote opening of the dropline valves. For this scenario, local opening of the dropline valves (i.e., action HHL1B), may be necessary to establish long-term DHR cooling. Therefore, if a cooldown and depressurization was required and successfully initiated, the evaluation of action HHL1B assumes low dependence on success of HCD1 and HCD2.

In the event of a loss of all AC power (i.e., loss of offsite power and initial failure of both diesels), two different accident scenarios are identified in which dependencies among human actions are assumed. The scenarios are distinguished by whether EFW is available or not. In the event of a loss of all AC power, the operator is instructed to send an operator to locally control EFW flow. The analysis of the action to recover electric power (i.e., HRE1), is, of course, partially dependent on the successful control of EFW by the operator although the overwhelmingly more important factor is the extension of the length of the allowable recovery time. If EFW fails, the length of the allowable electric power recovery time is, of course, much shorter. Although one of the reasons for EFW failure could be the operator failing to locally control flow, only a very low dependence on this potential cause of EFW failure is assumed when evaluating the likelihood of electric power recovery; i.e., action HRE3. Actions HRE3 and HRE1 are evaluated using the detailed recovery analysis methods described in Section 2.4. The specific analysis performed is reported in Section 4.3.

The final scenario in Table 4-2 involves a failure to cool down sufficiently to terminate appreciable leakage from the RCS during a steam generator tube rupture or a very small break accident sequence. The failure of normal DHR cooldown may result from a failure of the DHR system itself or because the operators fail to cool down and depressurize the RCS sufficiently to allow DHR cooling. If main feedwater is operable (i.e., MF- success), then the RCS may be cooled to cold shutdown conditions without using the DHR system. The turbine stop valves would be opened to allow sufficient steam flow to the condenser, which would then be maintained at a vacuum, and the cooldown could then be continued using main feedwater. If the operators fail to initiate a cooldown to DHR entry conditions, it is not as likely that they would initiate turbine cooling. A medium dependence is assumed between the action to cool down to DHR entry conditions and the action to initiate turbine cooling. The support systems required for successful turbine cooling are no greater than those required for normal main feedwater following plant trip.

If the reason DHR cooling is unavailable is in part because the 1DC power train is unavailable, the operators may decide to locally actuate the affected pump train. Since RCS cooldown is successful, success of HCD1 is assumed. Since the cooldown and the local start of the DHR pump train are directed at the same goal, a medium dependence is assumed between these actions.

4.2.1.2 Independent Actions

The remaining dynamic actions listed in Table 1-1 were evaluated by assuming they were independent of any other human actions that might be required or attempted during the scenario. The review of the number of crew members av ilable on a normal shift at TMI Unit 1, as documented in Section 3.4, indicates that the manpower required to perform these actions would be available, even in very manpower-demanding scenarios. Therefore, no dependencies resulting from manpower limitations were assumed in their evaluation.

This conclusion is especially true for those actions that require relatively little time to perform. Actions that are assumed to be independent of other actions and that fall into this category include the actions to manually initiate individual systems (HBW2, HINJ1, HNS2, and HEF5), isolate seal return (HC31), realign equipment in the control building ventilation system (HCV1, HCV2, and HCV6), notify divers removing silt from the river water pumps that they sho stand clear so that the pumps may be started (HHA1), switch over HPI suction to the BWST from the makeup tank (HLT1A), close the PORV block valve (HRC1), isolate main steam following a steam line break (HSI1, HSI2, and HTC2), close reactor building sump drain valves (HSV1), transfer power sources to an inverter (HVB1), and trip the MFW pumps (HIC2).

A second group of such actions that are assumed to be independent take a somewhat longer time. These actions involve control of specific systems, generally in response to a failure of automatic control. Such actions include EFW flow control (HEF2 and HEF8), MFW control (HFW4, HFW5, and HIC1), main stream control (HIC3, HIC4), and reactor building emergency cooling pressure control (HCF2). Specific, planned manual actions that take a relatively short time are also independent. Such actions include switchover to sump recirculation during a medium or large LOCA (HSR1 and HSR3).

Specific recovery actions that are only required if some equipment fails are also assumed to be independent. Examples of these actions include local realigning of the makeup system (HINJ2 and HINJ3), turning off a DHR pump if the corresponding train of decay heat fails closed (HDH1), aligning a fire hose to the river water side of a DCCW heat exchanger (HRE9), initiating repair of an unavailable DHR or DCCW pump following ESAS actuation (HRE11), taking control building ventilation system recovery actions (HCV3, HCV4, HCV5, HCV7, HCV8, and HCV9), remotely controlling EFW (HEF9 and HEF10), and taking nuclear services closed and river water recovery actions (HNS1, HNS6, HNS7A, HNS7B, HNS8A, and HNS8B).

Planned, long-term actions for which a substantial amount of time is available are also evaluated as independent of other actions. Two examples of this type are the prevention of long-term boron concentration effects following a LOCA (HDT1) and switch over to sump recirculation following a small LOCA (HSR2).

The qualitative judgments about performance-shaping parameters for each of these actions are documented in Table 4-1 along with the calculated frequencies for the nonresponse errors.

4.2.2 ERRORS OF MISDIAGNOSIS

Dynamic human errors resulting from faulty event detection or diagnosis (i.e., sequence A2B6C2 in Figure 2-3) are considered in this section. The methods described in Section 2.3.3 for errors of misdiagnosis were adopted here for evaluating the TMI Unit 1 plant and procedures. The plant-specific preliminary tables presented in Section 3.5 form the basis for preparation of the TMI Unit 1 operator-plant status confusion matrix. Table 4-3 presents the TMI Unit 1 confusion matrix. The evaluation for each initiating event sequence (i.e., row in the table) is provided below.

4.2.2.1 <u>ICS Malfunction (ATA Loss)</u>

An ICS malfunction can appear to be a malfunction in one of the systems controlled by ICS. An overcooling or undercooling event can be caused by the main feedwater system components failing or the ICS commanding them to operate erroneously. The ICS can also cause a reactor/turbine trip should a failure cause improper control rod movement. ICS-induced transients can be very rapid, sometimes causing a plant trip before the operator is aware there is a problem. Consequently, it is not always apparent that an ICS malfunction may have caused the trip. The procedures direct the operators to monitor and control specific plant parameters in order to place the reactor in a stable condition, regardless of what caused the trip.

Only one type of ICS malfunction is included in the assessment of misdiagnosis, total loss of instrument bus ATA. Loss of ATA causes an excessive cooling to occur. Consequently, the operator may select Procedure 1210-3, Excessive Cooling, rather than the more appropriate one, Procedure 1202-40, ICS Power Failure. RCS temperature T_{cold} would decrease, as required, to satisfy the entry condition for 1210-3. However, failure of ATA has its own loss of power alarm, and the ICS/NNI hand/auto station lights would go off and the indications would fail to midscale. These indications are fairly obvious to the operator, so the chance of his confusing ATA loss for a simple excessive cooling is judged to be low.

If he did confuse them, the impact would be small. The excessive cooling procedure does not ask the operating crew to dispatch an operator to restore ATA, but no credit was taken for this action in the event sequence model anyway. In both Procedures 1210-3 and 1202-40, the operators are instructed to trip the main feedwater pumps. Therefore, the impact of this potential misdiagnosis is judged to be negligible.

4.2.2.2 <u>Loss of River Water</u>

A total loss of river water would result in a loss of secondary river system pressure and a number of other alarms indicating trouble in the river water pump house and the nuclear services and intermediate closed cooling water systems. The NSCCW system trouble alarms would also occur, but at a later time. None of the other event sequences considered for misdiagnosis have similar plant responses. Therefore, the confusion matrix was assigned a negligible chance that this initiator sequence would be confused with any other.

4.2.2.3 Loss of Main Feedwater

A loss of main feedwater would result in a plant trip with an increase in subcooling margin, RCS pressure, pressurizer level, and RCS temperature. Abnormal Procedure 1210-1 provides the guidance necessary to mitigate this event. No other procedures are required. As none of the plant responses for the other initiator sequences resemble this event, the chance of confusing this sequence for any other is judged to be negligible.

4.2.2.4 Loss of Offsite Power

Plant response to a loss of offsite power resembles a loss of main feedwater. Important distinguishing differences involve the loss of 230-kV bus voltage and the increase in diesel generator voltage and frequency. These indications are very apparent to the operating crew. Although the plant response also satisfies the entry conditions for Procedures 1210-4 (Loss of Primary to Secondary Heat Removal), 1210-8 (RCS Superheated), 1202-9A (Loss of DC Train A), 1202-36 (Loss of Instrument Air), and 1203-34 (Control Building Ventilation Failure), the operators are trained to jump directly to the procedure for loss of offsite power; i.e., 1202-2. The chances of confusing this sequence with any other is judged to be negligible.

4.2.2.5 Steam Generator Tube Rupture

A steam generator tube rupture might possibly be confused with a small LOCA or an interfacing LOCA event if the operators did not recognize the increasing secondary system radioactivity levels or the increase in the steam generator level of the affected steam generator. For this reason, the potential for confusion with a small LOCA is judged to be low. The potential for confusion with an interfacing LOCA is judged to be negligible because of the perception that the interfacing LOCA is very unlikely and because no procedures are specifically designed for it. For either event, the operators would monitor the primary system subcooling margin and control the inventory of primary coolant. The Small Break LOCA Procedure, 1210-2 (loss of subcooling margin), requires the operators to stop the reactor coolant pumps, but the Steam Generator Tube Rupture Procedure, 1210-5, requires them to be left on (one per loop). If the operator stopped the RCPS while believing the event to be a LOCA, then realized the event was a steam generator tube rupture, he would still be able to restart the RCPs to provide forced circulation for cooling down. The one situation for which this might be too late to be successful is in the very infrequent event that would combine a tube rupture with a failure of reactor trip. In this case, however, the operator would be unlikely to trip the RCPs until he was assured that a reactor trip had occurred. Reactor trip would be ensured before he left the Reactor/Turbine Trip Procedure, 1210-1, which would be entered first in either case.

A steam generator tube rupture would satisfy several of the entry conditions for the Pressurizer System Failure Procedure, 1202-29. However, a pressurizer system failure would not adequately describe the plant response on the secondary side. In particular, it would not account for the radiation reading on RM-A-5, for the increase in steam generator level, or for the original plant trip. Therefore, the chance of entering the pressurizer system failure procedure is judged to be negligible.

In the long term, the operators must recognize the tube rupture to ensure that the RCS is cooled down and depressurized to stop the continued loss of RCS inventory, or to recognize it in time to establish a long-term source of makeup to the BWST before it is exhausted. There are several cues to allow the operators to decide that a tube rupture rather than a LOCA has occurred in the long term. One very important one is the reactor building sump level indication. Because the two events must be confused for a very long time before any significant impact results from the confusion, it was decided that the procedure for assigning the frequency of such an error, as discussed in Section 2.3.3, did not apply to this event. Therefore, the methods for assigning frequencies to nonresponse dynamic actions (See Section 2.3.2) was used instead to estimate the frequency of failing to recognize the steam generator tube rupture as such and cooling down sufficiently. The analysis for dynamic human actions HID1 and HID2, presented in Section 4.2.1, are believed to adequately cover the potential for confusion between these events.

4.2.2.6 Reactor Trip

In the event of a reactor trip, a number of plant indications change. These are summarized in Table 3-17. The reactor trip alarm and rod bottom lights being on are very clear indications that a reactor trip has occurred. The Reactor Trip Procedure, 1210-1, should be entered. This procedure is also entered for a large number of other transients. It is very likely that the operators would choose the correct procedure. A negligible chance of misdiagnosis is assumed except for the initiator sequence, turbine trip. This is because turbine trip leads to reactor trip and vice-versa. Since the response is the same, the initial cause of the plant trip may be confused. The impact is negligible, however, because Procedure 1210-1 is the desired operator response for either cause of plant trip.

4.2.2.7 Turbine Trip

Similar to the remarks for the reactor trip initiator sequence made in Section 4.2.2.6, this event has a high likelihood of being confused with a reactor trip. Both lead to the same plant response. Because they both call for the operators to follow Procedure 1210-1, the impact of mistaking the cause of the plant trip is assumed to be negligible.

4.2.2.8 Loss of Control Building Ventilation

The operators would first notice a failure or degradation of the control building ventilation system by individual room temperature alarms in the control building and/or increased temperature in the control room. Such indications are not normally keyed on by the operators, but there is very little chance for confusion because none of the other initiators have similar indications. A new procedure is being prepared to address such total ventilation system failures. Credit for this procedure was taken in this study. A negligible chance of confusion with other sequences was assumed.

4.2.2.9 Excessive Feedwater

An excessive feedwater event would result in a decrease in subcooling margin, RCS pressure, pressurizer level, OTSG pressure, and a decrease in RCS temperature T_{cold}. Because of the similar plant response, the excessive feedwater event may be confused with a loss of power (i.e., bus ATA) to the ICS. In this case, the operator has the opportunity to mitigate the excessive feedwater from the control room using the ICS controls in manual and stopping the excessive flow. Given a loss of bus ATA, the operator could only prevent the overfeeding by tripping the pumps because the main feedwater regulating valves fail to half open. A loss of ICS power also prevents the automatic operation of the turbine bypass valves, which then requires the operator to control the cooldown by using the ADVs. Numerous alarms are available to aid the operator in diagnosing the event as a loss of power to the ICS. Therefore, the potential for confusion with a loss of ICS power is judged to be low.

As discussed in the Section on ICS power failure (i.e, Section 4.2.2.1) the impact of such a diagnosis is negligible because both the Excessive Feedwater Procedure, 1210-3, and the ICS Power Failure Procedure, 1202-40, instruct the operators to trip the main feedwater pumps, thereby terminating the overcooling.

The operators are not likely to confuse an excessive feedwater event with a steam generator tube rupture because they would monitor the post-trip main feedwater response to verify that it ramped back correctly. The rampback should allow the steam generator to boil down to 30 inches. If feedwater is not behaving normally and steam generator level continues to increase, the operators will attempt to manually control the flow using the feed regulating valves or by tripping the main feedwater pumps, as instructed in the Reactor/Turbine Trip Procedure, 1201-1. If flow is normal, but the steam generator level is still increasing and the RM-A-5 radiation monitor shows increasing secondary activity, the operators know that a tube rupture has occurred. Also, OTSG pressure and RCS temperature T_{cold} should both increase following a tube rupture. In an excessive feedwater event, they might both be expected to decrease. Therefore, a negligible chance of confusing a tube rupture with an excessive feedwater event is assumed.

Excessive main feedwater causes similar RCS symptoms to those of a steam line break if the different secondary conditions are not noted; i.e., OTSG level. However, the same procedure (1210-3, Excessive Cooling) is used to mitigate the effects of either event once the reactor/turbine trip procedure is exited. Therefore, a negligible impact and a medium potential to confuse these event types are assumed.

An excessive feedwater or loss of feedwater transient should not be confused with a main steam line break in the reactor building because of the steam released to the reactor building. Reactor building pressure and sump level would increase, which cues the operator to either a LOCA or a steam line break. The steam generator level and pressure response following SLRDS actuation (0% on the ruptured steam generator) and the reactor building radiation level trend (upward, given a LOCA) then allows him to differentiate between a steam line break and a LOCA.

4.2.2.10 Loss of DC Train A

The plant response to a loss of DC train A is similar to a normal reactor or turbine trip event sequence. The difference is that an upscale indication of diesel generator voltage and frequency would result and the alarms for a loss of the DC Train A distribution system would be on. These indications sufficiently distinguish it from any other considered initiators to allow us to judge that there is a negligible chance of confusing it with other events.

4.2.2.11 Interfacing LOCA (V-Sequence)

The plant response to an intefacing LOCA sequence is similar to that for a steam generator tube rupture and for a medium or small LOCA. Only a low potential for confusion with a tube rupture is assumed because, although the subcooling margin is downscale in both events, the interfacing LOCA would not result in high radiation readings on RMA-5 or in a high OTSG water level. There are no specific procedures at TMI to address an interfacing LOCA sequence. Therefore, the PRA event sequence model does not provide for any operator-initiated alternate success paths in the event such an event were postulated to occur. Consequently, the impact of misdiagnosing this event for another is assumed to be negligible. The interfacing LOCA might be confused with a medium or small LOCA. To distinguish this event from a LOCA within the reactor building, the operator would receive indications that the coolant from the RCS is not collecting in the reactor building sump, but instead is accumulating in the auxiliary/fuel handling building. He would then have to direct his attention to ensuring an adequate supply of makeup water to the borated water storage tank and to minimizing the loss of equipment due to the location of the leak. The loss of subcooling margin and the decrease in RCS pressure may lead the operator to select the Loss of Subcooling Margin Procedure, 1210-2, which is the same as he would select for a LOCA. Thus, a medium potential for confusion with a LOCA is assumed. Again, because the event sequence model gives no credit for subsequent operator actions in response to an interfacing LOCA, there is only a negligible impact of this potential confusion with a LOCA.

4.2.2.12 Loss of Instrument Air

Loss of instrument air causes failure of main feedwater, seal injection, and RCP thermal barrier cooling and causes the turbine-driven EFW pump steam admission valves to fail open. The most distinguishing indication in the control room of this event is the presence of the instrument air system alarms coming on. The only other initiator for which these come on is the loss of offsite power. These two events are easily distinguished by the operators. Therefore, a negligible frequency of confusion was assumed.

4.2.2.13 Large LOCA

A LOCA causes an increase in reactor building temperature, pressure, and radiation level, all of which are keyed on by the operators. The reactor building sump level will also increase as the steam/water mixture in the reactor building collects and drains into the sump. The increase in reactor building pressure causes the operators to consult the control building ventilation failure procedure, (1203-34), but this does not affect the subsequent selection of procedures. The plant response to a large or medium LOCA differs most markedly from a small LOCA because the core flood tank level decreases. As seen in Table 3-17, the direction of the plant indications following a large or a medium LOCA are essentially the same. The timing of the response of the indication is, of course, much different. Because of this difference in timing, only a low chance of confusing a large LOCA with a medium LOCA is assumed. However, since the same procedures are consulted for these events [i.e, loss of subcooling margin (1210-2) and large break LOCA cooldown (1210-7)], the impact of confusing one for the other is negligible.

A large LOCA event results in decreasing OTSG pressure and in RCS temperature T_{cold}. These are the entry conditions for the excessive cooling procedure, i.e., 1210-2. It is possible that the operators might initially confuse a large LOCA for excessive cooling, but the difference in steam generator level response and the reactor building radiation levels decrease this potential. A negligible potential for confusion between these two events is assumed. Even if they were to be confused, the difference in operator response is that, for excessive feedwater, the operator may trip the feedwater pumps. This has only a negligible impact on the plant response to a large LOCA.

A LOCA event appears to be very similar to a main steam line break in the reactor building through the primary (RCS) system response. However, the secondary response (steam generator level and pressure) provides the operator with information to diagnose the event correctly. After SLRDS isolates the ruptured steam generator, the HPI system would refill and repressurize the reactor coolant system. The operator would then throttle and finally stop the HPI system. He would then cool down using the intact steam generator. As an additional check, the operator is trained to first think of the event as a large LOCA and to check for reactor building radiation level trends to confirm whether the leak is from the primary or secondary system. The difference in core flood tank level response also allows the operators to distinguish a medium or large LOCA from such a steam line break. Therefore, the potential for confusion between a large LOCA and a main steam line break inside the containment is assumed to be negligible.

There is little chance of confusing a steam line break outside the reactor building with a large LOCA. The reactor building pressure response to this event is sufficiently different to ensure that they would not be confused.

4.2.2.14 Medium LOCA

The plant response to a medium LOCA is similar to that for a large LOCA except for the timing of events. Therefore, a low potential for confusion with a large LOCA is assumed, but the impact of this confusion is negligible.

The discussion provided above for large LOCAs also applies to medium LOCAs because there is only a negligible potential for confusion of medium LOCAs with steam line breaks inside or outside the reactor building or with an excessive feedwater event.

4.2.2.15 Small LOCA

There is some potential that a small LOCA could be confused with a steam generator tube rupture. The primary system responds the same; i.e., RCS pressure, subcooling margin, and pressurizer level all decrease. However, the steam generator with the failed tube leads to differences on the secondary side. The flow of primary water to the secondary side causes an increase in steam generator level and a smaller feedwater flow rate. The secondary side would become contaminated due to the leak and would be monitored by the condenser vacuum pump exhaust radiation detector (RM-A-5) and on the detectors on the steam lines to the atmospheric dump valves. These differences are judged to lead to a low potential for misdiagnosis. If the operator did select the tube rupture procedure (1210-5) instead of the loss of subcooling margin procedure (1210-2), the only real difference in his response would be the failure to trip the RCPs. This difference in operator response is judged to be negligible.

4.2.2.16 Very Small LOCA

A very small LOCA results in a drop in pressurizer level and RCS pressure. It would not necessarily cause an automatic plant trip although it may on low RCS pressure. The plant response to a very small LOCA of the pressurizer level, makeup tank level, makeup flow, and RCS pressure is similar to a small LOCA or a steam generator tube rupture event. It should not be confused with a tube rupture, however, because none of the three indications keyed on to enter the tube rupture procedure (1210-5) are satisfied. There is no decrease in subcooling margin, no radiation detected on RM-A-5, and the steam generator levels are not increasing. Therefore, the potential for confusing this event with a tube rupture is assumed to be negligible.

The best response to a very small LOCA may be to enter the loss of subcooling margin procedure (1210-2), which would be the proper response to a small LOCA. However, the decrease in RCS pressure and the change in subcooling margin may not be sufficient to key the operators to enter the procedure. Instead, the indications may direct them to enter the pressurizer system failure procedure (1202-29) although, again, the subcooling margin remaining unchanged decreases the chance that this procedure would be selected. A low potential for confusing the very small LOCA for a pressurizer failure is assumed. Normally, the operators would only suspect the PORV as the leak source if the reactor coolant drain tank pump high level or pressure alarm came on.

This procedure does not instruct the operators to trip the reactor or initiate plant shutdown. One step calls for the isolation of the PORV, which may indeed terminate the leak. On the other hand, if it is not the leak source, it would render the PORV inoperable for a brief time. The impact of this misdiagnosis is judged to be very small.

4.2.2.17 Turbine Building Steam Line Break

A steam line break in the turbine building results in a decrease in OTSG pressure and in RCS temperature T_{cold}. It therefore satisfies the entry conditions for the excessive cooling procedure; i.e., 1210-3 (see Table 3-18). Although the two events would lead the operator to the same procedure, the two events would be distinguished by the difference in steam generator level response; i.e., increase for excessive feed and decrease for the steam line break. Also, after SLRDS actuates on a steam line break, main feedwater flow would go to zero, but flow would be higher than normal for the excessive feedwater event. Because the events are similar enough to lead to the same procedure, they are judged to have a medium potential for confusion. They are then assigned a negligible impact if they are confused, however, because they do use the same procedure.

From the control room, a steam line break in the intermediate or in the turbine building looks similar. The damage created by the steam impinging on equipment along with the temperature and moisture effects will be the only differences between the events. If the break is in the intermediate building, an instrument air system failure may occur. Such a failure would require the operators to compensate for additional equipment failures caused by the loss of air. An intermediate building steam line break could appear to be a turbine building break when the steam escaped through the intermediate building/turbine building access door. An operator could not approach the area close enough to determine where the break had occurred until after the steam line was isolated and blowdown stopped. A medium potential for confusion with an intermediate building steam line break is assumed. However, the impact on subsequent operator actions is negligible.

4.2.2.18 Intermediate Building Steam Line Break

Almost the entire discussion presented above for turbine building steam line breaks also applies to intermediate building steam line breaks. One difference is that if the break occurred in the turbine building, the operators could still take action to recover the instrument air compressors in the event of a coincident loss of offsite power. The time available for recovery of the air compressor is substantial, however, and can be performed from the control room. Certainly, there would be sufficient time to wait until after the blowdown had been stopped, regardless of where the operators initially thought the break had occurred. Consequently, despite the potential to confuse the break location initially, no impact on the analysis of the human action to recover the air compressors is assumed. A negligible impact on the operators' response is therefore assumed.

4.2.2.19 Toxic Chemical Release

One indication that the operators would have about a toxic chemical release is the air intake alarm in the control building tunnel. The response to this alarm is to use Procedure 1203-34, Control Building Ventilation Failure. Since no other procedures have this alarm as an entry condition, there is judged to be only a negligible chance of confusing this sequence with any other.

4.2.2.20 Station Blackout

The station blackout sequence satisfies the entry conditions for Procedure 1202-2A, Station Blackout, and a number of the other key procedures; i.e., 1210-4 1210-8, 1202-9A, 1202-17, 1202-37, and 1203-34. As in the case of the loss of offsite power sequence, this sequence is readily identified by a complete loss of power at the 230-kV bus and by the failure of the AC lighting. The station blackout sequence is easily distinguished from a loss of offsite power alone by the loss of voltage at the 4,160V buses 1D and 1E. The continued loss of AC lighting easily allows the operator to identify this sequence, so a negligible chance of misdiagnosis is assumed. The station blackout procedure (1202-2A) directs the control room crew to transfer to procedure 1202-2 (loss of offsite power only) if power is restored to one or both of the vital 4,160V buses, but there is no transfer to the blackout procedure (1202-2A) if both vital buses are lost after having first entered the loss of offsite power procedure. However, the loss of all vital AC power is so obvious that a negligible chance of confusing this sequence for another is assumed.

4.2.2.21 Fire at Either 1P or 1S Switchgear Rooms

A fire in the 1P or 1S switchgear rooms would result in a fire and smoke alarm. If left unchecked, it may also result in a loss of one vital 480V bus and possibly a reduction of makeup flow. Normally operating makeup pump B may be lost if the fire causes loss of the 480V switchgear that is powering MCC 1C-ESV, which in turn powers the pumps' auxiliary oil pump. Of the initiating event sequences considered, only this sequence would result in a fire alarm. Emergency procedure 1202-31 (for fires) only directs the operators to announce the fire and to initiate the actions to put it out. It does not describe what equipment may be lost because this would be very event specific. Depending on the particular fire location and magnitude, many confusing alarms may be experienced. It was not possible in this study to examine the potential for such indications leading the operators to take an improper action. As the initial selection of the fire response procedure is unambiguous, a negligible chance for misdiagnosis is assigned in the confusion matrix.

4.2.2.22 Seismic-Caused Loss of DC Power

The plant response to a seismic-caused loss of both trains of DC power would be similar to a loss of a single DC train, provided offsite power is not also lost. A key difference is that the seismic event would also yield a seismic alarm in addition to both DC train trouble alarms. There is no specific procedure at TMI for the loss of both trains of DC power whether it is caused by a seismic event or not. The operators are likely to select either the loss of DC train A procedure (1202-9A) or the earthquake procedure (1202-30). The chance of misdiagnosing the event should be negligible, but the appropriate procedures to follow are unclear. The operators may go to 1202-9A before entering the earthquake procedure. Based on the summary of these two procedures in Table 3-20, it is judged that there would be a negligible impact on the subsequent operator response, regardless of which one is entered first.

4.2.2.23 Nuclear Services Closed Cooling Water Failure

Failure of the nuclear services closed cooling water system is alarmed in the control room. Depending on the system failure mode, the system failure may be detected by a low surge tank pressure alarm, low level alarm, low pump discharge pressure alarm, or by heat exchanger temperature alarms. The guidance for the alarm response procedures is very specific. Because none of the other initiator sequences is expected to lead to such alarms, the chance of confusing this sequence with the other one is judged to have a negligible frequency.

4.2.2.24 Inadvertent HPI Initiation

There is no specific procedure for an inadvertent initiation of HPI. Inadvertent HPI would not cause a plant trip immediately. A rapid power decrease and filling of the pressurizer due to the injection of borated water from the BWST would alert the operator prior to a plant trip. It is expected that the operator would recognize the HPI initiation as a spurious event and would first throttle, then stop the HPI system accordingly. The HPI actuation would also cause a decrease in T_{cold}, similar to an excessive cooldown, but it is judged that the chance of confusing this event with an excessive cooldown and entering Procedure 1210-3 (i.e., excessive cooldown) is negligible, provided the plant has not yet tripped. A low chance of mistaking inadvertent HPI initiation with a small LOCA is assumed. It is natural for the operators to expect that the system actuation was due to a real LOCA condition. However, as indicated by the plant response indications listed in Table 3-17, the two event sequences differ substantially. The subcooling margin and RCS pressure would both increase instead of decrease as they would for a small LOCA. In the longer term, reactor building sump level and radiation level would not increase as they would for a small LOCA. As a result of these differing indications, only a low potential for confusion is assumed.

In the event a small LOCA was assumed to initially be the cause, the operator would likely trip the reactor but would probably not enter the Loss of Subcooling Margin Procedure, 1210-2, because subcooling margin would actually be increasing. Consequently, the operator may trip the RCPs and might fail to throttle HPI before the PORV is challenged. Therefore, in the confusion matrix, a rediagnosis is assumed required. It is very likely that the operators would subsequently realize that no LOCA had occurred, then throttle HPI. The complete impact of this misdiagnosis is therefore judged to be small. The initiator, "Inadvertent HPI," was not analyzed separately in this study.

4.2.2.25 Main Steam Line Break in the Reactor Building

The plant response to a main steam line break in the reactor building is similar to a break in the turbine building except that, in this case, reactor building pressure and sump level would increase. Because of these obvious differences, a negligible chance of confusing this event with another steam line break is assumed. However, these symptoms are similar to a small or medium LOCA plant response because subcooling margin and RCS pressure would also decrease. Therefore, the operators may mistake this event for a LOCA and enter the loss of subcooling margin procedure (i.e., 1201-2) instead of the excessive cooling procedure (1210-3). A high potential for confusion was assumed.

If the loss of subcooling margin procedure was incorrectly selected, Table 3-20 indicates that the chief difference in the operator's response would be to trip the RCPs instead of the main feedwater pumps. This confusion could therefore result in an aggravation of the conditions for pressurized thermal shock. This would only be of concern if the SLRDs system failed to isolate main feedwater. Therefore, some impact on the operator's response is expected, and a rediagnosis is required to avoid this impact. However, because of the reliability of the SLRDS, the impact should not contribute significantly to plant risk. The initiator, main steamline break in the reactor building, was not quantified in this study.

4.2.2.26 Failure of Reactor Trip (ATWS)

Events involving a failure of reactor trip should be easily identified by the operators because of the reactor trip alarm without concurrent rod bottom lights. In Table 3-17, the plant response is indicated, assuming a loss of main feedwater without automatic reactor trip. Most plant indications are similar to the loss of main feedwater with reactor trip. In either case the operators should select the Reactor/Turbine Trip Procedure, 1210-1. The first step in this procedure asks the operators to ensure that reactor trip has occurred. A low potential for confusing a loss of main feedwater with a loss of main feedwater without reactor trip is assumed. However, a negligible impact on the plant is assumed because they both direct the operators to the same procedure; i.e., 1210-1.

4.2.2.27 Summary of Errors of Misdiagnosis

The TMI Unit 1 operator-plant status confusion matrix is provided as Table 4-3. Only a few of the initiator event sequences were judged to have a significant potential to be confused with some other event. In this evaluation, the potential for confusion is based on the likelihood that the operating crew would select the wrong procedure for the event in progress. The degree of assessed potential for confusion ranged from high to negligible.

The second part of each entry in the confusion matrix qualitatively describes the potential impact of the postulated confusion should it occur. These impacts were interpreted from Table 3-20, which identifies the actions to be performed by the operating crew, as specified in each procedure. In very few cases are actions described that would be just the opposite of the correct action called for in a given sequence. For this reason and because one event is often confused for another although both follow the same procedure, there are very few entries in Table 4-3 in which the assessed impact was judged to be significant. Such entries are noted by "R," indicating that a rediagnosis is required to avoid the expected impact. In no case was the operator assumed to take an erroneous action that was not explicitly written in one of the procedures evaluated.

Four of the entries in the confusion matrix were judged to have a significant potential for confusion with another event and have an adverse impact on the plant if the operators follow the steps in the incorrect procedure. A tube rupture mistaken for a small LOCA was one. Given the very large amount of time available before the adverse impact would be realized and that the adverse impact results from a failure to take action (i.e., a nonresponse) or not cooling down in a timely fashion, the nonresponse frequency estimation procedures discussed in Section 2.3.2 were used to quantify this error. The methods described in Section 2.3.3 were not used.

The other three confusion matrix entries in which a significant potential for an adverse impact were judged possible involved the event sequences, inadvertent HPI initiation and main steam line break in the reactor building. Neither of these initiators were quantified in the current PRA model. If they had been quantified, the quantification estimates in Table 2-11 would have been used as best estimates. The uncertainties in these estimates would be assigned, using the methods in Section 2.3.6; i.e., range factors of either 5 or 10, assuming lognormal distributions.

4.2.3 NONVIABLE DYNAMIC HUMAN ERRORS

In the process of completing the dynamic human error questionnaires for each dynamic action listed in Table 1-1, the analyst was requested to note on the form if it was judged that there was a potential for a related nonviable action. These judgments are summarized in parts I and J of the questionnaire. The nonviable actions may be postulated to occur as a result of a misdiagnosis, a conscious decision to pursue the wrong action after a successful diagnosis, or an operator slip in selecting the wrong control after correctly diagnosing the accident scenario.

It is recognized that this process cannot be viewed as a complete coverage of nonviable actions (see Section 2.3.4). However, this approach does allow particular events of this type, if identified, to be factored into the study. The study team that tried to identify these actions included two persons from GPUN with substantial experience in operations at the TMI station and in training sessions at the simulator.

Table 4-4 lists the potential slips or nonviable actions identified while filling out the questionnaire. The human action identifiers listed in the table refer to the particular questionnaire in which these actions were first postulated. The postulated errors are described in the second column of the table. The third column provides the reasons for the disposition of each postulated slip or nonviable action.

Of the 11 actions identified, reasons are given for not explicitly quantifying 9 of them. One action was identified when assessing action HINJ2. HINJ2 represents the action to locally cross-connect makeup pump C for RCP seal injection in case makeup pumps A and B have failed. It was noted that the operators would possibly be more likely, in this scenario, to restore RCP seal injection too quickly, thereby shocking them with cold water and causing them to fail. The error frequency assigned to this nonviable action is HNV1 (see Section 2.3.4). This is the error rate for a general error of commission. Its impact is assumed to be the same as a failure of action HINJ2; i.e., failure of the RCP seals, leading to an eventual small LOCA. The eleventh action was identified in the evaluation of HBW1. HBW1 represents the action to initiate HPI cooling in the event of a loss of primary to secondary heat transfer. During the TMI-2 accident, it was mistakenly assumed that pressurizer level was restored after primary to secondary heat transfer was recovered. As a consequence, the HPI pumps were turned off prematurely. Since the accident, additional guidance has been provided in the procedures in the form of new HPI throttling criteria, and a subcooling margin monitor has been installed. The shift technical advisor has been assigned the responsibility to monitor the conditions required to satisfy the throttling criteria (i.e., 25°F subcooling margin, thermal shock curve limitations, and pump flow, in addition to pressurizer level). Because of these changes, the possibility of a repeat of this error is believed to be very small. It may also be argued that the frequency of this error is already accounted for in the frequency of human error HBW1; i.e., failure to initiate HPI cooling. For historical reasons, however, this event is treated separately from HBW1. The error frequency assigned to this nonviable action is also HNV1. Its impact is assumed to be the same as a failure of HBW1; i.e., failure of HPI cooling.

Other accident sequences in which the operators might inadvertently throttle HPI when makeup is required were considered. One particular scenario is of interest. This scenario begins with a plant trip and sufficient excessive cooling on the secondary side to cause an ESAS signal in low RCS pressure. If the operator fails initially to throttle in time, the pressurizer PORV would be challenged. Once the PORV lifts, the operators would likely then throttle HPI to allow the PORV to close. If the PORV then fails to reclose, however, we would be in a situation in which HPI has been throttled but a LOCA still exists. The operators throttle HPI under these circumstances by resetting ESAS (Procedures 1210-2 and 1105-3). ESAS would then reactuate if RCS pressure decreased a second time to the 1,600-psig setpoint as a result of the LOCA. Therefore, even if the operators failed to recognize that this PORV did not reclose after throttling, ESAS would actuate automatically, as pressure continued to decrease. Therefore, the failure of the operators to manually reinitiate HPI, when required for this scenario, was not modeled.

4.3 OPERATORS RESTORE ELECTRIC POWER FOLLOWING A LOSS OF ALL AC POWER

This section describes the analysis of electric power system hardware and the operators' actions to restore AC power to at least one Class 1E bus following a loss of all offsite power initiating event. Recognition of the power failure condition would be almost immediate. The nature of the AC power loss condition and the numerous indications available in the control room (dark panels, loss of lighting, failure of all AC equipment, etc.) make its identification relatively simple. There is, therefore, a negligible chance that control room personnel can misinterpret a loss of all AC power as being another condition and take inappropriate actions for the situation. The event, however, will cause some degree of stress and confusion among the operators because it is perceived as a severe transient. The principal concerns will be to:

- Restore AC power.
- Maintain and control emergency feedwater flow from the turbine-driven emergency feedwater pump.
- Monitor core subcooling and reactor coolant inventory.
- Monitor DC power availability and take actions to extend battery life.

This section analyzes the frequency of electric power failure and recovery under three conditions, depending on systems available for recovery (e.g., one of two diesels, only one diesel, offsite power) and the availability of emergency feedwater; i.e., heat removal via the OTSGs.

The three conditions are contained in five human recovery action failure rates, HRE1, HRE3, HRE5, HRE7, and HRE8. The failure rates are defined below.

- <u>HRE1</u>. This human recovery action models the failure to recover at least one engineered safeguards bus and its associated DC bus after a loss of all AC power, both offsite and onsite. Emergency feedwater is available throughout the loss of AC power, and the maximum mean time for recovery of AC power is 6 hours due to battery depletion.
- <u>HRE3</u>. This human recovery action models the failure to recover at least one engineered safeguards bus and its associated DC bus after a loss of all AC power, both offsite and onsite. Emergency feedwater failure has also occurred, and the maximum mean time for recovery of AC power is 1 hour due to leakage of fluid from the reactor.
- <u>HRE5</u>. This human recovery action models the failure to recover offsite power within 6 hours to allow starting the reactor coolant pumps. A primary to secondary tube rupture has occurred, and onsite power (i.e., diesel generators) is available throughout the recovery.
- <u>HRE7</u>. This human recovery action action models the failure to recover a second safeguards bus and its associated DC bus after a loss of offsite power and a failure of a support component on the energized safeguards bus. In this case, one diesel generator starts

and is assumed to run satisfactorily during the study period, while the other diesel generator fails to start and must be recovered. Emergency feedwater is assumed to be available throughout the loss of AC power, and the maximum mean time for recovery of AC power is 6 hours due to battery depletion.

- HRE8. This human recovery action models the failure to recover a second safeguards bus and its associated DC bus. It is like HRE7 except that emergency feedwater failure has also occurred. The maximum mean time to recovery is 1 hour due to leakage of fluid from the reactor.

Factors that influence the time available to restore AC power include the availability of 125V DC power (i.e., battery lifetime) and the time to core damage due to pump seal leakage or PORV discharge following a loss of all onsite AC power. Coolant inventory loss out the PORV would occur during a loss of all AC power after the time of OTSG dryout and along sequences in which the turbine-driven emergency feedwater pump is postulated to fail. The result of this analysis is the conditional frequency (i.e., given a loss of offsite power initiating event) of loss of onsite power and failure to restore onsite or offsite power to at least one Class 1E AC bus before core damage occurs. The analysis is performed for a 24-hour period following the loss of offsite power. The analysis is applicable to several different initiating events other than "loss of offsite power" that also entail a loss of offsite power condition; e.g., destruction of a 230-kV substation, transient with subsequent loss of offsite power, and fires and floods that cause a loss of offsite power. This analysis is not applicable to seismic-induced loss of offsite power.

The Three Mile Island Unit 1 offsite electrical power recovery (Station Blackout with Loss of Both Diesel Generators) instructions include detailed load-shedding procedures in order to extend battery life. Procedures exist for the operator to manually operate offsite breakers (e.g., 230-kV and 4.16-kV switchgear breakers) in order to restore power if DC power is not available. Sufficient instrumentation not dependent on AC or DC power (e.g., thermocouples, mechanical pressure gauges) exists so that control room operators can monitor plant parameters should AC and DC power become unavailable. The procedure for loss of all AC power used as a basis for this analysis is the Three Mile Island Nuclear Station Unit Number 1 Emergency Procedure 1202-2A (Revision 12), Station Blackout with Loss of Both Diesel Generators.

4.3.1 MODEL FOR ELECTRIC POWER FAILURE AND RECOVERY

The electric power system analysis presented in Section 2 of the Systems Analysis Report evaluates the unavailability of power at the Class 1E buses. These are AC buses 1D and 1E, one for each train of safeguards equipment, and DC buses 1A/1E and 1B/1F, which supply the two primary DC power trains and instrument inverter 1A. These buses are presented in Figures 4-2 through 4-4. System success in Section 2 (Systems Analysis Report) is defined as a minimum of one of two engineered safeguards buses and its associated DC bus being available. The system is analyzed in Section 2 (Systems Analysis Report) under two sets of boundary conditions: power available for 24 hours following an initiating event (1) with offsite power available and (2) with no offsite power available.

In general, specification of the recovery event scenarios provides two important pieces of information necessary for the evaluation of human actions and equipment response. The initiating event and subsequent system failures define the status of the plant when the operators are required to act. Control room alarms, emergency procedural guidance, and the status of critical plant parameters provide basic input to focus the initial actions. For each scenario, there is also a fairly well-defined time window for successful system recovery. Core damage will be prevented if the identified recovery actions are completed within this time window. The amount of time available depends on the type of initiating event and the nature and timing of subsequent component failures.

A realistic model for the recovery of electric power during a specific event scenario must account for the causes and timing of the power failure events, the sequencing of failure and recovery actions, and the available time window for success before the onset of core damage. Equipment failures and recovery can occur at any time during the nominal 24-hour study period after event initiation. These factors were built into a SIMSCRIPT-II.5 simulation model. A copy of the SIMSCRIPT program for recovery of electric power at TMI-1 (EPR model) is contained in Appendix C to this report.

The EPR model tracks the failure and recovery of specific essential power sources through time and provides a distribution of the time to recover power from any source; e.g., offsite power, one or both diesel generators. This power recovery time distribution is then compared with the time distribution for onset of core damage. The result is a probability of successful recovery of electric power before the onset of core damage.

A general description of the simulation model and the computer program sections are contained in Section 2.4. The PROCESS/EVENT routines used in the electric power recovery analysis are described below.

- <u>PROCESS INITIALIZE</u>. Initializes the other processes contained in the simulation.

- <u>PROCESS OFFSITE POWER</u>. Initially unavailable, this process sets the recovery time for offsite power to be used in the simulation.

- <u>PROCESS FIRST DIESEL</u>. This process determines both the time to failure and time to recovery after failure of diesel generator A.

- <u>PROCESS SECOND DIESEL</u>. This process determines both the time to failure and time to recovery after a failure of diesel generator B.

- <u>PROCESS FIRST DC BUS</u>. This process models the restrictive effect of losing train A of DC power.

* PROCESS SECOND DC BUS. This process models the restrictive effect of losing train B of DC power.

* EVENT REPAIR DECISION. This event provides a method to change the repair effort from one diesel to the other when both have failed.

The following assumptions are made concerning the EPR model.

* When both diesel generators have failed, the batteries will supply vital loads for 2 hours unless DC load shedding occurs. A discussion of the extended battery lifetime due to load shedding is contained in Section 4.3.4.2. If AC power is not recovered within the appropriate time window, the batteries will fail and will not be recoverable.

* If the batteries fail, the diesel generators are no longer recoverable and offsite power must be restored through manual means. However, plant operators indicate that DC power is necessary to operate the 230-kV substation breakers locally. Therefore, when this occurs, core melt is guaranteed.

* When both diesel generators are failed, repair will be performed on the first diesel for a period of time determined by EVENT REPAIR DECISION. Repair effort is then switched to the second diesel, and the first diesel repair continues in parallel.

* Two failure rates are used for diesel generators: one rate for failures within the first hour of operation and a second rate for failures that occur at a time longer than 1 hour of operation.

4.3.2 TIME-DEPENDENT POWER FAILURE ANALYSIS

The evaluation of a detailed power recovery model requires careful treatment of the sequencing of power failures and recovery actions after the initiating event has occurred. Failures may occur at different times during the analysis period. For example, offsite power failure could be the cause of a plant transient initiating event, and the onsite diesel generators could fail during operation at some later time. It is possible for some recovery actions to proceed in parallel, while the time sequencing of other recovery actions must be carefully modeled. The actions required to restore power from the offsite grid and the repairs of a failed diesel generator can be performed at the same time if there are enough personnel available to support both tasks. However, the analyst must be careful to account for the fact that diesel generator repairs and offsite power recovery actions may be started at significantly different times during the event scenario. In general, offsite grid recovery efforts will begin soon after the initial power failure. Diesel generator repairs will begin only after the diesel generators have failed, which may not occur for several hours after the initiating event. Careful treatment of these time dependencies ensures that the model does not incorrectly include the effects of recovery actions quantified before a failure has occurred, such as assigning a frequency for diesel generator recovery within 1 hour after the initiating event when, for example, the diesel generator has not failed until 2 hours after the event. This treatment also eliminates the quantitative contribution from failures of one power supply that occur after power has been recovered from another source, such as diesel generator failures that occur after offsite power has been restored. Once normal power has been restored, the diesel generators may be shut down. The quantitative effects from an analysis of diesel generator operation for times after offsite power recovery should not contribute to the power unavailability model results. The EPR model accounts for the time sequencing of failures and recovery actions. It allows the evaluation of parallel and time-sequenced recovery models.

The EPR model results provide a distribution of power recovery times from any source. This distribution, Figure 4-5, when compared with the time to the onset of core damage, provides a probability of successful restoration of power.

4.3.3 POWER RECOVERY OPTIONS

4.3.3.1 Offsite Power Recovery

The Three Mile Island substation is connected with the Metropolitan Edison Company 230-kV transmission network by four circuits: two full capacity circuits to Middletown Junction, one-half capacity circuit to Jackson, and one full capacity circuit through a 230/500-kV autotransformer to the Metropolitan Edison 500-kV grid. Following a loss of power at these three substations, restoration of offsite power is defined as reenergizing one or more of the four transmission lines (Middletown Junction line 1091 or 1092, Jackson line 1051, or 230/500-kV line) and supplying electrical power to TMI-1 through the 230-kV substation.

The first step in developing a model for offsite power recovery at TMI-1 plant site is to specify a simplified functional model, which bounds the actual dynamic system response for a variety of scenarios. In this study, loss of offsite power is defined as a loss of all four transmission lines connected to TMI or the 230-kV substation up to and including the auxiliary transformers (1A and 1B). Functionally, this power failure must be severe enough to cause the unit to trip offline and to require emergency power to the Class 1E buses from the onsite diesel generators. Although this represents a severe disturbance of the Metropolitan Edison transmission grid, similar failures have occurred at other operating nuclear power plants. Localized transient grid disturbances have also occurred after generating units have tripped offline, and these events are included in the development of the loss of offsite power frequency quantification. Recovery of offsite power must be modeled within the context of these general failure scenarios. The experiential data indicate a high degree of coupling among diverse lines and different transmission voltages for severe failure events. The data also show that most events involve combinations of hardware failures, spurious operation of protective devices, preexisting maintenance outages, and human actions, which are extremely difficult to model.

Transient stability and power flow have been performed to determine the effect of TMI-1 and its associated facilities on the reliability of the interconnected transmission grid. Detailed information on the reliability of the 230-kV grid is provided in the TMI-1 FSAR (Reference 4-3).

The offsite power failure events modeled in this study are more severe than the grid disturbances used for power system planning and design evaluations. Severe and widespread power outages can be caused by a combination of diverse factors, including inclement weather, component hardware failures, abnormal system loading conditions, and human interaction. These failure scenarios are extremely difficult to model analytically and fall outside the scope of system design criteria. Therefore, while extremely useful for evaluating the relative grid stability effects of various system hardware configurations, the system design load flow models do not provide good predictive results for the frequency of major disruptions.

Because of these modeling limitations, the analysis of offsite power failures for this study relies heavily on experience data obtained from all the operating nuclear power plant sites in the United States. It is recognized that the TMI power supply grid has some unique characteristics. In fact, each site in the United States presents its own unique set of design problems and advantages. The methodology used to evaluate the generic data accounts for the site-to-site variability introduced by these differences. Transmission system design criteria and operating guidelines have become reasonably standardized throughout the United States over the last decade. However, the historical experience of TMI and the Pennsylvania, New Jersey, Maryland (PJM) grid have been included in this analysis. A detailed analysis of TMI site-specific loss of power is available in References 4-4 and 4-5. These studies were used because both TMI-1 and TMI-2 use the same 230-kV substation as a supply of offsite power.

A detailed recovery analysis based on models for each of the 230-kV and 500-kV transmission lines and each of the interconnected substations and generating facilities is too complex for the purpose of this study. As with the power failure frequency models discussed previously, a complex model based on hardware configurations alone may not afford adequate treatment of such common factors as parallel and time-sequenced recovery efforts, limitations imposed because of the power outage, communications problems, and personnel availability.

For this analysis, successful offsite power recovery requires at least one of the 230-kV lines or the 500-kV line be reenergized to the substation. The coupling between the lines could be quite significant during recovery efforts after a major disruption. For example, the most important factors determining the time to restore power could be the mobilization of repair crews and the phased recovery of generating capacity. These actions would broadly affect the recovery times for several lines in the area. The experience data from power system outages at other sites strongly support a model with elements of independence and coupling among diverse transmission lines. Typical recovery scenarios show a delay time during which all power remains off while repair crews are mobilized and load switching is initiated. When power is restored, two or more lines typically are reenergized in quick succession. As generation capacity and loads are restored to service, more lines are reclosed. Finally, lines experiencing severe structural damage are returned to service over extended periods after crews complete the necessary repairs. For this recovery model, the time of interest is the first increment until power is restored from any source.

Based on a review of the TMI offsite line configurations, it was found that the system hardware response can be bounded by two equivalent transmission line models. The lower bound for the power recovery frequency is provided by a model that considers the local grid at TMI as a single transmission line. This model essentially assigns complete dependence among all the 230-kV lines and the 500-kV line. It accounts for failure scenarios caused by extensive structural damage to the TMI substation or by widespread storm damage. The upper bound for the recovery frequency is evaluated by a model for two independent lines. This model acknowledges the fact that the offsite power enters the 230-kV substation through two separate corridors, one from Middletown Junction to the north and the other from the south containing the Jackson line and the 500-kV grid line. Although there are four transmission lines supplying the substation, the effects of these redundant supplies is limited by the commonality of the two entry corridors. It is believed that the equivalent model of two totally independent transmission lines provides a realistic upper bound recovery model for this configuration. To account for the facts that power recovery could be more difficult after a major local grid disturbance or that the diversity in lines could make power recovery easier than exhibited by this simplified model, the one-line and two-line bounds are assessed as the 5th and 95th percentiles for the recovery response model.

Metropolitan Edison has several years of operating experience from their 230-kV and 500-kV transmission networks. There have been no instances of total 230-kV/500-kV transmission grid unavailability since December 1983 (References 4-4 and 4-5). Records of forced outages of the PJM 230-kV and 500-kV lines were reviewed. Single-line outages of less than 5 minutes duration were removed from the data base, and the remaining events were ranked by duration. A majority of the events of less than a 5-minute duration represent momentary outages that are cleared within a few seconds by automatic relay operation and circuit breaker reclosure. Although about 78% of the line outages in the PJM data base are of this momentary type, experience has shown that extensive outages affecting all offsite power to a plant usually involve firm faults, which prevent immediate line reclosure and are not usually cleared by the operation of automatic protective devices. Therefore, momentary single-line outages were excluded from this data base because their restoration times were not characteristic of observed data from actual offsite power failures. The remaining events represent a conservative summary of line recovery times after forced outages. Table 4-5 summarizes the line outage data and provides a comparison of the recovery time distributions with and without the momentary outages.

The line outage duration data generally include times for repair crews to reach the location of the fault, time to repair the fault, and switching time to restore the line to service. Short duration events represent faults that were cleared by automatic or remote manual operation of fault protection circuit breakers or faults occurring when repair crews were in the immediate vicinity of the equipment. Extended outages are characterized by more extensive damage to conductors in remote locations.

The forced outage duration distribution, excluding momentary outages, from Table 4-5 is used in this analysis to characterize the minimum time to restore power from a single transmission line model, limited by hardware repairs and not including event specific personnel response times. This provides a conservative estimate for the time to recover power for the following reasons:

- Momentary line outages of less than a 5-minute duration have been excluded from the data base. Some offsite power failures at TMI could allow rapid line reclosure, depending on the cause and extent of the initiating event.

- The line outage duration data include repair crew response times for extended duration events.

- Although the duration data are from forced outages only, which have a high priority for restoration, a single line forced out of service in an area where a second parallel circuit remains available will not receive the same priority as will the restoration of power to TMI after all offsite power has been lost. Therefore, some of the extended duration events may not represent the same repair urgency as would be evident during a loss of offsite power event for this study.

Figure 4-6 summarizes the hardware limited recovery time distribution used for this analysis. The lower bound is the 5th percentile of the model uncertainty distribution. It is a cumulative plot of the single-line forced outage duration data from Table 4-5, excluding momentary outages. The upper bound is the 95th percentile of the model uncertainty distribution. It is obtained by assuming that successful power recovery will occur if either one of two independent transmission lines is reenergized, with each line characterized by the data from Table 4-5, excluding momentary outages.

4.3.3.2 Diesel Generator Power Recovery

4.3.3.2.1 Diesel Generator Hardware Recovery Model

The two standby diesel generators and their support systems are described in the TMI-1 FSAR, Reference 4-3. Each diesel generator has an independent air-starting system and requires a supply of 125V DC from its respective DC bus (i.e., bus 1A/1E for train A and bus 1B/1F for train B diesel generators) for generator field flashing and generator start and control. The effect of the unavailability of DC power on diesel generator recovery is accounted for in the PROCESS FIRST DC BUS and PROCESS SECOND DC BUS section of the EPR model.

The time to return a diesel generator to operation after a hardware failure depends on many factors, such as the cause of failure, repair personnel availability, alternate power supply status, reactor operating conditions, etc.

A diesel generator may fail to supply power to its associated bus for any one of several reasons. In this study, two specific types of causes have been identified that contribute most significantly to these failures: (1) the diesel generator may experience some type of hardware-related failure, either during its starting sequence or during subsequent operation; and (2) the diesel generator may have been out of service for maintenance when the initiating event occurred.

The causes of diesel generator hardware failures can range from the spurious operation of a trip solenoid to major physical damage of mechanical or electrical components. Recovery from these failures may involve the simple resetting of a local trip interlock and restarting of the diesel generator, or may require disassembly and repair of the engine, generator, or their control systems. The following table indicates some of the key actions that can be accomplished within given recovery time periods:

Time Following Operator Response	Action
0 to 5 Minutes	Reset Trip Relay and Attempt Local Manual Restart of Diesel Generators
5 to 15 Minutes	Troubleshoot Simple Problems; Check Electrical and Mechanical Indications
15 to 30 Minutes	Perform Step-by-Step Problem Diagnosis; Notify Cognizant Engineering and Maintenance Personnel
30 to 60 Minutes	Operators Refer to Technical Manuals and Drawings for Diagnosis of More Complex Failures; Response Time for First Offsite Personnel
1 to 2 Hours	Offsite Personnel Troubleshoot Problems Not Requiring Component Repair; Make Complex Adjustments to Control Systems
2 to 4 Hours	Replacement of Simple Failed Components (includes maintenance crew response time)
4 to 8 Hours	Repair of Failed Components Requiring Minor Disassembly

Time Following Operator Response	Action
8 to 24 Hours	More Complex Repairs
24 to 72 Hours	Repairs Requiring Disassembly
3 to 7 Days	Diesel Engine Overhaul

It is emphasized that these key actions apply to the recovery for a given failed diesel generator following operator response to that unit and only to the recovery from hardware-related failures. It is not the time required to recover any one of the failed units. These key actions are used as one piece of information in developing a distribution for the time to recover a failed diesel generator.

The recovery time distribution summarized below applies to situations involving moderate to high urgency for diesel generator repairs. It is broadly based on generic recovery data (References 4-6 and 4-7) from operating plants, the experience of operations and maintenance experts, and specific features at TMI. The TMI-1 Shift Manning Log recommends a staff of one maintenance foreman and two maintenance personnel (either electrical or mechanical) on all shifts. During the day shift of the normal work week, Monday through Friday, additional personnel are available. Designated technicians are available on call during weekends.

TIME TO RECOVER A FAILED DIESEL GENERATOR

Time Following Operator Response (hours)	Relative Frequency
0 to 1	.25
1 to 4	.26
4 to 8	.25
8 to 24	.11
> 24	.12

This distribution is used to model the time to restore a single diesel generator to operation after the diesel has experienced a hardware failure. It assumes that the repair efforts are continuous from the initial troubleshooting until the diesel generator is returned to service. Recovery cannot begin until someone responds to the diesel generator room to investigate the failure, and this distribution does not include scenario-specific delays for operating or maintenance personnel reaching the room. The personnel response times are evaluated in Section 4.3.3.2.2 and are contained in the PROCESS FIRST DIESEL and PROCESS SECOND DIESEL portion of the EPR model.

4.3.3.2.2 Diesel Generator Recovery Personnel Response Time Model

A TMI-1 auxiliary operator is responsible for operating the diesel generators and for initial problem troubleshooting. A minimum of four auxiliary operators will be available. During the normal work day, additional personnel are also available. An auxiliary operator's normal responsibilities include monitoring plant equipment (e.g., service water pumps), changing valve positions and system configurations under the direction of the control room operator, and performing walk-through inspections of plant [illegible] shift working conditions, the operators will usually [illegible] various locations (e.g., the turbine building and [illegible] handling building) or will be at designated watch areas. [illegible] but less likely, location is the main control room.

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When offsite power is lost, both diesels will receive signals to start. An auxiliary operator will normally proceed to the diesel generator building soon after they start. The recovery analysis does not include credit for an immediate response because the operator's precise location at the time of diesel generator failure is uncertain since a diesel may fail during operation at any time before offsite power is restored.

It is expected that the first indications of diesel generator failure will be noticed by the control room operators who may attempt to manually restart the affected engine from its control room switch. However, experience has shown that many failures require local troubleshooting to correct the problem and to reset engine trip relays. The control room operators may also be reluctant to quickly restart a diesel generator that tripped during operation before they determine a cause for the failure. This analysis assumes that an auxiliary operator must investigate all failures locally before any engine restarts are attempted. The control room operators or the control room shift supervisor will contact an auxiliary operator by telephone or page soon after the diesel generator fails. After he has been notified of the failure, the auxiliary operator will proceed to the diesel generator building to investigate the cause, reset engine trip relays, and begin local recovery efforts including manual restart attempts. It is estimated that the operator's response time to the diesel generator building from any of his normal duty locations is approximately 5 to 10 minutes after notification. It is assumed that the auxiliary operators will carry keys to manually unlock controlled access doors if required. The following distribution is used to model the response time for an auxiliary operator. It applies to the elapsed time from failure of the diesel generator until the operator begins local troubleshooting activities in the diesel generator room. This time includes delays for the control room to contact the operator and describe the problem, the operator transit time to the diesel generator building, and possible additional delays due to communications problems, locked doors, or other considerations that could impede the operator's response.

TIME FOR FIRST OPERATOR RESPONSE TO
FAILED DIESEL GENERATOR

(Includes Notification Time and Transit Time)

Response Time (minutes)	Relative Frequency
0 to 5	.01
5 to 10	.25
10 to 15	.50
15 to 20	.20
20 to 30	.03
30 to 60	.01

It is also expected that the in-plant shift supervisor and the onsite maintenance technicians will respond to diesel generator failures that are not quickly corrected by the auxiliary operator. Depending on the status of equipment in other parts of the plant, additional qualified auxiliary operators may also be available to help with the recovery efforts. The participation of this normal complement of shift personnel has been considered in this recovery time distribution.

If both diesel generators for a unit fail, the operating and maintenance personnel would concentrate their initial recovery efforts on one of the diesels. A preliminary evaluation would be made to determine whether one of the diesels was likely to be repaired more quickly than the other, and that diesel would receive the most concentrated attention. For example, efforts would be made to restart a diesel generator that tripped spuriously before repairs were started on a diesel engine that sustained extensive mechanical damage. This recovery model assumes that the initial response team will concentrate their efforts almost exclusively on one diesel generator for approximately 30 minutes after the auxiliary operator reaches the building. If the first diesel is not restored to operation after 30 minutes, it is expected that the response team will begin parallel efforts to recover the other failed unit. For example, the maintenance technicians could remain with the first diesel to begin component repairs or replacement while the operators turned their attention to troubleshooting and restart attempts on the second unit. As more support personnel respond to the site, repairs of both diesel generators can proceed in parallel and the recovery models can be substantially decoupled.

For this analysis, if both diesel generators have failed, recovery of only one is allowed during the first 30 minutes after initial operator response. Power can be restored from the diesel generators to only one of the two Class 1E buses in this interval. For times longer than 30 minutes, the model allows recovery efforts to be started on the second diesel generator, and work is assumed to proceed on both diesels in parallel until power is restored. Thus, the minimum amount of time required to begin power recovery to both Class 1E buses by repairs of failed diesel generators is more than 30 minutes after the diesel generators fail.

4.3.3.2.3 Overall Diesel Generator Power Recovery Model

In the EPR model, overall diesel generator recovery is modeled by first simulating the response of personnel by selecting a delay from the distribution presented in Section 4.3.3.2.2. During this delay, no recovery or repair of the diesel can occur. A second delay is then simulated, which represents the repair time selected from the distribution presented in Section 4.3.3.2.1. These simulated delays describe the time from loss of a diesel to recovery of operation of that diesel.

Several simulation runs of the EPR model were made. In these simulation runs, each diesel generator was represented by the following initial conditions:

- A diesel generator is not available at time = 0 and cannot be recovered during the 24-hour study period (condition 1).

- A diesel generator is lost initially at time = 0 (i.e., fails to start), but can be recovered during the 24-hour study period (condition 2).

- A diesel generator starts and runs for some time, fails, and can be recovered (condition 3).

Recovery distributions were generated for each of the six combinations above; e.g., A1B1, A1B2, A1B3, A2B2, A2B3, and A3B3. In addition, a seventh distribution, for common cause failure, was generated. Each of these distributions was generally categorized into one of three recovery models: (1) offsite power (A1B1) detailed in Section 4.3.3.2.3.3, (2) single diesel generator (A1B2 and A1B3) detailed in Section 4.3.3.2.3.1, and (3) dual diesel generator (A2B2, A2B3, A3B3, and common cause) detailed in Section 4.3.3.2.3.2.

4.3.3.2.3.1 Single Diesel Generator Recovery Model. Immediately following the loss of offsite power, buses 1D and 1E will remain deenergized if both diesel generators fail to start due to either being out of service for maintenance or experiencing failure during the starting sequence. A single diesel generator will supply 100% of the equipment required to ensure plant safety. Thus, recovery of only one diesel generator is required. The model for a single diesel generator consists of the summation of the distributions for all simulations where one diesel is in condition 1, and the other diesel is in condition 2 or 3. This condition is modeled in distributions A1B2 and A1B3. The combined distribution for a single diesel generator model is shown in Figure 4-7.

4.3.3.2.3.2 Dual Diesel Generator Recovery Model. The model for dual diesel generator recovery is described by the summation of all distributions where both diesels are in either condition 2 or 3; i.e., A2B2, A2B3, A3B3, and the common cause case. These distributions include scenarios where one or both diesels fail to start on demand or where both diesels fail during operation either independently or as the result of a common cause failure. The distribution that results from the summation of these scenarios is presented in Figure 4-8.

The EPR model of dual diesel generator recovery allows the recovery of the first of two diesel generators to begin when an auxiliary operator/shift foreman arrives at the diesel generator room. Recovery of the second diesel begins 30 minutes after the auxiliary operator/shift foreman arrives, and the repairs of both diesels are modeled as continuing in parallel thereafter.

4.3.3.2.3.3 Offsite (no diesel generator) Recovery Model. The model for recovery without diesel generators is described by the distribution in which both diesel generators are in condition 1; i.e., A1B1. This situation could occur if one diesel is out of service for maintenance (technical specifications allow a diesel to be out of service for maintenance for up to 7 days during plant operation) and the remaining diesel has a catastrophic failure (e.g., a fire or explosion) that results in a loss of the diesel for longer than the 24-hour study period. The distribution that results from this situation is presented in Figure 4-9.

4.3.4 ELECTRIC POWER RECOVERY SCENARIOS

The electric power recovery analysis is performed for Top Event RE1 in the TMI event trees under the three conditions discussed in Section 4.3.

Recall from Section 4.3.1 that a variable time window is used for each recovery option. The available time for recovery is a function of both support system availability and core thermal hydraulics. Each diesel generator requires a supply of 125V DC in order to start and operate. If, for example, battery life lasted only 2 hours after the loss of all onsite (diesel) power, the auxiliary operators would have a time window of only 2 hours to recover the diesels if the thermal hydraulic window, for this case, is longer than or equal to 2 hours. The thermal hydraulic time window is a function of the availability of emergency feedwater and the leak rate from the reactor coolant pump seals, which start to leak when all onsite power is lost. If in this case, for example, emergency feedwater (the emergency turbine-driven feedwater pump) is available when and after onsite power is lost, the time window for onsite power recovery is dependent on the leak rate from the reactor coolant pump seals; i.e., the time to core uncovery from this leak.

4.3.4.1 Time Window Based on Plant Thermal Hydraulics

Within the framework of the complete loss of AC power, the status of the turbine-driven emergency feedwater pump and the status of the reactor coolant pump seals are very important for determining the available time window before the onset of core damage. The time window is the time available for the operators to take action (e.g., restore electric power and restart the motor-driven emergency feedwater pump or the makeup pumps) before core damage occurs. This time available for action generally increases after the initial reactor trip (at t = 0) because the reactor decay heat generation rate decreases with time.

The emergency feedwater system is described in Section 11 of the Systems Analysis Report. Emergency feedwater is assumed to be available as long as onsite AC power is available. When onsite power is lost (i.e., the diesels fail), emergency feedwater is available only if the turbine-driven feed pump did not fail or was recovered within 1 hour after the loss of onsite power. The scenarios of electric power recovery include both states (i.e., available or unavailable) of emergency feedwater. In the scenarios in which emergency feedwater is available, the turbine-driven pump and its support systems are assumed to be available for 24 hours after the loss of all AC power.

The analysis assumes that a primary system leak from the reactor coolant pump seals will occur sometime after the systems supplying cooling water to these seals have stopped due to the loss of all AC power. The leakage rate from the seals varies, but is assumed to be 80 gpm (decreasing with pressure) for the first 10 hours due to the specially designed seals in use. After 10 hours, the leakage rate rises rapidly to a maximum of 300 gpm per pump.

The variable time window based on thermal hydraulics is presented in Table 4-6. The time window is about 1 hour if emergency feedwater is not available or is lost during the first 24 hours. A time window of 9 hours is used in scenarios in which emergency feedwater is available throughout the loss of all AC power. This 9-hour time was selected because the core will be uncovered due to the PORV lifting in 9.1 hours.

4.3.4.2 Time Window Based on Availability of DC Power

During the time window established by thermal hydraulic considerations, the operators will be restoring power to one engineered safeguards bus by recovering either a diesel generator or power from the offsite grid. The availability of DC power has a direct influence on this recovery. DC power must be available to start the diesel generator. In addition, DC power must be available to operate onsite switchgear breakers from the control room. IF DC power is not available, these breakers may be operated manually. The breakers in the 230-kV substation also require DC power be available; however, these breakers cannot be manually operated by onsite personnel.

The availability of DC power is dependent on the discharge rate, battery temperature, specific gravity, and the minimum useful or final battery voltage. The analysis of the battery availability is highly dependent on the scenario under consideration. Under a scenario with no operator action to shed DC loads and with 100% load on each DC bus, for example, the batteries will last for 2 hours. This is the licensing design basis discharge used to size the batteries (Reference 4-3).

By reducing the load on the DC buses, the battery availability can be extended. On the other hand, adequate instrumentation (e.g., reactor system pressure, pressurizer level, steam generator level, core neutron power level, etc.) must be available to the control room operators. Control room supervisory personnel must decide what load level should be established. They would be in constant communication with the auxiliary operators and maintenance personnel repairing the emergency diesel generators as well as the transmission system dispatchers at the electric system control center. Discussions with these personnel indicate that a DC load level could be established that would extend battery availability to between 6 and 8 hours. For this reason, a lengthened battery availability of 6 hours was used in this study.

4.3.5 ELECTRIC POWER RECOVERY MODEL ASSEMBLY

The simulation model output is a distribution of AC power recovery for each set of initial conditions discussed in Section 4.3.3.2.3. These distributions are conditional on the frequency of the initial conditions. Therefore, the seven distributions were combined by removing the conditional status of each distribution and summing them. The result was an unconditional distribution of AC power recovery. This distribution is shown in Figure 4-5.

The distributions for recovery of AC power is then examined with respect to the time windows of Sections 4.3.4.1 and 4.3.4.2. The result is a conditional frequency of core melt, given a loss of offsite power. This is done by determining the relative frequency of AC power not being recovered within the time window of interest and is calculated from the following equation.

$$\Phi_{\text{core melt}} = 1 - \sum_i C_i F_i(t)$$

where

C_i ≡ the correction factor applied, based on the conditions placed the simulation model.

$F_i(t)$ ≡ the frequency of recovery of AC power for the individual initial diesel generator condition.

t ≡ the limit of the time window, battery lifetime, or thermal hydraulic.

The five human recovery action failure rates can now be calculated. Four of the failure rates, HRE1, HRE3, HRE7, and HRE8, are calculated from the above equations. Human recovery action failure rate HRE5 is calculated from a portion of the information presented in the previous sections.

Human recovery action failure rate HRE1 is calculated by examining the AC power recovery distribution at a time window of 6 hours. The 6-hour time was developed in Section 4.3.4.2. By using the equation above, the distribution for HRE1 is:

Mean Value:	5.1×10^{-5}
5th Percentile:	1.68×10^{-6}
50th Percentile:	1.80×10^{-5}
95th Percentile:	1.87×10^{-4}

Human recovery action failure rate HRE3 is calculated by examining the AC power recovery distribution at a time window of 1 hour. The 1-hour time window was developed in Section 4.3.4.1. The calculation is done in the same manner as in HRE1 above. The distribution for HRE3 is:

Mean Value:	8.7×10^{-4}
5th Percentile:	2.61×10^{-5}
50th Percentile:	2.94×10^{-4}
95th Percentile:	3.18×10^{-3}

Human recovery action failure rate HRE5 is calculated by examining Figure 4-6. Since only offsite power must be recovered because onsite power is available from the diesel generators, the failure rate is a distribution of the failure to recover power before 6 hours from the event in Figure 4-6. The distribution for HRE5 is:

Mean Value:	4.04×10^{-2}
5th Percentile:	9.64×10^{-3}
50th Percentile:	3.11×10^{-2}
95th Percentile:	9.79×10^{-2}

Human recovery action failure rate HRE7, like HRE1, is calculated by examining the AC power recovery distribution at a time window of 6-hours. However, only the conditional distributions for recovery with a single diesel generator are used. The calculation is done in the same manner as for HRE1 above. The distribution for HRE7 is:

Mean:	5.02×10^{-2}
5th Percentile:	1.64×10^{-3}
50th Percentile:	1.76×10^{-2}
95th Percentile:	1.90×10^{-1}

Human recovery action failure rate HRE8, like HRE3, is calculated by examining the AC power recovery distribution at a time window of 1 hour. Like HRE7, HRE8 only considers cases of single diesel generator recovery. The calculation is done in the same manner as for HRE1 above. The distribution for HRE8 is:

Mean:	3.93×10^{-1}
5th Percentile:	9.36×10^{-2}
50th Percentile:	2.98×10^{-1}
95th Percentile:	9.51×10^{-1}

4.4 RECOVERY OF DHR COOLING

This section describes the recovery analysis of a DHR pump train under conditions in which there is a loss of coolant from the RCS and cooldown to cold shutdown conditions are required. The time available for recovery depends on the size of the leak. Recovery is considered, if at least 6 hours are available, until DHR cooling is required, which is measured from the time an ESAS signal occurs and the operators notice that both DHR pump trains are unavailable. This excludes medium and small LOCAs from consideration for recovery of the DHR pump trains. For small LOCAs, 6 hours are assumed to be available. For steam generator tube ruptures, very small breaks, RCP seal LOCAs, and stuck-open pressurizer PORV or relief valves, 12 hours are assumed to be available for recovery. For very small leaks (i.e., too small to initiate a plant trip by themselves) more than 24 hours are assumed to be available.

There are a number of ways in which both trains of DHR pumps may be unavailable. Each DHR pump train requires DC control power to start, vital AC power to operate, and the corresponding trains of decay heat closed cooling water and decay heat river water systems to provide an ultimate heat sink. The recovery analysis presented here considers all such combinations of both pump trains failing. Success of a recovery action considered here is the restoration of one DHR pump train for operation.

The DHR pump train recovery actions considered were identified in Section 1, Table 1-1. These actions are HDH1, HHA1, HRE9, HRE11, HRE12 (A, B, and C), HRE13 (A, B, and C), and HRE14 (A, B, and C). HDH1, HHA1, HRE9, HRE11, and HRE12 are dynamic human actions, which were quantified using the methods described in Section 2.3. These actions are mentioned here because they are used in conjunction with HRE13 and HRE14 to account for recovery of all the many ways in which the DHR pump trains can fail.

If a decay heat closed cooling water pump or a decay heat river water pump fails, the corresponding DHR pump must be secured before it overheats due to lack of cooling. This action is modeled by HDH1. If the pump is not shut down in time, repair of the overheated DHR pump then must be considered for recovery as well.

One of the most frequent ways in which a decay heat river water pump train is taken out of service is for preventive maintenance to remove excess silt from the pump intake. Once the divers are recalled, the DHR pumps can be started. The action to recall the divers is considered by dynamic human action HHA1. Successful performance of HHA1 would restore a decay heat river water system pump train for the specified conditions. A more general recovery action has been identified (HRE9); however, that applies to many more ways in which the decay heat river water pump train may fail. As long as the decay heat service cooler on the affected pump train is operable, the operators, with enough time, may establish flow to the cooler using a fire hose outlet in the DHCCW service cooler room. The fire hose could be connected to the cooler via a 2-inch drain line. There are four diverse fire service water pumps that can provide the needed flow. Although the flow established in this way would probably not be enough to cool down quickly, it should be enough to provide additional time for recovery actions and to allow the DHR pumps to only operate to recirculate inventory back to the RCS from the sump. As the action represented by HRE9 is more encompassing than HHA1, only HRE9 is considered for the recovery analysis.

If DC power is lost to one of the DHR pump trains, the operators may locally initiate all three pumps in the train to establish flow. This action does not require that any equipment be physically repaired. Therefore, these actions (i.e., HRE12A, HRE12B, and HRE12C) were evaluated using the methods of Section 2.3.

Recovery actions to consider the timely repair of a failed DHCCW pump or a DHR pump were also considered. Dynamic action HRE11 was used to model the decision to initiate repair of the affected pump. The likelihood of successfully repairing a pump in time, once the decision to attempt such a recovery is made, is represented by recovery actions HRE13 and HRE14. These actions could not be analyzed according to the methods of Section 2.3

Recovery actions HRE13 and HRE14 were quantified by reviewing historical data from a variety of plants. The failure and maintenance event data reviewed for pumps simliar to TMI's DHR and DHCCW pumps are summarized in Table 4-7. Part 1 of the table indicates that 25 failure events and 44 maintenance events were reviewed. All of the pump maintenance events came from TMI Unit 1.

A repair time is not recorded for all of the failure events. Repair times were therefore estimated for these events. Events estimated to require less than 6 hours for repair involved relay failures, tripped breakers, and packing leaks. A shaft sleeve replacement was estimated to require between 6 and 12 hours. No events were estimated to require less than 24 hours but more than 12 hours. One event involving replacement of bearings and seals was estimated to require more than 24 hours. The frequency of not repairing a DHR or DHCCW pump, as a function of allowable repair time, is reported in part 2 of the table. The frequencies of nonrepair in the table for allowable repair times of 6, 12, and 24 hours correspond to the median estimates of the frequency distributions for human actions HRE13A, HRE13B, and HRE13C. A factor of 2 was used to describe the uncertainty in each of these estimates; i.e., the ratio of the 95% to 50% was assumed to be 2.

A total of 44 DHR and DHCCW pump maintenance events at TMI Unit 1 were reviewed. All 44 maintenance restoration times were recorded. Part 2 of Table 4-7 indicates the frequency of the pump not being restored from maintenance as a function of the allowable repair time. The frequencies in part 2 of the table were assumed to represent the median nonrepair fractions if the pump train was initially in maintenance. The frequencies listed in the final column of the second part of Table 4-7 are used as the median nonrepair frequencies for recovery actions HRE14A, HRE14B, and HRE14C. A factor of 2 was used to describe the uncertainty in each of these estimates.

The above human action failure estimates were used to evaluate the potential recovery of a single DHR pump train, given both trains were initially unavailable due to a combination of causes. These actions were only considered if a minimum of 6 hours is available before the DHR system is required.

4.5 REFERENCES

4-1. GPU Nuclear Corporation, letter from C. D. Adams to D. Wakefield, April 29, 1986.

4-2. GPU Nuclear Corporation, letter from C. D. Adams to D. Wakefield, May 9, 1986, Document Number GPUNC-768-DOC-327.

4-3. GPU Nuclear Corporation, TMI-1 FSAR, Section 8, Update 1, July 1982.

4-4. GPU Nuclear Corporation, Risk Assessment Section, "Probability of Loss of Offsite Power at TMI-2," Task EP-02, October 1984.

4-5. R. M. Becker, Jr., "TMI-2 Sources - Forced Outage Study," Letter, Metropolitan Edison Company, L&NS-84-M-0915, June 19, 1984.

4-6. U. S. Nuclear Regulatory Agency, "Data Summaries of Licensee Event Reports of Diesel Generators at U.S. Commercial Nuclear Power Plants," NUREG/CR-1362, March 1980.

4-7. Electric Power Research Institute, "Diesel Generator Reliability at Nuclear Power Plants: Data and Preliminary Analysis," EPRI-NP-2433, June 1982.

TABLE 4-1. QUANTIFICATION RESULTS FOR DYNAMIC HUMAN ACTIONS

HAM1- BYPASS INSTRUMENT AIR TRANSFER VALVE,OSP AVAILABLE

INPUT ECHO:

```
TYPE OF COGNITIVE PROCESSING IS =                      RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =                AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =                      POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =         GOOD
TYPE OF HUMAN ACTION TASK IS =                         RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =           SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =          YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =                  ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =       FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =         1.000  MINUTES
ESTIMATES OF TIME AVAILABLE ARE =                      POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)     MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 16.000  MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)
```

RESULTS:

```
FAILURE FREQUENCY RANGE
   LOWER BOUND= 4.77E-05
   BEST ESTIMATE= 4.77E-04
   UPPER BOUND= 4.77E-03
BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.77E-04
```

TABLE 4-1 (continued)

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```
HAM2- RESTART INSTRUMENT AIR COMPRESSORS,OSP LOST

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             3.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 19.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 1.86E-03
           BEST ESTIMATE= 1.86E-02
           UPPER BOUND= 1.86E-01
        BEST ESTIMATE TIME DEPENDENT= 1.76E-02
        BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.86E-02
```

```
HBW1- INITIATE HPI COOLING

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           CAUSE EXTENDED OUTAGE
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           3.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 27.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 1.29E-03
            BEST ESTIMATE= 1.29E-02
            UPPER BOUND= 1.29E-01
         BEST ESTIMATE TIME DEPENDENT= 2.86E-03
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.29E-02
```

```
HBW2- INITIATE HPI,AFTER BLACKOUT,NO EFW

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                      RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                      POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =         FAIR
    TYPE OF HUMAN ACTION TASK IS =                         RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =           SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =          YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                  ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =       FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =         5.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                      POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)     MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 27.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 8.77E-03
            BEST ESTIMATE= 4.39E-02
            UPPER BOUND= 2.19E-01
         BEST ESTIMATE TIME DEPENDENT= 3.39E-02
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.39E-02
```

TABLE 4-1 (continued)


```
HBW3- INITIATE HPI,AFTER LOSS OF RIVER WATER, EFW AVAIL.

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    LOW
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HRE2
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.100  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   6.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 4.53E-05
            BEST ESTIMATE= 4.53E-04
            UPPER BOUND= 4.53E-03
         BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

```
HC31- ISOLATE SEAL RETURN,30# AUTOMATIC SIGNAL FAILED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          GRAVE
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             BACKUP AUTO. ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             2.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =       9.500  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 6.90E-04
            BEST ESTIMATE= 6.90E-03
            UPPER BOUND= 6.90E-02
         BEST ESTIMATE TIME DEPENDENT= 5.90E-03
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=6.90E-03
```

TABLE 4-1 (continued)


```
HCA2- MANUAL CONT. ISOLATION,RB INITIALLY UNISOLATED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          GRAVE
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             BACKUP AUTO. ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             2.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =      7.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 3.65E-02
            BEST ESTIMATE= 1.83E-01
            UPPER BOUND= 9.13E-01
         BEST ESTIMATE TIME DEPENDENT= 1.82E-01
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.83E-01
```

```
HCD1- INITIATE CD WITH ADVS+PZR SPRAY

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                        SKILL
   EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                        OPTIMAL CONDITIONS
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
   TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.250  HOURS
   ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =    4.000  HOURS
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

       FAILURE FREQUENCY RANGE
          LOWER BOUND= 4.76E-06
          BEST ESTIMATE= 4.76E-05
          UPPER BOUND= 4.76E-04
       BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
       BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
       TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-05
```

TABLE 4-1 (continued)


```
HCD2- INITIATE SLOW CD,RCP OR SPRAY NOT AVAILABLE

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                      SKILL
   EXPERIENCE LEVEL OF OPERATING CREW IS =                AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                      OPTIMAL CONDITIONS
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =         FAIR
   TYPE OF HUMAN ACTION TASK IS =                         RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =           SHIFT SUPERVISOR
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =          YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                  HIGH
   TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =        HCD1
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =       SUCCEEDED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =         0.250  HOURS
   ESTIMATES OF TIME AVAILABLE ARE =                      POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)     HOURS
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   5.500  HOURS
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 2.38E-05
           BEST ESTIMATE= 2.38E-04
           UPPER BOUND= 2.38E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

```
HCD3- INITIATE CD W/O ATA,RCP+SPRAY AVAILABLE,SGTR OCCURS

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                        SKILL
   EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
   TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             FULL SUPPORT
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                    MEDIUM
   TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HID1
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         SUCCEEDED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.250  HOURS
   ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  3.500  HOURS
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 4.09E-06
           BEST ESTIMATE= 4.09E-05
           UPPER BOUND= 4.09E-04
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.77E-05
```

TABLE 4-1 (continued)

HCD4- INITIATE CD WITH ADVS+ PZR SPRAY,SGTR

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	PLANNED MANUAL ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	MEDIUM
TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =	HID1
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	SUCCEEDED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	3.500 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.09E-06
BEST ESTIMATE= 4.09E-05
UPPER BOUND= 4.09E-04
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.77E-05

```
HCD5- INITIATE CD W/PORV,SGTR AND LOOP

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           CAUSE EXTENDED OUTAGE
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    HIGH
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HID1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.250  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   3.500  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 2.94E-05
            BEST ESTIMATE= 2.94E-04
            UPPER BOUND= 2.94E-03
         BEST ESTIMATE TIME DEPENDENT= 1.11E-04
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.87E-04
```

TABLE 4-1 (continued)

HCF1- ESTABLISH RB COOLING AFTER RIVER WATER FAILS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	GRAVE
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	POOR
TYPE OF HUMAN ACTION TASK IS =	DETRACT FROM ES
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	MEDIUM
TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =	HRE2
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.100 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	0.500 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 2.35E-01
BEST ESTIMATE= 3.89E-01
UPPER BOUND= 6.44E-01
BEST ESTIMATE TIME DEPENDENT= 1.97E-01
BEST ESTIMATE TIME INDEPENDENT = 9.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.87E-01

```
HCF2- MANUAL REGULATION OF RBEC WATER PRESSURE

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        GRAVE
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           VERY POOR
    TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =          10.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)      MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  9.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 2.00E-01
           BEST ESTIMATE= 1.00E+00
           UPPER BOUND= 1.00E+00
        BEST ESTIMATE TIME DEPENDENT= 1.00E+00
        BEST ESTIMATE TIME INDEPENDENT = 7.00E-02
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.00E+00
```

TABLE 4-1 (continued)


```
HCS5- MANUALLY INITIATE SPRAY,PURGE IN PROGRESS

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                         KNOWLEDGE
   EXPERIENCE LEVEL OF OPERATING CREW IS =                   AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                         GRAVE
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =            POOR
   TYPE OF HUMAN ACTION TASK IS =                            BACKUP AUTO. ACTION
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =              SHIFT SUPERVISOR
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =             NO
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                     MEDIUM
   TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =           HCA2
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =          FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =            2.000  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                         POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)        MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =      7.000  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

       FAILURE FREQUENCY RANGE
          LOWER BOUND= 2.85E-01
          BEST ESTIMATE= 4.38E-01
          UPPER BOUND= 6.72E-01
       BEST ESTIMATE TIME DEPENDENT= 3.41E-01
       BEST ESTIMATE TIME INDEPENDENT = 3.00E-03
       TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.44E-01
```

HCV1- REALIGN FOR ONCE THROUGH FLOW(AH-D36,OR NS FAILS)

INPUT ECHO:

TYPE OF COGNITIVE PROCE. 'NG IS =	RULE
EXPERIENCE LEVEL OF OPERA. 'NG CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROO. - =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	POOR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.500 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	1.00E-01	3.59E-02	1.00E-01
6.00E+00	1.00E-01	3.20E-02	4.00E-01
1.10E+01	1.00E-01	3.00E-02	3.00E-01
2.40E+01	1.00E-01	3.00E-02	2.00E-01

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 6.28E-03
BEST ESTIMATE= 3.14E-02
UPPER BOUND= 1.57E-01
BEST ESTIMATE TIME DEPENDENT= 1.39E-03
BEST ESTIMATE TIME INDEPENDENT = 3.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.14E-02

TABLE 4-1 (continued)

HCV2- START STANDBY CBV TRAIN AFTER OPERATING TRAIN FAILS,OSP AVAILABL

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	LOW VIGILANCE
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.100 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	1.00E-01	4.76E-04	1.00E-01
6.00E+00	1.00E-01	4.76E-04	4.00E-01
1.10E+01	1.00E-01	4.76E-04	3.00E-01
2.40E+01	1.00E-01	4.76E-04	2.00E-01

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.76E-05
BEST ESTIMATE= 4.76E-04
UPPER BOUND= 4.76E-03
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04

TABLE 4-1 (continued)

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HCV3- FRACTION OF TIME OUTSIDE AIR TEMP HIGH

POINT VALUE IS =5.00E-02

HCV4- ESTABLISH ALTERNATE CBV COOLING FOLLOWING LOCV

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.50	0.75	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.20	0.60	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	5.00E-01	4.85E-04	2.00E-02
5.00E+00	7.50E-01	4.93E-04	6.00E-02
5.00E+00	1.00E+00	5.08E-04	2.00E-02
6.00E+00	5.00E-01	4.77E-04	8.00E-02
6.00E+00	7.50E-01	4.78E-04	2.40E-01
6.00E+00	1.00E+00	4.79E-04	8.00E-02
1.10E+01	5.00E-01	4.76E-04	6.00E-02
1.10E+01	7.50E-01	4.76E-04	1.80E-01
1.10E+01	1.00E+00	4.76E-04	6.00E-02
2.40E+01	5.00E-01	4.76E-04	4.00E-02
2.40E+01	7.50E-01	4.76E-04	1.20E-01
2.40E+01	1.00E+00	4.76E-04	4.00E-02

RESULTS:

FAILURE FREQUENCY RANGE

LOWER BOUND= 4.79E-05

BEST ESTIMATE= 4.79E-04

UPPER BOUND= 4.79E-03

BEST ESTIMATE TIME DEPENDENT= 2.44E-06

BEST ESTIMATE TIME INDEPENDENT = 4.76E-04

TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.79E-04

HCV5- OPEN DAMPER THAT TRANSFERRED CLOSE

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	LOW VIGILANCE
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	POOR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	2.50E-01	3.19E-02	1.00E-01
6.00E+00	2.50E-01	3.06E-02	4.00E-01
1.10E+01	2.50E-01	3.00E-02	3.00E-01
2.40E+01	2.50E-01	3.00E-02	2.00E-01

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 6.09E-03
BEST ESTIMATE= 3.04E-02
UPPER BOUND= 1.52E-01
BEST ESTIMATE TIME DEPENDENT= 4.45E-04
BEST ESTIMATE TIME INDEPENDENT = 3.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.04E-02

TABLE 4-1 (continued)

HCV6- RESTART CBV AFTER OSP LOST AND 1 DG FAILED

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	PLANNED MANUAL ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	2.50E-01	5.25E-05	1.00E-01
6.00E+00	2.50E-01	4.80E-05	4.00E-01
1.10E+01	2.50E-01	4.76E-05	3.00E-01
2.40E+01	2.50E-01	4.76E-05	2.00E-01

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.83E-06
BEST ESTIMATE= 4.83E-05
UPPER BOUND= 4.83E-04
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.83E-05

HCV7- ALIGN CBV TO RECICULATION MODE,NO ESAS PRESENT

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	LOW VIGILANCE
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	VERY POOR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.200 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00 6.00 11.00 24.00 0.00 0.00 0.00 0.00 0.00 0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10 0.40 0.30 0.20 0.00 0.00 0.00 0.00 0.00 0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.25 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

1.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	2.50E-01	1.08E-02	1.00E-01
6.00E+00	2.50E-01	1.03E-02	4.00E-01
1.10E+01	2.50E-01	1.00E-02	3.00E-01
2.40E+01	2.50E-01	1.00E-02	2.00E-01

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 1.02E-03
BEST ESTIMATE= 1.02E-02
UPPER BOUND= 1.02E-01
BEST ESTIMATE TIME DEPENDENT= 1.79E-04
BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.02E-02

HCV8- ESTABLISH ALTERNATE VENTILATION AFTER PLANT TRIP

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.50	0.75	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.20	0.60	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	5.00E-01	4.85E-04	2.00E-02
5.00E+00	7.50E-01	4.93E-04	6.00E-02
5.00E+00	1.00E+00	5.08E-04	2.00E-02
6.00E+00	5.00E-01	4.77E-04	8.00E-02
6.00E+00	7.50E-01	4.78E-04	2.40E-01
6.00E+00	1.00E+00	4.79E-04	8.00E-02
1.10E+01	5.00E-01	4.76E-04	6.00E-02
1.10E+01	7.50E-01	4.76E-04	1.80E-01
1.10E+01	1.00E+00	4.76E-04	6.00E-02
2.40E+01	5.00E-01	4.76E-04	4.00E-02
2.40E+01	7.50E-01	4.76E-04	1.20E-01
2.40E+01	1.00E+00	4.76E-04	4.00E-02

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.79E-05
BEST ESTIMATE= 4.79E-04
UPPER BOUND= 4.79E-03
BEST ESTIMATE TIME DEPENDENT= 2.44E-06
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.79E-04

HCV9- ESTABLISH ALTERNATE VENTILATION AFTER PLANT TRIP,WITH 2 HOUR DEL

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

0.50	0.75	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.20	0.60	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	5.00E-01	4.85E-04	2.00E-02
5.00E+00	7.50E-01	4.93E-04	6.00E-02
5.00E+00	1.00E+00	5.08E-04	2.00E-02
6.00E+00	5.00E-01	4.77E-04	8.00E-02
6.00E+00	7.50E-01	4.78E-04	2.40E-01
6.00E+00	1.00E+00	4.79E-04	8.00E-02
1.10E+01	5.00E-01	4.76E-04	6.00E-02
1.10E+01	7.50E-01	4.76E-04	1.80E-01
1.10E+01	1.00E+00	4.76E-04	6.00E-02
2.40E+01	5.00E-01	4.76E-04	4.00E-02
2.40E+01	7.50E-01	4.76E 04	1.20E-01
2.40E+01	1.00E+00	4.76E-04	4.00E-02

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.79E-05
BEST ESTIMATE= 4.79E-04
UPPER BOUND= 4.79E-03
BEST ESTIMATE TIME DEPENDENT= 2.44E-06
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.79E-04

HDH1- TURN OFF DHR PUMP GIVEN DECAY HEAT CLOSED FAILS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	2.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	20.000 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.76E-05
BEST ESTIMATE= 4.76E-04
UPPER BOUND= 4.76E-03
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04

```
HDT1- PREVENT BORON CONCENTRATION EFFECTS FOLLOWING LOCA

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.250  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 24.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 3.33E-05
           BEST ESTIMATE= 3.33E-04
           UPPER BOUND= 3.33E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 3.33E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.33E-04
```

TABLE 4-1 (continued)


```
HEF1- REPLENISH 2-HOUR BOTTLES OR CONTROL EF-V30S,LOOP

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      LOW
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =            HAM2
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             0.100  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   2.400  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 1.78E-02
           BEST ESTIMATE= 5.05E-02
           UPPER BOUND= 1.43E-01
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

TABLE 4-1 (continued)


```
HEF2- MANUAL EFW FLOW CONTROL,AUTO. CONTROL FAILS,FOR EF-

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           BACKUP AUTO. ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.050  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =     0.200  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 1.04E-03
            BEST ESTIMATE= 1.04E-02
            UPPER BOUND= 1.04E-01
         BEST ESTIMATE TIME DEPENDENT= 9.37E-03
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.04E-02
```

HEF3- REPLENISH 2 HOUR BOTTLES,SLB SEQUENCE

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	VERY POOR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	3.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	15.000 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 5.06E-02
BEST ESTIMATE= 2.53E-01
UPPER BOUND= 1.00E+00
BEST ESTIMATE TIME DEPENDENT= 1.83E-01
BEST ESTIMATE TIME INDEPENDENT = 7.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.53E-01

HEF4- CONTROL EFW FLOW FOLLOWING LOSS OF ALL AC

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	GRAVE
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	PLANNED MANUAL ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.100 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	2.500 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.83E-06
BEST ESTIMATE= 4.83E-05
UPPER BOUND= 4.83E-04
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.83E-05

HEF5- MANUALLY INITIATE EFW, AUTO .INITIATION FAILS

INPUT ECHO:

```
TYPE OF COGNITIVE PROCESSING IS =                      RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =                AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =                      POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =         FAIR
TYPE OF HUMAN ACTION TASK IS =                         BACKUP AUTO. ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =           SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =          YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =                  ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =       FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =         2.000  MINUTES
ESTIMATES OF TIME AVAILABLE ARE =                      POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)     MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 27.000  MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)
```

RESULTS:

```
FAILURE FREQUENCY RANGE
   LOWER BOUND= 6.61E-04
   BEST ESTIMATE= 6.61E-03
   UPPER BOUND= 6.61E-02
BEST ESTIMATE TIME DEPENDENT= 5.61E-03
BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=6.61E-03
```

TABLE 4-1 (continued)


```
HEF8- MANUAL EFW FLOW CONTROL,EF-V 30 FAILS,FOR EF+

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           1.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =    5.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 1.11E-03
            BEST ESTIMATE= 1.11E-02
            UPPER BOUND= 1.11E-01
         BEST ESTIMATE TIME DEPENDENT= 1.10E-03
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.11E-02
```

```
HEF9- REMOTE MANUA'. EFW FLOW CONTROL,EF-V 30 FAILS,FOR EF+

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                         SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                   AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                         POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =            FAIR
    TYPE OF HUMAN ACTION TASK IS =                            RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =              SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =             YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                     ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =          FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =            1.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                         POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)        MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 14.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 4.76E-05
            BEST ESTIMATE= 4.76E-04
            UPPER BOUND= 4.76E-03
         BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
         T   L BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

TABLE 4-1 (continued)


```
HEF10- REMOTE ISOLATION OF C T DRAINING INTO HOTWELL

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           1.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 55.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 4.76E-05
            BEST ESTIMATE= 4.76E-04
            UPPER BOUND= 4.76E-03
         BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

TABLE 4-1 (continued)


```
HFW4- MANUALLY CONTROL OTSG LEVEL AFTER AUTO FAILS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           BACKUP AUTO. ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             NO ADDITIONAL
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.330  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =     1.330  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 9.80E-04
            BEST ESTIMATE= 9.80E-03
            UPPER BOUND= 9.80E-02
         BEST ESTIMATE TIME DEPENDENT= 8.80E-03
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=9.80E-03
```

HFW5- MANUALLY CONTROL MAIN STEAM PRESSURE AFTER AUTO FAILS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	BACKUP AUTO. ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	2.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES

BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 19.000 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.76E-06
BEST ESTIMATE= 4.76E-05
UPPER BOUND= 4.76E-04
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-05

HGA1- CONSERVATIVE ESTIMATE OF OSP NONRECOVERY IN 6 HOURS
POINT VALUE IS =1.00E-02

```
HHA1- PULL DIVERS FROM PUMP HOUSE TO RECOVER DHRW PUMPS FROM MAINT.

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                          SKILL
   EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
   TYPE OF HUMAN ACTION TASK IS =                             RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               FULL SUPPORT
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             2.000  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 20.000  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 4.76E-05
           BEST ESTIMATE= 4.76E-04
           UPPER BOUND= 4.76E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

```
HHL1A- REMOTELY OPEN DROPLINE VALVES    GO ON DHR

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                       SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                 AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                       OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =          FAIR
    TYPE OF HUMAN ACTION TASK IS =                          PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =            SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =           YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                   LOW
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =         HCD1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =        SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =          0.200  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                       POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)      HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  8.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 4.53E-06
           BEST ESTIMATE= 4.53E-05
           UPPER BOUND= 4.53E-04
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.77E-05
```

```
HHL1B- LOCALLY OPEN DROPLINE GIVEN 1C FAILED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      LOW
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =            HCD1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             0.200  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =     4.800  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 4.53E-05
           BEST ESTIMATE= 4.53E-04
           UPPER BOUND= 4.53E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

HHP1- RESTART B MAKEUP AFTER LOOP,ONE DG &HA OR HB FAILED

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	10.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	109.000 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.76E-05
BEST ESTIMATE= 4.76E-04
UPPER BOUND= 4.76E-03
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04

TABLE 4-1 (continued)


```
HIC1- MANUAL CONTROL OF MFW VALVES,ICS FAILED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                         SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                   AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                         OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =            FAIR
    TYPE OF HUMAN ACTION TASK IS =                            BACKUP AUTO. ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =              SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =             NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                     ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =          FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =            0.500  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                         POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)        MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  2.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 1.85E-04
           BEST ESTIMATE= 1.85E-03
           UPPER BOUND= 1.85E-02
        BEST ESTIMATE TIME DEPENDENT= 8.48E-04
        BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.85E-03
```

TABLE 4-1 (continued)

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HIC2- MANUAL TRIP OF MFW PUMPS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	BACKUP AUTO. ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	NO ADDITIONAL
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.500 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	1.500 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 1.38E-02
BEST ESTIMATE= 6.91E-02
UPPER BOUND= 3.45E-01
BEST ESTIMATE TIME DEPENDENT= 6.81E-02
BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=6.91E-02

```
HIC3- SET ADVS MANUAL LOADER TO ZERO ,IF NOT INITIALLY AT ZERO

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                      SKILL
   EXPERIENCE LEVEL OF OPERATING CREW IS =                AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                      POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =         FAIR
   TYPE OF HUMAN ACTION TASK IS =                         RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =           NO ADDITIONAL
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =          YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                  ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =       FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =         1.000  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                      POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)     MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   4.500  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 1.33E-03
           BEST ESTIMATE= 1.33E-02
           UPPER BOUND= 1.33E-01
        BEST ESTIMATE TIME DEPENDENT= 3.27E-03
        BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.33E-02
```

```
HIC4- MANUAL CONTROL OF TBV/ADV WHEN ATA FAILS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             NO ADDITIONAL
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           1.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   4.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 1.94E-03
            BEST ESTIMATE= 1.94E-02
            UPPER BOUND= 1.94E-01
         BEST ESTIMATE TIME DEPENDENT= 9.37E-03
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.94E-02
```

HID1- IDENTIFY SGTR, CONDENSER AVAILABLE

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	PLANNED MANUAL ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPEND. ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	4.500 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.76E-06
BEST ESTIMATE= 4.76E-05
UPPER BOUND= 4.76E-04
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-05

TABLE 4-1 (continued)


```
HID2- IDENTIFY SGTR,OFFSITE POWER LOST

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             0.25   HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =     4.5    HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

          FAILURE FREQUENCY RANGE
             LOWER BOUND= 5.67E-06
             BEST ESTIMATE= 5.67E-05
             UPPER BOUND= 5.67E-04
          BEST ESTIMATE TIME DEPENDENT= 9.04E-06
          BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
          TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.67E-05
```

```
HINJ1- START STANDBY MU PUMP FOR SEAL INJ.,NO ESAS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.050  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   2.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 4.76E-06
            BEST ESTIMATE= 4.76E-05
            UPPER BOUND= 4.76E-04
         BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-05
```

```
HINJ2- CROSSCONNECT MU PUMP FOR SEAL INJ,A+B FAILED

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                         RULE
   EXPERIENCE LEVEL OF OPERATING CREW IS =                   AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                         POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =            FAIR
   TYPE OF HUMAN ACTION TASK IS =                            RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =              SHIFT SUPERVISOR
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =             YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                     ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =          FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =            0.033  HOURS
   ESTIMATES OF TIME AVAILABLE ARE =                         POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)        HOURS
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  1.500  HOURS
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 4.76E-05
           BEST ESTIMATE= 4.76E-04
           UPPER BOUND= 4.76E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

TABLE 4-1 (continued)


```
HINJ3- CROSSCONNECT MU PUMP C FOR SEAL INJ,ESAS PRESENT

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                       RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                 AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                       POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =          FAIR
    TYPE OF HUMAN ACTION TASK IS =                          RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =            SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =           NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                   ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =        FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =          0.100  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                       POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)      HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  1.300  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 3.54E-04
           BEST ESTIMATE= 3.54E-03
           UPPER BOUND= 3.54E-02
        BEST ESTIMATE TIME DEPENDENT= 2.10E-04
        BEST ESTIMATE TIME INDEPENDENT = 3.33E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.54E-03
```

HINJ4- OPEN MU-V20 FOR SEAL INJ,LOSS OF AIR

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	LOW
TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =	HAM1
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	2.200 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 3.74E-02
BEST ESTIMATE= 7.96E-02
UPPER BOUND= 1.70E-01
BEST ESTIMATE TIME DEPENDENT= 2.11E-02
BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.11E-02

```
HLT1A- SWITCH FROM MU TANK TO BWST,NORMAL COOLDOWN FAILED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           5.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 24.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 2.71E-04
            BEST ESTIMATE= 2.71E-03
            UPPER BOUND= 2.71E-02
         BEST ESTIMATE TIME DEPENDENT= 1.71E-03
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.71E-03
```

```
HLT1B- LONGTERM MU TO BWST,NORMAL COOLDOWN FAILS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    LOW
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HCD1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           3.000  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 57.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 1.82E-02
           BEST ESTIMATE= 5.12E-02
           UPPER BOUND= 1.44E-01
        BEST ESTIMATE TIME DEPENDENT= 5.56E-04
        BEST ESTIMATE TIME INDEPENDENT = 7.15E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.27E-03
```

HLT2- LONGTERM MU TO BWST,SGTR.CD FAILS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	LOW
TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =	HCD4
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.100 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	5.000 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 2.04E-02
BEST ESTIMATE= 5.48E-02
UPPER BOUND= 1.47E-01
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 5.00E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.00E-03

```
HMR1- ESTABLISH MU PUMP RECIRC AFTER ESAS AND TH

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             POOR
    TYPE OF HUMAN ACTION TASK IS =                             PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      MEDIUM
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =            HTH2
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             1.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   3.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 4.36E-02
            BEST ESTIMATE= 2.18E-01
            UPPER BOUND= 1.00E+00
         BEST ESTIMATE TIME DEPENDENT= 2.51E-01
         BEST ESTIMATE TIME INDEPENDENT = 3.00E-03
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.54E-01
```

TABLE 4-1 (continued)

HNS1- ISOLATE A LEAKING NS HEAT EXCHANGER

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	OPTIMAL CONDITIONS
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	3.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	15.000 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 2.68E-03
BEST ESTIMATE= 2.68E-02
UPPER BOUND= 2.68E-01
BEST ESTIMATE TIME DEPENDENT= 1.68E-02
BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.68E-02

```
HNS2- START NSRW PUMP,GB FAILED PUMP NOT ESAS SELECTED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             BACKUP AUTO. ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =               YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             0.200  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  2.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 2.47E-04
           BEST ESTIMATE= 2.47E-03
           UPPER BOUND= 2.47E-02
        BEST ESTIMATE TIME DEPENDENT= 1.47E-03
        BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.47E-03
```

HNS3- START STANDBY AUX.BLDG. VENT.TRAIN,RUNNING TRAIN FAILED

POINT VALUE IS =1.00E-01

HNS4- START STANDBY AUX. BLDG. VENT. TRAIN,NO ESAS PRESENT
POINT VALUE IS =1.00E-01

HNS5- START STANDBY AUX. BLDG. VENT. TRAIN, FOR LOCV IE

POINT VALUE IS =1.00E-01

HNS6- ISOLATE LEAKING NSCCW HEAT EXCHANGER

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	OPTIMAL CONDITIONS
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	2.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES

DISTRIBUTION FOR TIMES ALLOWED

30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

5.00	10.00	20.00	25.00	30.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.15	0.15	0.30	0.25	0.15	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
3.00E+01	5.00E+00	3.36E-03	1.50E-01
3.00E+01	1.00E+01	3.57E-03	1.50E-01
3.00E+01	2.00E+01	2.68E-02	3.00E-01
3.00E+01	2.50E+01	1.80E-01	2.50E-01
3.00E+01	3.00E+01	1.00E+00	1.50E-01

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.08E-02
BEST ESTIMATE= 2.04E-01
UPPER BOUND= 1.00E+00
BEST ESTIMATE TIME DEPENDENT= 1.98E-01
BEST ESTIMATE TIME INDEPENDENT = 8.00E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.04E-01

```
HNS7A- POWER TO NSCCW PUMP LOST +CHECK VALVE FAILS

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                         KNOWLEDGE
   EXPERIENCE LEVEL OF OPERATING CREW IS =                   AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                         POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =            POOR
   TYPE OF HUMAN ACTION TASK IS =                            RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =              SHIFT SUPERVISOR
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =             YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                     ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =          FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           20.000  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                         POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)        MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  50.000  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 9.60E-02
           BEST ESTIMATE= 4.80E-01
           UPPER BOUND= 1.00E+00
        BEST ESTIMATE TIME DEPENDENT= 4.50E-01
        BEST ESTIMATE TIME INDEPENDENT = 3.00E-02
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.80E-01
```

```
HNS7B-NSCCW PUMP FAILS+CHECK VALVE FAILS TO RESEAT

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             POOR
    TYPE OF HUMAN ACTION TASK IS =                             RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =            20.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 50.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 9.60E-02
            BEST ESTIMATE= 4.80E-01
            UPPER BOUND= 1.00E+00
         BEST ESTIMATE TIME DEPENDENT= 4.50E-01
         BEST ESTIMATE TIME INDEPENDENT = 3.00E-02
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.80E-01
```

```
HNS8A-NSRW PUMP IDLE+CHECK VALVE FAILS TO RESEAT,POWER NOT AVAILABLE

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             POOR
    TYPE OF HUMAN ACTION TASK IS =                             RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             3.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  30.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

       FAILURE FREQUENCY RANGE
          LOWER BOUND= 1.16E-02
          BEST ESTIMATE= 5.80E-02
          UPPER BOUND= 2.90E-01
       BEST ESTIMATE TIME DEPENDENT= 2.80E-02
       BEST ESTIMATE TIME INDEPENDENT = 3.00E-02
       TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.80E-02
```

```
HNS8B-NSRW PUMP IDLE+CHECK VALVE FAILS TO RESEAT,OSP AVAIL.

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                         KNOWLEDGE
   EXPERIENCE LEVEL OF OPERATING CREW IS =                   AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                         POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =            POOR
   TYPE OF HUMAN ACTION TASK IS =                            RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =              SHIFT SUPERVISOR
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =             YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                     ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =          FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =            3.000  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                         POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)        MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 59.000  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 5.87E-04
           BEST ESTIMATE= 5.87E-03
           UPPER BOUND= 5.87E-02
        BEST ESTIMATE TIME DEPENDENT= 1.58E-03
        BEST ESTIMATE TIME INDEPENDENT = 4.29E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.87E-03
```

TABLE 4-1 (continued)


```
HP01- MANUALLY OPEN PORV FOR HPI COOLING,ATA FAILED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           CAUSE EXTENDED OUTAGE
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    MEDIUM
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HBW1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           3.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 27.500  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 4.08E-05
            BEST ESTIMATE= 4.08E-04
            UPPER BOUND= 4.08E-03
         BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

```
HRC1- CLOSE PORV BLOCK VALVE AFTER PORV FAILS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              NO
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             2.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 28.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 3.33E-04
           BEST ESTIMATE= 3.33E-03
           UPPER BOUND= 3.33E-02
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 3.33E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.33E-03
```

```
HRC2- THROTTLE HPI AFTER PORV PASSES WATER

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           GOOD
    TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    LOW
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HTH1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.050  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   4.750  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 1.78E-02
           BEST ESTIMATE= 5.05E-02
           UPPER BOUND= 1.43E-01
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

HRE1- RECOVER ELECTRIC POWER ,LOSS OF ALL AC,EFW AVAIL

POINT VALUE IS =4.94E-05

HRE2- RESTORE RW WITH FIRE SERVICE WATER OR ROTATE MU PUMPS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	POOR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	LOW
TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =	HRE6
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.100 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	4.900 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 2.65E-02
BEST ESTIMATE= 6.43E-02
UPPER BOUND= 1.56E-01
BEST ESTIMATE TIME DEPENDENT= 1.03E-06
BEST ESTIMATE TIME INDEPENDENT = 1.50E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.50E-02

HRE3- RECOVER ELECTRIC POWER,LOSS OF ALL AC,EFW FAILED

POINT VALUE IS =8.36E-04

TABLE 4-1 (continued)

HRE4- UNPLUG RW SREENS BEFORE TURBINE TRIP

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	POOR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.050 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

1.30	2.60	4.00	6.00	8.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.01	0.04	0.25	0.55	0.15	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

1.00	2.00	4.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.25	0.45	0.25	0.05	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 4-1 (continued)

HRE4- UNPLUG RW SREENS BEFORE TURBINE TRIP (continued)

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
1.30E+00	1.00E+00	1.40E-01	2.50E-03
1.30E+00	2.00E+00	1.00E+00	4.50E-03
1.30E+00	4.00E+00	1.00E+00	2.50E-03
1.30E+00	6.00E+00	1.00E+00	5.00E-04
2.60E+00	1.00E+00	3.01E-02	1.00E-02
2.60E+00	2.00E+00	4.49E-02	1.80E-02
2.60E+00	4.00E+00	1.00E+00	1.00E-02
2.60E+00	6.00E+00	1.00E+00	2.00E-03
4.00E+00	1.00E+00	3.00E-02	6.25E-02
4.00E+00	2.00E+00	3.00E-02	1.12E-01
4.00E+00	4.00E+00	1.00E+00	6.25E-02
4.00E+00	6.00E+00	1.00E+00	1.25E-02
6.00E+00	1.00E+00	3.00E-02	1.37E-01
6.00E+00	2.00E+00	3.00E-02	2.47E-01
6.00E+00	4.00E+00	3.00E-02	1.37E-01
6.00E+00	6.00E+00	1.00E+00	2.75E-02
8.00E+00	1.00E+00	3.00E-02	3.75E-02
8.00E+00	2.00E+00	3.00E-02	6.75E-02
8.00E+00	4.00E+00	3.00E-02	3.75E-02
8.00E+00	6.00E+00	3.00E-02	7.50E-03

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 2.98E-02
BEST ESTIMATE= 1.49E-01
UPPER BOUND= 7.44E-01
BEST ESTIMATE TIME DEPENDENT= 1.23E-01
BEST ESTIMATE TIME INDEPENDENT = 3.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.49E-01

HRE5- LOOP W/ONSITE POWER AVAILABLE,RECOVER OSP FOR SGTR

POINT VALUE IS =3.94E-02

TABLE 4-1 (continued)

HRE6A- UNPLUG RW SREENS BEFORE SEAL FAILURE,EFW AVAILABLE

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.050 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

7.30	8.60	10.00	12.00	14.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.01	0.04	0.25	0.55	0.15	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

1.00	2.00	4.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.25	0.45	0.25	0.05	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 4-1 (continued)

HRE6A- UNPLUG RW SREENS BEFORE SEAL FAILURE,EFW AVAILABLE (continued)

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
7.30E+00	1.00E+00	7.15E-04	2.50E-03
7.30E+00	2.00E+00	7.15E-04	4.50E-03
7.30E+00	4.00E+00	7.15E-04	2.50E-03
7.30E+00	6.00E+00	7.74E-04	5.00E-04
8.60E+00	1.00E+00	7.15E-04	1.00E-02
8.60E+00	2.00E+00	7.15E-04	1.80E-02
8.60E+00	4.00E+00	7.15E-04	1.00E-02
8.60E+00	6.00E+00	7.15E-04	2.00E-03
1.00E+01	1.00E+00	7.15E-04	6.25E-02
1.00E+01	2.00E+00	7.15E-04	1.12E-01
1.00E+01	4.00E+00	7.15E-04	6.25E-02
1.00E+01	6.00E+00	7.15E-04	1.25E-02
1.20E+01	1.00E+00	7.15E-04	1.37E-01
1.20E+01	2.00E+00	7.15E-04	2.47E-01
1.20E+01	4.00E+00	7.15E-04	1.37E-01
1.20E+01	6.00E+00	7.15E-04	2.75E-02
1.40E+01	1.00E+00	7.15E-04	3.75E-02
1.40E+01	2.00E+00	7.15E-04	6.75E-02
1.40E+01	4.00E+00	7.15E-04	3.75E-02
1.40E+01	6.00E+00	7.15E-04	7.50E-03

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 7.15E-05
BEST ESTIMATE= 7.15E-04
UPPER BOUND= 7.15E-03
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 7.15E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=7.15E-04

TABLE 4-1 (continued)

HRE6B- UNPLUG RW SREENS BEFORE CORE DAMAGE,EFW FAILED

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.050 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

2.30	3.60	5.00	7.00	9.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.01	0.04	0.25	0.55	0.15	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

1.00	2.00	4.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.25	0.45	0.25	0.05	0.00	0.00	0.00	0.00	0.00	0.00

HRE6B- UNPLUG RW SREENS BEFORE CORE DAMAGE,EFW FAILED (continued)

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
2.30E+00	1.00E+00	1.49E-03	2.50E-03
2.30E+00	2.00E+00	7.63E-02	4.50E-03
2.30E+00	4.00E+00	1.00E+00	2.50E-03
2.30E+00	6.00E+00	1.00E+00	5.00E-04
3.60E+00	1.00E+00	1.00E-02	1.00E-02
3.60E+00	2.00E+00	1.00E-02	1.80E-02
3.60E+00	4.00E+00	1.00E+00	1.00E-02
3.60E+00	6.00E+00	1.00E+00	2.00E-03
5.00E+00	1.00E+00	1.00E-02	6.25E-02
5.00E+00	2.00E+00	1.00E-02	1.12E-01
5.00E+00	4.00E+00	1.04E-02	6.25E-02
5.00E+00	6.00E+00	1.00E+00	1.25E-02
7.00E+00	1.00E+00	1.00E-02	1.37E-01
7.00E+00	2.00E+00	1.00E-02	2.47E-01
7.00E+00	4.00E+00	1.00E-02	1.37E-01
7.00E+00	6.00E+00	1.04E-02	2.75E-02
9.00E+00	1.00E+00	1.00E-02	3.75E-02
9.00E+00	2.00E+00	1.00E-02	6.75E-02
9.00E+00	4.00E+00	1.00E-02	3.75E-02
9.00E+00	6.00E+00	1.00E-02	7.50E-03

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 7.51E-03
BEST ESTIMATE= 3.75E-02
UPPER BOUND= 1.88E-01
BEST ESTIMATE TIME DEPENDENT= 2.78E-02
BEST ESTIMATE TIME INDEPENDENT = 9.98E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=3.75E-02

HRE6C- UNPLUG RW SCREENS BEFORE LOSS OF AC OR SEAL FAILURE,CV FAILED

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	KNOWLEDGE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	LOW
TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =	HCV4
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.050 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

6.30	7.30	7.60	8.60	9.00	10.00	11.00	12.00	13.00	14.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.00	0.00	0.00	0.02	0.02	0.11	0.08	0.22	0.14	0.41

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

1.00	2.00	4.00	6.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

0.25	0.45	0.25	0.05	0.00	0.00	0.00	0.00	0.00	0.00

HRE6C- UNPLUG RW SCREENS BEFORE LOSS OF AC OR SEAL FAILURE,CV FAILED (continued)

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
6.30E+00	1.00E+00	7.15E-04	2.50E-04
6.30E+00	2.00E+00	7.15E-04	4.50E-04
6.30E+00	4.00E+00	7.15E-04	2.50E-04
6.30E+00	6.00E+00	7.63E-02	5.00E-05
7.30E+00	1.00E+00	1.00E-02	1.00E-03
7.30E+00	2.00E+00	1.00E-02	1.80E-03
7.30E+00	4.00E+00	1.00E-02	1.00E-03
7.30E+00	6.00E+00	1.01E-02	2.00E-04
7.60E+00	1.00E+00	1.00E-02	1.00E-03
7.60E+00	2.00E+00	1.00E-02	1.80E-03
7.60E+00	4.00E+00	1.00E-02	1.00E-03
7.60E+00	6.00E+00	1.00E-02	2.00E-04
8.60E+00	1.00E+00	1.00E-02	4.00E-03
8.60E+00	2.00E+00	1.00E-02	7.20E-03
8.60E+00	4.00E+00	1.00E-02	4.00E-03
8.60E+00	6.00E+00	1.00E-02	8.00E-04
9.00E+00	1.00E+00	1.00E-02	6.25E-03
9.00E+00	2.00E+00	1.00E-02	1.12E-02
9.00E+00	4.00E+00	1.00E-02	6.25E-03
9.00E+00	6.00E+00	1.00E-02	1.25E-03
1.00E+01	1.00E+00	1.00E-02	2.63E-02
1.00E+01	2.00E+00	1.00E-02	4.72E-02
1.00E+01	4.00E+00	1.00E-02	2.63E-02
1.00E+01	6.00E+00	1.00E-02	5.25E-03
1.10E+01	1.00E+00	1.00E-02	1.88E-02
1.10E+01	2.00E+00	1.00E-02	3.37E-02
1.10E+01	4.00E+00	1.00E-02	1.88E-02
1.10E+01	6.00E+00	1.00E-02	3.75E-03
1.20E+01	1.00E+00	1.00E-02	5.50E-02
1.20E+01	2.00E+00	1.00E-02	9.90E-02
1.20E+01	4.00E+00	1.00E-02	5.50E-02
1.20E+01	6.00E+00	1.00E-02	1.10E-02
1.30E+01	1.00E+00	1.00E-02	3.50E-02
1.30E+01	2.00E+00	1.00E-02	6.30E-02
1.30E+01	4.00E+00	1.00E-02	3.50E-02
1.30E+01	6.00E+00	1.00E-02	7.00E-03
1.40E+01	1.00E+00	1.00E-02	1.03E-01
1.40E+01	2.00E+00	1.00E-02	1.84E-01
1.40E+01	4.00E+00	1.00E-02	1.03E-01
1.40E+01	6.00E+00	1.00E-02	2.05E-02

TABLE 4-1 (continued)

HRE6C- UNPLUG RW SCREENS BEFORE LOSS OF AC OR SEAL FAILURE,CV FAILED (continued)

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 2.34E-02
BEST ESTIMATE= 5.95E-02
UPPER BOUND= 1.51E-01
BEST ESTIMATE TIME DEPENDENT= 3.33E-06
BEST ESTIMATE TIME INDEPENDENT = 9.99E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=9.99E-03

HRE7- RECOVER ELECTRIC POWER,LOOP &1 DG FAILED,EFW SUCCESS POINT VALUE IS =5.01E-02

HRE8- RECOVER ELECTRIC POWER,LOOP &1DG FAILED,EFW FAILED

POINT VALUE IS =.382

```
HRE9- ALIGN FIRE HOSE TO THE RIVER WATER SIDE OF DCCW HEAT EXCHANGERS

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                       KNOWLEDGE
   EXPERIENCE LEVEL OF OPERATING CREW IS =                 AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                       POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =          FAIR
   TYPE OF HUMAN ACTION TASK IS =                          RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =            FULL SUPPORT
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =           YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                   ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =        FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =          0.050  HOURS
   ESTIMATES OF TIME AVAILABLE ARE =                       POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)      HOURS
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  6.000  HOURS
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 7.15E-05
           BEST ESTIMATE= 7.15E-04
           UPPER BOUND= 7.15E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 7.15E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=7.15E-04
```

HRE11-INITIATE REPAIR OF DHR/DHCW PUMPS GIVEN ESAS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	SKILL
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	GOOD
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	FULL SUPPORT
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.250 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	3.000 HOURS
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
- LOWER BOUND= 4.76E-05
- BEST ESTIMATE= 4.76E-04
- UPPER BOUND= 4.76E-03

BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04

```
HRE12A-LOCALLY START DH PUMPS GIVEN DC FAILS,6 HOURS

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                     KNOWLEDGE
   EXPERIENCE LEVEL OF OPERATING CREW IS =               AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                     OPTIMAL CONDITIONS
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =        FAIR
   TYPE OF HUMAN ACTION TASK IS =                        RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =          FULL SUPPORT
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =         YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                 MEDIUM
   TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =       HCD1
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =      SUCCEEDED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =        0.250  HOURS
   ESTIMATES OF TIME AVAILABLE ARE =                     POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)    HOURS
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  5.000  HOURS
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

       FAILURE FREQUENCY RANGE
          LOWER BOUND= 6.70E-05
          BEST ESTIMATE= 6.70E-04
          UPPER BOUND= 6.70E-03
       BEST ESTIMATE TIME DEPENDENT= 6.69E-05
       BEST ESTIMATE TIME INDEPENDENT = 7.15E-04
       TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=7.82E-04
```

TABLE 4-1 (continued)


```
HRE12B-LOCALLY START DH PUMPS GIVEN DC FAILS,12 HOURS

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                        KNOWLEDGE
   EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                        OPTIMAL CONDITIONS
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
   TYPE OF HUMAN ACTION TASK IS =                           RECOVER FAILED SYSTEM
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             FULL SUPPORT
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                    MEDIUM
   TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HCD1
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         SUCCEEDED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.250  HOURS
   ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 11.000  HOURS
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 6.13E-05
           BEST ESTIMATE= 6.13E-04
           UPPER BOUND= 6.13E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 7.15E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=7.15E-04
```

```
HRE12C-LOCALLY START DH PUMPS GIVEN DC FAILS,24 HOURS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                      KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                      OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =         FAIR
    TYPE OF HUMAN ACTION TASK IS =                         RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =           FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =          YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                  MEDIUM
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =        HCD1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =       SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =         0.250  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                      POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)     HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 23.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 6.13E-05
            BEST ESTIMATE= 6.13E-04
            UPPER BOUND= 6.13E-03
         BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
         BEST ESTIMATE TIME INDEPENDENT = 7.15E-04
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=7.15E-04
```

HRE13A-NON-REPAIR OF DHR/DCCW PUMPS IN 6 HOURS IF FAILED TO START
POINT VALUE IS =4.00E-01

HRE13B-NON-REPAIR OF DHR/DCCW PUMPS IN 12 HOURS IF FAILED TO START

POINT VALUE IS =2.80E-01

HRE13C-NON-REPAIR OF DHR/DCCW PUMPS IN 24 HOURS IF FAILED TO START

POINT VALUE IS =2.80E-01

TABLE 4-1 (continued)

HRE14A-NON-RECOVERY FROM MAINTENANCE DHR/DCCW PUMPS IN 6 HOURS
POINT VALUE IS =3.60E-01

HRE14B-NON-RECOVERY FROM MAINTENANCE DHR/DCCW PUMPS IN 12 HOURS POINT VALUE IS =1.40E-01

HRE14C-NON-RECOVERY FROM MAINTENANCE DHR/DCCW PUMPS IN 24 HOURS POINT VALUE IS =2.00E-02

TABLE 4-1 (continued)


```
HRT7- MANUAL REACTOR TRIP W/SCRAM BUTTON

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                          SKILL
   EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             GOOD
   TYPE OF HUMAN ACTION TASK IS =                             BACKUP AUTO. ACTION
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               NO ADDITIONAL
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             0.100  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =       0.300  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

       FAILURE FREQUENCY RANGE
          LOWER BOUND= 5.80E-04
          BEST ESTIMATE= 5.80E-03
          UPPER BOUND= 5.80E-02
       BEST ESTIMATE TIME DEPENDENT= 4.80E-03
       BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
       TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.80E-03
```

```
HRT8- INTERRUPT POWER TO CRD ,AUTO TRIP FAILS

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                          SKILL
   EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             GOOD
   TYPE OF HUMAN ACTION TASK IS =                             BACKUP AUTO. ACTION
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               NO ADDITIONAL
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                      LOW
   TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =            HRT7
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             0.100  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =       0.200  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 8.03E-02
           BEST ESTIMATE= 1.32E-01
           UPPER BOUND= 2.17E-01
        BEST ESTIMATE TIME DEPENDENT= 8.52E-02
        BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=8.62E-02
```

HRV1 - ISOLATE MFW FOLLOWING STUCK OPEN MSSV IN 30 MINUTES

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	BACKUP AUTO. ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	2.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	14.000 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 1.21E-03
BEST ESTIMATE= 1.21E-02
UPPER BOUND= 1.21E-01
BEST ESTIMATE TIME DEPENDENT= 1.11E-02
BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.21E-02

```
HSI1- ISOLATE MAIN STEAM LINES ,DOWNSTREAM STEAM LINE BREAK

 INPUT ECHO:

   TYPE OF COGNITIVE PROCESSING IS =                        RULE
   EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
   STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
   QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
   TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
   ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
   ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
   TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
   STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
   THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           3.000  MINUTES
   ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
   BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 15.000  MINUTES
   (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

 RESULTS:

       FAILURE FREQUENCY RANGE
          LOWER BOUND= 9.21E-03
          BEST ESTIMATE= 4.60E-02
          UPPER BOUND= 2.30E-01
       BEST ESTIMATE TIME DEPENDENT= 4.50E-02
       BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
       TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.60E-02
```

HSI2- SHUT MSIVS + STOP EFW TO FAILED SG,UPSTREAM BREAKS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	PLANNED MANUAL ACTION
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	3.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	14.500 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 1.04E-02
BEST ESTIMATE= 5.18E-02
UPPER BOUND= 2.59E-01
BEST ESTIMATE TIME DEPENDENT= 5.08E-02
BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.18E-02

3. TMI-1 SPECIFIC HUMAN PERFORMANCE INFORMATION

This section describes in general terms, the conduct of operations at TMI-1; particularly, the relationship of available, qualified manpower to man plant control stations in the event of an emergency. This background information is presented separately so that it need not be repeated in the documentation for each human action evaluated.

3.1 CONTROL ROOM CREW AND SUPPORT PERSONNEL

3.1.1 NORMAL SHIFT MANNING

Table 3-1 compares the shift manning requirements found in the plant technical specifications with the requirements of Administrative Procedure 1029 (Revision 18). The shift manning requirements listed in Administrative Procedure 1029 are more stringent than the plant technical specifications. Since GPUN has committed itself to the requirements of Administrative Procedure 1029 as part of its restart requirements for the state of Pennsylvania, the shift manning requirements outlined in that procedure are assumed to be applicable to the PRA shift manning model. This assumption is still somewhat conservative because the current shift duty roster indicates that each of the six operating crews is assigned the manpower indicated in the third column of Table 3-1. By comparison, one can see that the actual duty roster assignments are intended to ensure that the minimum requirements of Administrative Procedure 1029 are either met or exceeded. An extra control room operator trainee and an extra auxiliary operator trainee are permanently assigned to each of the six crews. A minimum of one senior reactor operator and one reactor operator are required to be in the control room whenever the reactor coolant system temperature is greater than 200°F.

Normally, one control room operator is assigned to the primary side of the plant, one to the remainder of the plant, and a third CRO would be assigned to switching and tagging. All three would be reactor operator qualified.

The five auxiliary operators would each be assigned specific areas of responsibility. Two auxiliary operators would be assigned responsibility for the primary side of the plant and radwaste systems, including equipment mostly located in the containment, the auxiliary building, and the fuel handling building. They are titled the primary auxiliary operator and the primary reading auxiliary operator. Two other auxiliary operators are assigned responsibility for the secondary plant, including equipment located in the control, turbine, and intermediate buildings. One is titled the secondary auxiliary operator, and the other is called the secondary reading auxiliary operator. These two auxiliary operators are also qualified to operate equipment in the outbuildings. The fifth auxiliary operator is assigned primary responsibility for the outbuildings; i.e., the circulating water and river water pump houses. If a sixth auxiliary operator is available for duty, he is used as a floater.

Normally, one auxiliary operator is assigned to the outbuildings (e.g., river water pumphouse), two auxiliary operators are assigned to primary systems and support systems, and two other auxiliary operators are assigned to the secondary and turbine plant systems. As a result of these assignments, there should be two auxiliary operators in the auxiliary and fuel handling buildings and two in the turbine and intermediate buildings at all times.

Not all of the personnel listed in Table 3-1 are always present in the control room. Because of the minimum requirements noted, either the shift supervisor or the shift foreman may be outside the control room. One of the reactor operator licensed control room operators may also be outside the control room although on duty at the start of an accident. For the purposes of the PRA, one SRO and one reactor operator are always assumed to be initially present in the control room. A second control room operator, who may not be reactor operator qualified, is also to be assumed present. The shift technical advisor, second SRO, and second reactor operator are assumed to arrive at the control room in less than 5 minutes after an abnormal event; e.g., plant trip.

The shift supervisor's office is directly adjacent to the control room. From his desk, he can look into the control room and view almost the entire area (i.e., most of the panels) through a window located behind the shift foreman's desk in the control room. An intercom connects the control room to his office.

The shift technical advisor, although not required to be, is almost always present in the control room. His role, however, is limited to one of independently reviewing the status of the plant (i.e., acting as an overseer), interpreting plant indications, and offering guidance to the operating crew.

Trainees are only permitted to manipulate controls or take log readings if under the direct supervision of a qualified operator. Except in extreme emergencies or if necessary to prevent personnel injury or equipment damage, the auxiliary operators operate plant systems and equipment only on the direct orders of the shift supervisor, shift foreman, or the control room operator on duty at the panel. The authority to order or affect a plant shutdown or to take the appropriate actions necessary to protect the health and safety of the public is also the responsibility of the shift supervisor, the shift foreman, and the CRO on duty at the panel.

The normal crew on duty also make up a five-man fire brigade, which is onsite. The SRO and CRO, who are required to be in the control room at all times, may not also be assigned to the fire brigade.

3.1.2 EMERGENCY RESPONSE SUPPORT PERSONNEL

Other TMI personnel than those listed in Table 3-1 are available for emergencies should these occur during normal working hours. The personnel are available from the control room crew in training or the relief crew. The auxiliary operators, control room operators, shift foremen, STAs, and the shift supervisors from these crews are instructed to report to the operations support center, the control room, or the fire brigade, depending on their positions (Reference 3-1). During the day, the operations manager and the operations engineer, who are both SRO licensed, are also onsite.

It is possible that an event could happen when the training crew is at Lynchburg, Virginia, for simulator training or during the night when neither the training crew nor the relief crew are onsite. Often, plant upsets occur in the middle of the night. Consequently, the PRA human factors evaluation conservatively assumes no additional credit for the presence of these additional crews.

During any time of the day or night, the TMI-1 shift supervisor's designee may initiate a callout for emergency situations (Reference 3-2). Personnel assigned to the initial response emergency organization duty roster and the emergency support organization duty roster would respond to the callout by first telephoning the shift supervisor's office, then by reporting to their preassigned stations. Each individual is provided a beeper during their duty week to ensure that the individual can be notified to respond in time. Persons on the initial response emergency organization duty roster must report within 1 hour for onsite assignments. Personnel assigned to the Emergency support organization duty roster must also report to their assigned stations within 1 hour (usually to the emergency operations facility). Certain personnel on the emergency support organization duty roster are allowed up to 4 hours after callout. Notification to activate the emergency operations facility and to call out additional support is expected to occur nearly simultaneously with the declaration of a site or general emergency. Even before initiating a formal callout in accordance with procedures, the control room crew is likely to initiate a partial callout of a few key personnel in the first few minutes following a significant plant disturbance. No credit is assumed for this additional early action, however, since it is not covered in the written procedures. Within 1 hour of the callout, the following offsite locations are assumed to be staffed and ready to assist the normal control room crew

1. Emergency Operations Facility (Commerce Park, Harrisburg, Pennsylvania)

2. Annex to the EOF (Crawford Station, Middletown, Pennsylvania)

3. Parsippany Technical Functions Center (Room 3087 Cherry Hill Building, Parsippany, New Jersey)

4. Recovery Technical Support Center (Unit 2) (Room 201/203 Unit 2 Administration Building)

5. Media Center (Crawford Station, Middletown, Pennsylvania)

In addition, within 1 hour of the callout support, personnel will have arrived at the Unit 1 onsite technical support center, the operations support center, and, in some limited cases, at the control room to assist the normal shift crew. The emergency director (normally the operations manager or the operations and maintenance director) will report to the control room within 1 hour to take charge. He does so by first being briefed about the status of the plant, then announcing aloud that he is assuming the responsibility of emergency director. The shift supervisor on duty at the time of the initiator then reports to the emergency director. If the accident were to occur during normal working hours, the onsite support personnel would likely be available much sooner than 1 hour after call out, probably within just a few minutes.

The EOF, the onsite technical support center, and the Parsippany technical support center are each equipped with plant computer alarm indications and instrument readings. Plant engineering supplies analytical support from the onsite technical support center located two floors below the control room in the control tower. Engineering in Parsippany also provides analytical support from the Parsippany technical support center. The staff at the emergency operations facility also provide analytical support although its primary function is to interface with the state government and to provide recommendations about the appropriateness and timing of evacuations. Since the EOF is farther than 10 miles from the site, this support center would remain manned even if a full evacuation were ordered. All necessary onsite personnel (i.e., including those at the onsite technical support center and the operations support center) would also remain onsite after an evacuation is called. Personnel assigned to the onsite operations support center would not provide additional analytical support since the center is not equipped with access to the plant computer. Instead, their actions would be directed by the responsible personnel in the control room. The onsite operations support center staff who would collect in the health physics area of the control tower on Elevation 306' would provide additional skilled manpower to implement recovery actions, as directed from the control room.

Thus, within 1 hour of a callout, the human factors evaluation performed here assumes that each of the three emergency response facilities equipped with access to plant computer output would be staffed and ready to assist the control room crew in their diagnosis and to suggest corrective actions. Also, within 1 hour of the callout, the human factors evaluation assumes that sufficient skilled manpower would be available onsite, in parallel, to attempt to accomplish virtually any recovery actions identified. The timing of initiation of the callout is considered separately for each human action evaluated.

3.2 TMI UNIT 1 PROCEDURES

Guidance for the proper use and organization of written procedures at TMI Unit 1 is provided in Reference 3-3. The types of written procedures available are listed below:

- Operating Procedures
- Abnormal Transient Operational Guidelines
- Abnormal Procedures
- Emergency Procedures

- Alarm Response Procedures
- Maintenance Procedures
- Surveillance Procedures
- Fueling and Refueling Procedures
- Chemistry Procedures
- Security Procedures
- Radiological Controls Procedures
- Special Temporary Procedures

In the event of a plant disturbance or emergency, the ATOGs abnormal procedures, emergency procedures, and alarm response procedures are available at the center console in the control room for the operating crew's use. Generally, one or two men, depending on the emergency, would carry out the manual actions, while another person (generally, the shift foreman or the other CRO) would read the appropriate procedure aloud to check the man's performance at the console of the specified manual actions and followup actions.

Figure 3-1 illustrates the relationship between the written procedures likely to be used by the control room crew. When an alarm comes in, it is prioritized by color. A red alarm indicates the conditions requiring a plant trip. The operating crew is directed to ATOG Procedure 1210-1, "reactor/turbine trip." A blue alarm indicates the conditions requiring engineered safeguards actuation. If both a blue and a red alarm come in, the crew is also directed to ATOG Procedure 1210-1. If a blue alarm comes in without a red alarm, this would indicate an inadvertent actuation of engineered safeguards. In either case, the operating crew would first go to abnormal transient Procedure 1210-1. If the alarm is neither red nor blue, the operators are instead directed to the alarm response procedures. These procedures are generally just a single page although, for some alarms, they may contain many pages. The alarm response procedures indicate the steps the operators may need to take in response to the alarms. For some alarms, they may just document the potential causes of a trouble indication. Some alarms are merely indicating normal or expected conditions for which no action is required. Alarms resulting from instrument malfunctions may be bypassed if there is an increased monitoring frequency of the operating parameters associated with the alarm and an out-of-service sticker is placed on the alarm window (Reference 3-3). Table 3-2 provides a sample page from the index of alarm response procedures.

Abnormal transient Procedure 1210-1 is symptom-oriented. It may direct the operators to refer to the other abnormal transient procedures for further actions. An index of the abnormal transient procedures is provided in Table 3-3. The abnormal transient procedures may direct the operators to the abnormal procedures, emergency procedures, or, once conditions have stabilized, to normal operating procedures.

The abnormal procedures and emergency procedures are more specifically event-oriented. The indexes of these procedures are provided in Tables 3-4 and 3-5. The abnormal procedures generally address problems related to a single system, while emergency procedures are intended more to address plantwide impacts.

Normal operating procedures are entered from any of the previously mentioned procedures after the impacted plant or specific system has been stabilized. The normal operating procedures are essentially of two types; major plant evolution procedures (e.g., plant heatup to 525°F and RCS natural circulation cooling) and system operating procedures. These procedures can be categorized as goal-oriented.

In the event that there are no procedures to cover a specific emergency situation, plant personnel are directed to take whatever action is necessary to protect the health and safety of the general public and site personnel (Reference 3-3). In addition, special temporary procedures may be prepared and implemented in response to a particular situation during the course of the event. For the purposes of the PRA model, however, such special temporary procedures are not credited with the same completeness and careful review as those procedures in place beforehand. Of course, for routinely performed actions that are frequently repeated and for which procedures do exist, the operators are not required to have the procedure available or signed off.

Fueling and refueling, chemistry, security, and radiological controls procedures are not discussed in this report since they have little bearing on the risk assessment of plant power operations, at least insofar as the operator actions identified for evaluation in this report. Maintenance and surveillance procedures can determine the likelihood of correction and detection of previous equipment failures and system misalignments or miscalibrations. From the steps in these procedures, one can also speculate about the most likely errors that may occur as a result of performing the required surveillance or maintenance actions.

Administrative Procedure 1002 (Reference 3-4) is important for the consideration of routine human actions (i.e., those performed prior to an accident initiator) because it describes the tagging and switching procedures followed at TMI Unit 1. Table 20-15 of the NRC handbook (Reference 3-5, pages 1 to 5) qualitatively describes four levels of tagging or switching systems. The NRC handbook suggests that human error rates for routine errors of omission be scaled up or down to reflect the quality of the switching and tagging system implemented. A brief summary of the tagging and switching system at TMI-Unit 1 is provided below and compared to the qualitative levels of the handbook.

At TMI Unit 1, an extensive and formal tagging and switching procedure has been implemented. The process of applying for and installing tags, issuing and implementing switching orders, and restoring equipment to service is controlled by the completion of written request forms and signoffs. Only trained personnel on an authorized list are permitted to even request switching and tagging actions. Only one device requiring a tag is listed per line in the application. Applications for apparatus to be taken out of service must be approved by the department foreman of the person making the request, then submitted to the shift foreman who verifies the application for accuracy and compliance with plant technical specifications.

The approved application is then presented to the CRO assigned to switching and tagging. The CRO responsibility for switching and tagging is rotated daily. The responsible CRO assigns a control number to the application, which then becomes a clearance controlling document for all parties affected by the tagging. In this way, duplicate requests to manipulate the same equipment are combined, and switching orders are only granted when all parties grant clearance. The responsible CRO then prepares a switching order that documents the control number, date, time, and order of switching and prepares the required tags. Listed on each tag are the date and time placed, the control number, the name and number of the device, and the position into which the device is to be placed. The actual position and tagging is performed by a person designated by the duty shift supervisor or shift foreman, then is verified by the individual who requested the tagging. The completed switching order is then returned to the responsible CRO, compared with the original, then destroyed. When all parties have completed their work, another switching and tagging order is prepared to return the system to service and the tags are removed. Again, the shift foreman verifies that the equipment is ready for service and gives his approval to the responsible CRO to issue a switching order. When the switching order is completed, the shift foreman signs the original application indicating that the equipment is approved for operation.

When the work is associated with ESAS-actuated systems or the emergency feedwater system, an independent review of the switching order is required when restoring the system to service. After restoration, applicable testing must be performed to demonstrate equipment operability. The systems covered by this independent verification requirement are listed in Table 3-6; i.e., enclosure 9 of AP1002. At the end of each shift, both ESAS and EFW readiness check lists and log sheets are reviewed by both oncoming and off-going operators (Reference 3-1). The independent verification requirement is an important consideration in the assessment of a system misalignment error and so is explicitly modeled when appropriate. Either remote light indications or visual sighting may be used to verify the position of switches and breakers covered by this requirement for independent verification. Remote indications may also be used for verification of valve positions. For manual valves, position verification is established by physically turning the valve in the closed direction (Reference 3-1).

Relative to the qualitative switching and tagging system levels defined in the NRC handbook (Reference 3-5), the system at TMI Unit 1 is judged to be level 2. The system has elements of a level 1 or excellent system because tags are uniquely identified by a separate line in the tagging application and a record is kept of each tag issued. However, the system also has some elements of a level 2 system. The duties of the tagging controller are frequently rotated among the operators, and no estimate of the expected time of return of the tag is made at the time it is issued. Therefore, the extra recovery factor for errors of omission or selection, which is associated with a level 1 system, are not credited. The nominal human error probabilities associated with a level 2 system are instead used in this evaluation.

3.3 OPERATOR STATIONS

The control room crew and support personnel were described in Section 3.1. The control room is located at Elevation 355' of the control room tower. The layout of the control room is shown in Figure 3-2. The control room "operator at the controls" must remain in the hatched area shown in the figure (Reference 3-2). The upright panels begin at the left with panel left and extend around to the right ending with panel right. Page phones are located adjacent to the console left, console center, and console right sections. All controls located in the control room are easily accessible to the operators. A brief description of the layout of controls in the control room is now provided.

The plant computer CRTs and printouts are located at the computer panel in the center of the control room. Controls for the primary system equipment are located mostly at console center and console right. Controls indications and alarms for the control rod drives and reactor trip, pressurizer, makeup, reactor coolant pumps, decay heat removal, emergency feedwater, reactor building spray, engineered safeguards power and actuation signals, reactor building emergency cooling, intermediate closed cooling water, turbine bypass valves, atmospheric dump valves, main feedwater, and the integrated control system are all found on these consoles. Console left has the controls for the main generator, main turbine (including turbine trip), secondary services closed and river water, and main feedwater pump start and trip. The back panels have the remaining controls for the secondary plant. Panel left has the controls for the instrument and service air systems and the reactor building purge system. Panel left front has the controls and indications for the circulating water system and the feedwater and condensate valves. Panel center left has indications for the main turbine. Panel center has indicating lights for the power supplies of the ICS/NNI systems. Large digital readouts are also displayed for key system parameters; i.e., saturation margin, primary system temperature (T_{hot} and T_{cold}) and pressure, and steam generator pressure. These displays can be read easily from the computer panel side of console center. Panel center right has additional indications and valve controls for engineered safeguards equipment. Panel right front has the radiation monitors and alarms for all the buildings. Panel right has the controls for the non-1E electrical buses downstream of the auxiliary transformers. Controls for breakers upstream of the auxiliary transformers are located on the substation panel, which is on the left side of the control room. The liquid waste disposal system panel, located near the right entrance to the control room, controls the reactor coolant drain tank, the bleed tanks, and the boric acid pumps.

There are three exits from the control room; one on either side of the shift superintendents' office at the bottom of Figure 3-2 and one behind panel right front.

In the event the control room must be abandoned, the operators are instructed to first ensure reactor trip and turbine trip, trip the main feedwater pumps, start emergency feedwater, and initiate emergency boration (Reference 3-6). These and other cooldown actions can also be accomplished outside the control room from a number of different local stations (Reference 3-6); i.e., generally from the switchgear supplying power to the equipment. The remote shutdown panel is in the control building, a floor below the control room; i.e., Elevation 322'. The remote shutdown panel allows the operator to control the atmospheric dump valves and the emergency feedwater flow control valves. Control for this equipment is transferred from the control room to the remote shutdown panel from outside the control room.

A number of the human actions defined in Section 1 require that the operators manipulate controls or equipment located outside the control room even if the control room is habitable. Dynamic human actions may be limited by the time required to reach these remote locations. Table 3-7 summarizes pertinent information about local control stations outside the control room where operators may have to go to perform some of the dynamic human actions included in the model. The relevant human actions, the equipment manipulated, the location of the control station, and some additional comments are provided for each of the dynamic human actions that require operator actions outside the control room. The comments in Table 3-7 indicate the likely members of the shift crew who would respond and whether radiation areas must be entered to accomplish the action. In estimating the amount of time it would take for an operator to reach the local station, it was recognized that auxiliary operators may already be in the area or at least in a nearby building. The times indicated for response should therefore not be interpreted as simple estimates of the transit times between the control room and the local stations. All other dynamic human actions included in the model can be performed remotely from the control room.

With regard to human action HNS6, any one of a number of heat exchanger loads may be the one leaking and require isolation. For the cooling loads located within the reactor building, some indications of a leak are provided outside the reactor building. In the intermediate building, flow indications are provided that allow one to determine whether the reactor building fan coolers are leaking. It would normally take 2 to 3 hours to enter the reactor building. However, in an emergency, it is expected that it could be entered in about 1 hour to isolate particular loads.

3.4 OPERATOR RESPONSE TIME LINES

This section presents the development of TMI-1 plant-specific, operator time lines for two important accident sequences. The intent is to illustrate the number of personnel available to carry out the actions required and to thereby demonstrate the adequacy of the existing number of personnel.

Figure 3-3 shows the operator time line for a general transient like one that would be initiated by a reactor or turbine trip. This particular accident sequence does not require an excessive number of personnel to perform the actions called for by procedure. The time line is not shown to scale in the figure but does illustrate the relative order of the actions. One reactor operator would be responsible for ensuring that both the reactor and the turbine trip. The operator is instructed to hit both the reactor trip and turbine trip buttons anytime the reactor/turbine trip procedure (i.e., 1210-1) is entered. These actions take only a few seconds. The reactor trip button is located on console center, and the turbine trip button is located on console left.

This same reactor operator would then also start the second makeup pump to maintain pressurizer level. The controls for makeup pump 1A (assume makeup pump 1B is already running) are located on console center. Similary, the controls for the decay heat closed and river water pumps, which must be started to provide cooling for makeup pump 1A, are also located on console center. Starting the second makeup pump and these support systems also only takes a few seconds.

The first reactor operator then also announces the reactor trip on the page system. Altogether, these actions would probably only take about 1 minute.

In parallel with the first reactor operator's actions, the auxiliary operators would also initiate posttrip actions. Each auxiliary operator carries with him a card with initial instructions about his responsibilities following a normal plant trip, a loss of offsite power, a loss of instrument air, and when the control room must be evacuated. For a normal plant trip, the secondary readings auxiliary operator would establish eighth-stage feedwater heating. This action would be performed locally at the north end of the fourth floor of the turbine building. This action is estimated to take about 45 minutes.

Meanwhile the secondary auxiliary operator is instructed to initiate the auxiliary boiler. The manual valves and controls needed to accomplish this action are located in the boiler area at the north end of the turbine building on the first floor. This action is estimated to require about 45 minutes.

The primary readings auxiliary operator would report to the north end of the second floor of the turbine building to adjust the lube oil temperature. He would then proceed to the east wall of the same floor to remove five of the six powdex vessels from service. Together, these actions are only estimated to take about 15 minutes.

After 6 to 8 minutes, the second reactor operator would initiate reactor cooldown. Normally, he would accomplish this by opening the turbine bypass valves from the control room. If the circulating water pumps are not available or the main condensor is for some other reason not available, he would instead initiate cooldown using the atmospheric dump valves. In either case, he would control the rate of RCS depressurization by opening the pressurizer spray valve. He would also turn off all pressurizer heaters. It is estimated that, within 10 minutes of a plant trip sample, the actions to initiate cooldown would be completed.

As can be seen in Figure 3-3, two of the auxiliary operators and the third reactor operator have no specific requirements for action and would be available to respond to any additional equipment failures. After only the first minute, the first reactor operator would also be available. This time line illustrates that the demands on the operating crew's time following a simple plant trip are minimal, so ample personnel would be available to respond to any abnormal conditions.

Figure 3-4 provides the operator response time line for a very severe personnel-demanding accident sequence; i.e., loss of offsite power with failure of diesel generator 1B. Total loss of all AC power is evaluated separately, as described in Section 4.3. For this accident sequence, it is expected that the shift foreman and the secondary readings auxiliary operator would report to the failed diesel and locally attempt recovery. A reactor operator would attempt diesel generator recovery from the control room. If recovery is not successful, it is judged that these three persons would not be released to perform other actions for about 1 hour. The recovery of the diesel would be assigned the highest priority until additional help arrives as a result of declaring an unusual event or an alert. A second reactor operator would meanwhile carry out the initially required actions in the plant trip procedure; i.e., 1210-1. He would also verify the automatic starting and loading of standby equipment when diesel 1A restores power. If train A of equipment is not automatically restarted, he would take action to manually initiate the equipment necessary to ensure nuclear services closed cooling, intermediate closed cooling, RCP seal injection, and RCS makeup are functional. This same reactor operator later then would initiate natural circulation cooldown and follow the progression of plant cooldown from 545°F to 200°F.

Only if an engineered safeguard activation signal occurred would the instrument air compressors be locked out. The third reactor operator would then be responsible for ensuring that compressed air was restored within 20 minutes of diesel generator 1A restarting. However, the coincident occurrence of a loss of offsite power and an ESAS signal is very unlikely.

The third reactor operator would be responsible for first injecting 4,814 gallons of boric acid (12,250 ppm boron) into the makeup tank, then into the RCS. This ensures that core shutdown margin is maintained during the cooldown. The third reactor operator should be able to complete the required boric acid makeup within the first hour. Afterward, he would be available to help ensure continued control building ventilation. Recall that, with train B of vital electric power unavailable, instrument buses powered from train B may be lost after train B batteries supplying DC power are depleted. Control building room dampers would then fail closed. The third reactor operator would be available to help establish alternate ventilation after the first hour. Any one of the three reactor operators would be available to establish long-term decay heat removal following natural circulation cooldown at about 8 hours.

The secondary auxiliary operator would report to the intermediate building to take manual control of the EFW flow control valves (EF-V30s) if necessary. His instructions are to remain there throughout the event. The primary readings auxiliary operator would report to the turbine-driven EFW pump (EF-P-1) to ensure proper operation and, if necessary, control the atmospheric dump valves (MS-V4A and MS-V4B) that are located in the same area. If both diesels are available, the blackout Procedure 1202-2 instructs the operators to load the pressurizer heaters onto a diesel. The secondary auxiliary operator would probably perform this action. Since this sequence includes failure of one diesel, this action is not required in this evaluation.

Another auxiliary operator would be assigned to rotate the main turbine by hand. This action would require his full attention for several hours. One other auxiliary operator would provide assistance in attempting to restore offsite power at the substation. If these efforts are unsuccessful, it is expected that he would be tied up pursuing this recovery action for at least the first hour. After the first hour, he would likely become available for other duties, as additional personnel report to assist in recovering offsite power.

The loss of offsite power sequence with diesel 1B also failed is one of the most limiting accident sequences insofar as demands on operations personnel are concerned. The above discussion indicates that the normal crew manning is sufficient to perform all the required actions. The shift supervisor and shift technical advisor would remain uncommitted and therefore available for continued accident sequence diagnosis and strategy. After the first hour, two of the reactor operators would be free for other duties. During the first half-hour, one reactor operator is uncommitted, and, during the second half-hour, an auxiliary operator is uncommitted. These observations indicate that if additional equipment failures were to occur, the operating crew should not be manpower-limited in attempting to respond. For example, if the 2-hour air bottles needed replacing, ample manpower is available with the normal crew manning to complete this action in time. Since this is true for such a manpower-demanding sequence, it is assumed to also be true for other accident sequences that are less demanding. In addition, for this limiting sequence, an alert would be declared that would bring additional personnel onsite within 1 hour. For other sequences with high demands on the number of personnel required, it is also very likely that an alert or site emergency would be declared. This would add substantially to the number of personnel available after the first hour.

3.5 TMI UNIT 1 PRELIMINARY TABLES FOR THE CONFUSION MATRIX

The procedure followed for developing a confusion matrix is described in Section 2.3.3. The first three preliminary tables prepared specifically for TMI Unit 1 are presented in this section as Tables 3-8, 3-9, and 3-10. In addition to the list of initiating events quantified in this study, three other accident sequences were included in the evaluation; inadvertent HPI, main steam line break in the reactor building, and ATWS. These events were added because of the initially perceived potential to confuse one of these events with the initiators that were quantified in detail.

Table 3-8 presents the expected plant response following each of the initiators evaluated in this study. The plant indications listed along the top axis of the table are those that the operator normally keys on to help him diagnose the event and select the appropriate procedure. The groups of alarms are identified in the footnotes for the table.

Table 3-9 summarizes the entry conditions for each procedure in terms of the same plant indications considered in Table 3-8. Not all procedures are evaluated. However, all 10 abnormal transient procedures in effect in April 1986, and a variety of other procedures judged to cover the initiators under consideration, were evaluated. By comparing the expected plant response in Table 3-8 with the procedure entry conditions in Table 3-9, one can judge which procedures the operator is most likely to consider applicable.

Table 3-10 then indicates the intended procedures to be entered and in what sequence they are expected to be followed for each initiator. If the entry conditions for some other procedure are met for a given initiator, or nearly met, such situations are then examined carefully to determine if there is some potential for misdiagnosis. Where the potential for misdiagnosis is judged to be significant, this is recorded in the confusion matrix described in Section 4.2.2. Also, the different plant responses in Table 3-8 for each initiator can be compared directly to see if they are similar enough to be confused. It is important, however, that the incorrectly selected procedure be identified so that any potential impact of this action can be noted and included in the model.

Table 3-11 was prepared to help identify the potential impacts of a given misdiagnosis. The actions called for in each procedure are identified in terms of the top events defined in the plant model. The "X" entries indicate those top event functions that the procedure instructs the operator to perform or to verify have been accomplished automatically. The "O" entries identify the actions called for in the procedure that are the opposite of, or that at least partially defeat, the functions represented by the corresponding top event in the plant model. When a potential for misdiagnosis is identified, the actions identified in the correct procedure, as summarized in this table, can be compared with those in the inadvertently selected procedure to determine what actions the operator might then omit or wrongly perform. If there is no significant impact, an "N" for negligible impact is entered in the confusion matrix. If a significant impact is identified, an "R" is entered to indicate that a rediagnosis is required. The specific impacts of each entry in the confusion matrix is discussed more fully in Section 4.2.2, where the confusion matrix is presented.

Table 3-12 documents the cross-references between the key procedures that were evaluated for potential misdiagnosis. It is readily apparent that there are many cross-references between the ATOG procedures; i.e., the 1210 series of procedures. Also, some of the other procedures instruct the operators to refer back to Procedure 1210-1 which puts them back into the abnormal procedure series. In considering the sequence of procedures followed for each initiator, particular attention should be given to those indications which lead the operators to select a procedure not normally transferred to from the original procedure selected.

3.6 TMI STATION PLANT-SPECIFIC DATA

This section reviews the available experience base at TMI station with regards to past human action performance. The source of information relied on for this qualitative review is Nuclear Power Experience (Reference 3-7) through September 1983. No attempt was made to extract quantitative human error rates from this source because of the potential for lack of completeness in the number of identified errors and because of the difficulty in determining the number of successful actions. Also, improvements in plant procedures since the TMI-2 accident in March 1979 is expected to lower the occurrence rate of such errors. Instead, this review was undertaken to identify the types of human errors that may occur. Since quantitative insights were not to be determined and Units 1 and 2 designs are similar in many ways, the experience of both units is included in the review although the operating crews for each unit are now completely separate.

Table 3-13 lists several errors that have occurred at the TMI units, resulting from such routine actions as equipment restoration following test or maintenance activities. Table 3-13 list 16 such errors, identifying the date reported, the unit and system affected, the type of routine action during which the error occurred, the number of trains affected, and some descriptive comments. The detection or recovery times are not always clearly identified in the referenced source, but some judgments can be made to estimate these time durations. Of those events reported, a large proportion of them involves actions in restoring systems following maintenance. A large proportion of such errors involves only one train of a redundant system. A key exception to this was the inadvertent valving out of all three trains of EFW on Unit 2, which played a role in the March 1979 accident at TMI-2. Several of the misalignment errors reported were discovered before the system was declared operable or prior to completion of the rise to power of the plant.

Figure 3-5 illustrates the distribution of detection or recovery times for such misalignment errors as those identified in Table 3-13. Often, such errors are detected by system operability tests performed prior to returning the system to service. Many of those errors that go initially undetected are then discovered within a day or two. Typical errors detected in the first day or two are mispositioned controls or errors that leave tell-tale signs (e.g., disassembled equipment or leaks) that may be visually discovered. Finally, errors that are only discovered at times later than a couple of days after they occur, but on or before the next system functional test, appear to be those that leave equipment functionally unavailable but that have either no visual indications that it is unavailable or that it is only locally positioned equipment (e.g., mispositioned manual valves) whose status attracts little attention.

These observations were considered in assigning the expected durations for each misalignment error included in the plant model (note the human actions classified as routine in Table 1-1).

Table 3-14 summarizes problems discovered at TMI Units 1 and 2 involving plant instrumentation. These events are reviewed here because such problems may mislead or confuse the operators and thereby contribute to a subsequent human error. Table 3-14 identifies the date of the reported problem, the unit affected, the system and instrument type involved, the number of instrument trains affected, the type of problem encountered, the detection or recovery time if available, and a brief description of the problem.

The instrument problems reported affect a variety of plant indications, but especially radiation monitors and level indications. Reported problems involving multiple indications or trains mostly involve level indications. Two problems involving redundant level indications, both of which occurred at Unit 2 after the accident, were probably caused by extreme environmental conditions, which are not present on Unit 1. The last problem listed in Table 3-14 occurred at Unit 1 and also involves a problem with level indications affecting multiple trains. This last event, which affected multiple trains, is believed adequately accounted for by the treatment adopted in this study of common cause failures of standby pumps.

In Table 3-14, the types of instrument problems are classified into four categories: not restored correctly, misleading indications, equipment failures, and environmental design. Of the 27 instrument problems listed in Table 3-14, 8 are said to involve human errors in restoring the instruments to service following test or maintenance activities. There were 14 problems involving instrument equipment failures of either the equipment itself or its power supplies, and there were 16 problems in which the instrumentation gave misleading results, and 5 problems that were caused by an abnormal environment for which the instrumentation was not designed. Each of these general causes of instrument problems would have to be investigated to thoroughly evaluate the impact of instrument problems on the operators' response. This detailed level of instrumentation review was not performed in the current study since the models for quantifying human errors are not currently sufficient to reflect such distinctions explicitly. However, the number and similarity of plant indications were considered qualitatively in judging the potential for misdiagnosis for each initiator.

Table 3-15 summarizes problems involving calibration of instrumentation at TMI Units 1 and 2. Calibration errors are explicitly modeled in the systems analyses for both RPS and ESAS. A multiple channel miscalibration of one parameter of the input to the RPS at Unit 1 occurred in its early years of operation. Whether a particular miscalibration is sufficiently in error to be called a system failure in the event a system demand occurred before it was detected must be determined on a sequence-specific basis. The miscalibration that was reported did, however, affect only one parameter, and multiple parameters should be present to initiate a reactor trip. The second and third miscalibration problems listed in Table 3-15 resulted from failures of common equipment, not as a result of human errors. The last problem listed resulted from an error in restoring the system following a calibration activity.

The experience base is limited with regard to dynamic human actions. Table 3-16 summarizes a number of observations about the response of plant personnel to previous sequences at TMI Units 1 and 2. Included in the listed observations are successes (i.e., items 2 and 10) as well as problems that may have arisen. With the exception of item 1, which is not a concern to plant safety, all the problems involving dynamic human actions occurred at Unit 2. The recovery or detection times listed in the table provide some indication of when correct actions may be taken in real life situations. However, it should be repeated that the experience base for dynamic human actions at Unit 1, as reported in Reference 3-7, is extremely limited. The observations listed could not be used quantitatively in the assignment of error rates.

3.7 REFERENCES

3-1. GPU Nuclear Corporation, Administrative Procedure 1029, Revision 20, "Conduct of Operations," November 12, 1985.

3-2. GPU Nuclear Corporation, Administrative Procedure 1014, Revision 13, "Administration of the TMI-1 Initial Response and Emergency Support Duty Roster," February 19, 1985.

3-3. GPU Nuclear Corporation, Administrative Procedure 1001G, Revision 11, "Procedure Utilization," December 20, 1985.

3-4. GPU Nuclear Corporation, Administrative Procedure 1002, Revision 37, "Rules for the Protection of Employees Working on Electrical and Mechanical Apparatus," December 23, 1985.

3-5. Swain, A.D., and H.E. Guttmann, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," Sandia National Laboratories, prepared for U.S. Nuclear Regulatory Commission, NUREG/CR-1278, SAND80-0200, August 1983.

3-6. GPU Nuclear Corporation, Emergency Procedure 1202-37, Revision 16, "Cooldown from Outside the Control Room," September 8, 1983.

3-7. Petroleum Information Corporation, Nuclear Power Experience, September 1983.

TABLE 3-1. SHIFT MANNING REQUIREMENTS

Personnel	Plant Technical Specifications Requirements (Table 6.2-1, when > 200°F)	Administrative Procedure 1029 Requirements (plant > 200°F RCS temperature)	Actual Duty Roster as of Early 1986
Senior Reactor Operators	One	Two (shift supervisor, shift foreman)	Two (shift supervisor, shift foreman, both SRO licensed)
Control Room Operators	Three	Three (two are reactor operator qualified)	Four (three reactor operators, reactor operator licensed, plus one trainee)
Auxiliary Operators	Two	Five	Seven (six auxiliary operators - A, one auxiliary operator - C)
Shift Technical Advisor (STA)	One	One	One

TABLE 3-2. EXCERPT FROM PROCEDURES INDEX REPORT FOR TMI UNIT 1
RECORD TYPE: 049-25 ALARM RESPONSE PROCEDURES

Procedure Number	Revision	Effdate	Title
PLB-6-6	000002	830118	Panel Left Annunciator B; Reactor Building Ventiltion Fan IC
PLB-6-7	000001	850402	Panel Left Annunciator B; Amertap Trouble
PLB-6-8	000001	850402	Panel Left Annunciator B; River Rake or Screens Trouble
PLB-6-9	000001	850402	Panel Left Annunciator B; Reactor Building Purge Supply Fan, Low Flow
PLB-6-10	000003	850402	Panel Left Annunciator B; Reactor Building Purge Exhaust Fan, High Flow
PLB-7-1	000002	850402	Panel Left Annunciator B; Auxiliary Building Filter 1 Manual Deluge
PLB-7-2	000002	850402	Panel Left Annunciator B; Auxiliary Building Filter 2A and 2D Manual Deluge
PLB-7-3	000003	850402	Panel Left Annunciator B; Circulating Water Pump House Sprinkler
PLB-7-4	000002	840829	Panel Left Annunciator B (PLB); EFP Room "A" Sump Level High
PLB-7-5	000001	830420	Panel Left Annunciator B; 1B Building Spray Pump Compartment
PLB-7-6	000001	850402	Panel Left Annunciator B; Turbine Plant Chemical Feed Trouble
PLB-7-7	000001	821228	Panel Left Annunciator B (PLG); River Chlorinator Trouble
PLB-7-8	000002	850402	Panel Left Annunciator B; Circulating Water Chlorinator Trouble
PLB-7-9	000001	821228	Panel Left Annunciator B (PLB); Reactor Building Purge Supply Duct, High Temperature

TABLE 3-3. PROCEDURES INDEX REPORT FOR TMI UNIT 1
RECORD TYPE: 049-36 ABNORMAL TRANSIENT PROCEDURES

Procedure Number	Revision	Effdate	Title
1210-1	000010	851223	Reactor/Turbine Trip
1210-2	000007	850410	Loss of 25°F Subcooled Margin
1210-3	000006	850308	Excessive Cooling
1210-4	000006	850308	Lack of Primary to Secondary Heat Transfer
1210-5	000006	850308	OTSG Tube Leak/Rupture
1210-6	000005	850308	Small Break LOCA Cooldown
1210-7	000006	850308	Large Break LOCA Cooldown
1210-8	000006	850314	RCS Superheated
1210-9	000006	850314	HPI Cooling - Recovery from Solid Operations
1210-10	000007	850816	Abnormal Transients Rules, Guides, and Graphs

TABLE 3-4. PROCEDURES INDEX REPORT FOR TMI UNIT 1
ABNORMAL PROCEDURES

Procedure Number	Revision	Effdate	Title
1203-1	000011	850128	Load Rejection
1203-5	000008	850410	High Cation Conductivity in the Condensate and/or Feedwater System
1203-7	000017	850820	Hand Calculations for Quadrant Power Tilt and Core Power Imbalance
1203-10	000006	850314	Unanticipated Criticality
1203-15	000009	831222	Loss of Reactor Coolant Makeup
1203-16	000018	850604	Reactor Coolant Pump and Motor Malfunction
1203-19	000006	831222	River Water System Failure (DR/SR)
1203-20	000007	850107	Nuclear Services Closed Cooling System Failure
1203-21	000005	831222	SSCC System Failure
1203-24	000019	831222	Steam Leak
1203-28	000010	850820	Post-Accident H_2 Purge
1203-34	000007	851230	Control Building Ventilation System
1203-40	000014	850128	Loose Parts Monitor System
1203-41	000005	850226	Low System (Grid) Voltage
1203-42	000004	850226	Inadvertent Closure of a Main Steam Isolation Valve
1203-43	000002	830211	Transfer Canal Seal Plate Gasket Failure
1203-44	000007	850402	Hazardous Releases

TABLE 3-5. PROCEDURES INDEX REPORT FOR TMI UNIT 1
EMERGENCY PROCEDURES

Sheet 1 of 2

Procedure Number	Revision	Effdate	Title
1202-2	000015	850305	Station Blackout
1202-2A	000013	850226	Station Blackout With Loss of Both Diesel Generators
1202-08	000026	850815	CRD Equipment Failures - CRD Malfunction Action
1202-9A	000011	850619	Loss of "A" DC Distribution System
1202-9B	000009	850619	Loss of "B" DC Distribution System
1202-11	000012	850606	High Activity in Reactor Coolant
1202-12	000024	851113	Excessive Radiation Levels
1202-13	000011	850305	Plant Response to Penetration of the Protected Area
1202-14	000021	850927	Loss of Reactor Coolant Flow, Reactor Coolant Pump Trip
1202-17	000006	831222	Loss of Intermediate Cooling System
1202-26	000010	831222	Loss of Feed to One Steam Generator
1202-29	000028	860106	Pressurizer System Failure
1202-30	000015	851209	Earthquake
1202-31	000024	850926	Fire
1202-32	000015	851114	Flood
1202-35	000012	850808	Loss of Decay Heat Removal System
1202-36	000011	841012	Loss of Instrument Air
1202-37	000025	850924	Cooldown from Outside the Control Room
1202-38	000014	850305	Nuclear Services River WAter Failure
1202-40	000006	850628	Total Loss of ICS/NNI Power

TABLE 3-5 (continued)

Procedure Number	Revision	Effdate	Title
1202-41	000007	850830	Total or Partial Loss of ICS/NNI Hand Power
1202-42	000007	850830	Total or Partial Loss of ICS/NNI Auto Power
1202-43	000000	851030	Total or Partial Loss of ICS/NNI HEX, HEY, or Auxiliary Power

TABLE 3-6. EMERGENCY FEEDWATER AND ESAS SYSTEMS AND COMPONENTS
(Requiring Two Independently Developed and Executed Switching Orders)

1. Reactor Building Spray (engineered safeguards) System
2. Containment Isolation Valves and components, as described in OP 1101-3 Containment Integrity and Access Limits
3. Low Pressure Injection (decay heat) System
4. Emergency Diesels
5. Engineered Safeguards Power Supplies
6. Engineered Safeguards Actuation Circuitry
7. Emergency Feed Water System
8. High Pressure Injection (makeup) System
9. Reactor Building Emergency Cooling System
10. Nuclear Service Closed System
11. Nuclear Service River System
12. Decay Heat Closed System
13. Decay Heat River System
14. Core Flood System
15. Reactor Building Cooling System

TABLE 3-7. SUMMARY OF LOCAL STATIONS FOR DYNAMIC HUMAN ACTIONS

Human Action	Equipment	Location	Comments
HAM1	Instrument Air Dryer Bypass	Intermediate Building Elevation 281'	(Drawing 1E-156-02-001, COORD F-7) No Radiation; Secondary Auxiliary Operator Responds within 5 Minutes
HCD2	Atmospheric Dump Valves MS-V4A, MS-V4B	Intermediate Building Elevation 281'	(Drawing 1E-156-02-001, COORD D-7) No Radiation; Secondary Readings Auxiliary Operator Responds within 5 Minutes after Being Notified by Control Room Operator
	Decay Heat Removal Injection Valves DH-V4A, DH-V4B	Auxiliary Building Elevation 281'	(Drawing 1E-154-02-002, COORD F-6) Primary Auxiliary Operator Responds within 15 Minutes after Being Notified by Control Room Operator; Radiation and Contamination Possible
HCV5	Control Building Ventilation Damper	Control Building Elevation 322' Elevation 338'6"	(Drawing 1E-155-02-002) Secondary Auxiliary Operator Responds within 15 Minutes; No Radiation or Contamination
HCV4 HCV8 HCV9	Standby Control Building Ventilation	Turbine Building Elevation 305'	(Drawing 1E-151-02-001, COORD B-4) Initial Equipment Location
		Control Building Elevation 322' and Elevation 338'6"	(Drawing 1E-155-02-002) Location for Ventilation Use
			Auxiliary Operator plus Others (shift foreman or maintenance people) Should Be Capable of Starting Ventilation within 30 Minutes; No Radiation

TABLE 3-7 (continued)

Sheet 2 of 5

Human Action	Equipment	Location	Comments
HEF1 HEF4	2-Hour Air	Diesel Building Elevation 305'	(Drawing 1E-157-02-001, COORD D-5) No Radiation; Response Time 5 Minutes by Secondary Readings Auxiliary Operator
	EF-V30A, EF-V30B	Intermediate Building Elevation 281'	(Drawing 1E-156-02-001, COORD F-7) No Radiation; Response Time 5 Minutes by Secondary Auxiliary Operator
HEF2	EF-V30A, EF-V30B	Intermediate Building Elevation 281'	(Drawing 1E-156-02-001, COORD F-7) Response Time 5 Minutes by Secondary Auxiliary Operator; No Radiation
HEF3	2-Hour Air	Diesel Building Elevation 305'	(Drawing 1E-157-02-001, COORD D-5) Response Time 5 Minutes by Secondary Readings Auxiliary Operator; No Radiation
HHL1B	DH-V1, DH-V2	Reactor Building Elevation 281'	(Drawing 1E-153-02-001, COORD D-4) Anticontamination Clothing Required due to Contamination; Air Filter may Also Be Required; Takes 2 to 3 Hours from Time Notified for Primary Auxiliary Operator To Open Valves
	DH-V3	Auxiliary Building Elevation 281'	(Drawing 1E-154-02-002, COORD E-6) Anticontamination Clothing Possibly Needed; Not Highly Contaminated Area; Time to Respond -- 0.5 to 1 Hour by Primary Readings Auxiliary Operator

TABLE 3-7 (continued)

Sheet 3 of 5

Human Action	Equipment	Location	Comments
HINJ2 HINJ3	MU-V76A, MU-V76B	Auxiliary Building Elevation 281'	(Drawing 1E-154-02-002, COORD F-5) Primary Auxiliary Operator Responds in 20 to 30 Minutes; High Radiation Area; Anticontamination Clothing Required
HINJ4	MU-V20	Auxiliary Building Elevation 305'	(Drawing 1E-154-02-003, COORD E-6) Primary Auxiliary Operator Responds within 10 to 15 Minutes; Area Normally Contaminated Requiring Anticontamination Clothing
HLT1B HLT2	BWST Borated Water Storage Tank	Outside	(Drawing 1E-154-02-003, COORD B-8) No Radiation; Emergency Response Personnel Fills Tank by Truck or Hose, whichever More Readily Available
HNS1	Nuclear Services Heat Exchanger	Auxiliary Building Elevation 271' NS-C-1A, NS-C-1B, NS-C-1C, NS-C-1D	Drawing 1E-154-02-001, COORD B-7 No Radiation; Easy Access; Primary Auxiliary Operator Should Respond within 10 to 15 Minutes
HNS6	Nuclear Services Heat Exchanger Loads	Auxiliary Building	(Drawing 1E-154-02-002, COORD D-4 and D-5 and Drawing 1E-154-02-002, COORD E-5) Evaporator Coolers; Makeup Pump 1B Cooler; Radiation and Contamination; Primary Auxiliary Operator
		Control Building	(Drawing 1E-155-02-001, COORD C-6) Secondary Auxiliary Operator; Air Conditioning Chillers Coolers; No Radiation

TABLE 3-7 (continued)

Sheet 4 of 5

Human Action	Equipment	Location	Comments
		Fuel Handling Building	(Drawing 1E-154-02-002, COORD F-5 and Drawing 1E-154-02-003, COORD F-5) Spent Fuel Coolers; Seal Return Coolers; Slight Contamination and Radiation; Primary Auxiliary Operator
		Reactor Building	(Drawing 1E-153-02-003, COORD D-5 and F-5-RCPS and Drawing 1E-153-02-001, COORD D-6, E-6, and F-6) RCP Motors; Fan Motor Coolers; Primary Auxiliary Operator Requires Anticontamination Clothing; Fans
		Intermediate Building	(Drawing 1E-156-02-002, COORD F-7) Area Coolers; No Radiation; Second Auxiliary Operator; Flow Indication for Reactor Building Air Coolers
HNS7A HNS7B	NS-P-1A, NS-P-1B, NS-P-1C	Auxiliary Building Elevation 305'	(Drawing 1E-154-02-003, COORD D-7) No Radiation or Contamination; Primary Auxiliary Operator Responds within 15 Minutes
HNS8A	Pump Discharge Valves NR-V-1A NR-V-1B NR-V-1C	River Water Pump House	(Drawing 1E-168-02-002, COORD E-4, F-4, and G-4) Outbuilding Auxiliary Operator Would Locally Close Valves within 20 Minutes; No Radiation
HRE2 HRE4	Screens SR-5-3A SR-5-3B SR-5-3C	Intake Screen and Pump House Elevation 308'	(Drawing 1E-168-02-002, COORD E-6, F-6, and G-6) Outbuilding Auxiliary Operator Starts Trying To Wash Screens Within 20 Minutes; No Radiation

TABLE 3-7 (continued)

Sheet 5 of 5

Human Action	Equipment	Location	Comments
HTC1 HTC2	MS-V13A MS-V13B	Intermediate Building Elevation 281'	(Drawing 1E-156-02-001, COORD D-7) Secondary Operator Responds within 10 Minutes; No Radiation
HTH3	MU-V16A MU-V16B	Auxiliary Building Elevation 305'	(Drawing 1E-154-02-003, COORD E-7) Primary Auxiliary Operator Would Respond within 5 Minutes; Anticontamination Clothing Required
HVB1	Inverters 1E, 1B, or 1D	Control Building Elevation 322'	(Drawing 1E-155-02-002, COORD F-6 and G-6) Secondary Auxiliary Operator Responds within 15 Minutes; No Radiation or Contamination

PLANT RESPONSE INDICATIONS / INITIATING EVENT	ROD BOTTOM LIGHTS	REACTOR TRIP ALARM	SUBCOOLED MARGIN	FIRE AND SMOKE ALARM	RMA 5	MAKEUP TANK LEVEL	MAKEUP FLOW	RCS PRESSURE	REACTOR BUILDING PRESSURE	INCORE THERMOCOUPLE	CFT LEVEL	PRESSURIZER LEVEL	RCS FLOW	OTSG LEVEL	OTSG PRESSURE	EFW FLOW	MFW FLOW	T_{cold}	230 kV BUS VOLTS	1D AND 1E BUS VOLTS	DIESEL GENERATOR VOLTS AND FREQUENCY	ALARMS(1)*	ALARMS(2)
ICS MALFUNCTION (ATA LOSS)(11)	ON	ON	D			D	U	D				D		U	U		U	D					
LOSS OF RIVER WATER																							
LOSS OF MAIN FEED(12)	ON	ON	U			D	U	U				U		D	U	U	0%	U					
LOSS OF OFFSITE POWER	ON	ON	U				D	U		U		U	0%	U	U	U	0%	U	0%	X	U	ON	
STEAM GENERATOR TUBE RUPTURE(13)	ON	ON	D		U	D	U	D				D		U	U		D	U					
REACTOR TRIP	ON	ON	U			D	U	X				D		D	U		D	U					
TURBINE TRIP(14)	ON	ON	U			D	U	D				D		D	U		D	U					
LOSS OF CONTAINMENT BUILDING VENTILATION(15)																							
EXCESSIVE FEEDWATER(16)	ON	ON	D			D	U	D				D		U	D		U	D					
LOSS OF DC TRAIN A(17)	ON	ON	U			D	U	D				D		D	U	X	D	U			U	ON	
V-SEQUENCE(18)	ON	ON	D			D	U	D				D		D	U		D	D			U		
LOSS OF INSTRUMENT AIR(19)	ON	ON	U				D	D				D	0%	U	U	X	D	D					
LARGE LOCA	ON	ON	D				0%	D	U		D	0%	0%	D	D	U	D	D			U		
MEDIUM LOCA	ON	ON	D				0%	D	U		D	0%	0%	D	D	U	D	D			U		
SMALL LOCA(20)	ON	ON	D			D	U	D	U			D		D	U		D						
VERY SMALL LOCA						D	U	D				D											
TURBINE BUILDING SLB	ON	ON	D				0%	D				D		D	D	U	0%	D			U		
INTERMEDIATE BUILDING SLB	ON	ON	D				0%	D				D		D	D	U	0%	D			U		
TOXIC CHEMICAL RELEASE																							
STATION BLACKOUT(21)	ON	ON	U				0%	U		U		U	0%	U	U	U	0%	U	0%	0%	0%	ON	O
FIRE AT 1P OR 1S				ON			D																
SEISMIC DC LOSS(22)	ON	ON	U			D	U	D				D		D	U	X	D	U			U	ON	
NSCCW FAILURE																							
INADVERTENT HPI(23)			U					U		D		U						D			U		
MSLB IN REACTOR BUILDING(24)	ON	ON	D				0%	D	U			D		D	D	U	0%	D			U		
ATWS(25)		ON				U	D	U		U		U		D	U	U	0%	U					

*SEE SHEET 2 OF 2 FOR FOOTNOTES.

LEGEND:

ON – INITIATION OF A SYSTEM OR ALARM
OFF – INDICAT[illegible]S LOST
U – INDICATION GOES UPSCALE
D – INDICATION GOES DOWNSCALE
0% – INDICATION OF 0% OF MEASURED PARAMETER

X – INDICATION MAY GO UPSC
DEPENDING ON THE SPECI
1/2 – THE FEEDWATER CONTRO
THE MIDPOSITION

T_{avg}	DELTA T_{cold}	FEEDWATER VALVE INDICATOR	ALARMS(3)	ALARMS(4)	ALARMS(5)	SECONDARY RIVER SYSTEM PRESSURE	RMA-1 ALARM	AIR INTAKE ALARM	SEISMIC ALARM	ALARMS(6)	ALARMS(7)	AC LIGHTS(8)	ALARMS(9)	ALARMS(10)	REACTOR BUILDING SUMP LEVEL	REACTOR BUILDING RADIATION LEVEL
D		1/2			ON											
				ON		D				ON						
U		X														
U			ON													
		D														
D		D														
D		D														
D		U														
D		D														
D		D					ON									
U		X	ON													
D		D													U	U
D		D													U	U
															U	U
															U	U
D	U	D														
D	U	D														
								ON								
U		D										OFF				
D		D							ON							
											ON					
D																
D	U	D													U	
U																

LE OR DOWNSCALE
IC SEQUENCE
VALVES FAIL TO

8806210078-02

TABLE 3-8. EXPECTED PLANT RESPONSE
TO EACH INITIATOR

1. Loss of "A" DC Distribution Alarms

- A-2-7 Battery Charger A/C/E Trouble
- A-1-7 Battery 1A Ground
- D-2-5 Battery Discharging
- C-2-2 4-kV Bus Trouble
- C-1-2 7-kV Bus Trouble
- C-3-2 480V Bus Trouble
- A-3-7 A/C/E Inverter System Trouble
- A-4-2 Control Building Battery Charger A Damper Trouble, Fire-Smoke

2. Loss of Intermediate Closed Cooling System (1202-17) Alarms

- IC Pump Discharge Pressure Low Alarm
- IC System Flow Low Alarm
- IC System CRD Cooling Flow Low Alarm
- IC Surge Tank High/Low Alarm
- IC Surge Tank High/Low Alarm-Bailey Computer
- IC Surge Tank High/Low Alarm
- IC Cooler Outlet Temperature High Alarm
- CRD Stator Temperature High Alarm
- IC Reactor Coolant Pump Cooling Outlet Temperature High Alarm

3. Loss of Instrument Air (1202-36) Alarms

- Instrument Air Low Pressure Alarms
  - Turbine Building
  - Auxiliary Building
  - Service Air Low Pressure
- Low Pressure on IA/SA Pressure Indicators

4. Nuclear Service River Water System Failure (1202-38) Alarms

- Screen House Pump Water Lubrication Delta Pressure Low Alarm
- River Water Pump Strainer Delta Pressure High Alarm
- Nuclear Service Heat Exchanger Outlet Temperature High Alarm
- IC Cooler Outlet Temperature High Alarm
- Loss of Pressure in NSRW (PI-217)
- Increasing IC Outlet Temperature (IC6-TI)

5. ICS Power Failure (1202-40) Alarms

- All ICS/NNI Hand/Automatic Stations Fail to Midscale
- All ICS/NNI Hand/Automatic Stations Hand/Automatic Lights Go Off
- ATA Power Lost Alarm
- ICS System Power Transfer Alarm
- Loss of ICS/NNI Feed Alarm
- ICS/NNI Subfeed Lights on Panel PCL Deenergize

6. River Water System Failure (1203-19) (DR/SR) Alarms

- River Water Pump Strainer Differential Pressure High Alarm
- 480V Engineered Safeguards Motor Overload Alarm
- 480V Engineered Safeguards Motor Trip Alarm
- 480V Motor Overload Alarm
- 480V Motor Trip Alarm

7. Loss of Nuclear Services Closed Cooling System (1203-20) Alarms

- Nuclear Services Surge Tank Pressure Low Alarm
- Nuclear Services Cooling Pump Discharge Pressure Low Alarm
- Nuclear Services Surge Tank Low-Level Alarm
- Nuclear Services Heat Exchanger Outlet Temperature High Alarm
- Components Cooled by NSCCW High Temperature Alarms

8. AC Lighting Off. After a blackout event, the only lights on in the plant will be the circuits supplied from batteries.

9. Secondary Services Closed Cooling System Failure (1203-21) Alarms

- SSCCW Pump Discharge Pressure Low Alarm
- SSCCW Surge Tank Level High/Low Alarm
- Components Cooled by SSCCW High Temperature Alarms

10. Loss of Decay Heat Removal System (1202-35) Alarms

- Increasing RCS Temperature when on DHR
- Decay Heat Removal 1A/B Flow Low Alarm
- Decay Heat Out Decay Heat Removal Cooler A/B Temperature High Alarm
- Pressurizer Level High/Low Alarm
- 4-kV Engineered Safeguards Motor Trip Alarm
- Increasing RCS P ure
- Decay Heat Remova ystem Valve Closed or Partially Closed

11. ICS Malfunction. Some ICS failures can result in trip, while others may cause a reactor trip due to system perturbations, resulting in over or under-cooling transients. This initiator is evaluated for loss of instrument bus ATA, which leads to an overcooling.

12. Loss of Main Feedwater. Emergency feedwater start is initiated by the heat sink protection system. The effects on makeup tank level and makeup flow are delayed until after reactor trip.

13. Steam Generator Tube Rupture. It is assumed the rupture is of sufficient magnitude to cause a reactor trip.

14. Turbine Trip. A turbine trip occurring above 20% power automatically causes a reactor trip.

15. Loss of Control Building Ventilation. Indicated by heating and ventilation panel alarms and increasing control building temperatures. The initiator considered here would not result in a high radiation alarm or an air-intake alarm.

16. Excessive Feedwater. A reactor trip occurs due to high power or low RCS pressure.

17. Loss of DC Train A. EF-P-1 starts due to MS-V-13A failing open, but no EFW flow will be present. Diesel generator A will start but not load. Vacuum in the main condenser may be lost due to vacuum pump suction valve closure. This could lead to main feedwater system failure.

18. V-Sequence. There are numerous radiation monitor alarms and indications along with cubicle leak detector and auxiliary building sump level indications that will alert the operator to the LOCA in the building. However, there is no procedure dealing with this specific problem.

19. Loss of Instrument Air. EF-P-1 will start when air pressure is lost at MS-V-13A or MS-V-13B, causing them to fail open.

20. Small LOCA. RCS pressure stays high long enough that the core flood tanks are not needed for cooling and the operator isolates them during the cooldown.

21. Station Blackout. Loss of offsite power, and both onsite diesel generators fail.

22. Seismic DC Loss. All DC power trains are assumed lost, but vital AC power is still available.

23. Inadvertent HPI. A spurious 1,600-psig ESAS signal initiates HPI. Neither a LOCA nor an excessive cooldown is in progress.

24. MSLB in Reactor Building. This main steam line break results in increasing reactor building pressure.

25. ATWS. A plant trip condition occurs, but the control rods do not go in. The plant trip is assumed caused by a loss of main feedwater.

TABLE 3-8 (continued)

PLANT RESPONSE INDICATIONS(1)* / PROCEDURES	ROD BOTTOM LIGHTS	REACTOR TRIP ALARM	SUBCOOLED MARGIN	FIRE AND SMOKE ALARM	RMA 5	MAKEUP TANK LEVEL	MAKEUP FLOW	RCS PRESSURE	REACTOR BUILDING PRESSURE	INCORE THERMOCOUPLE	CFT LEVEL	PRESSURIZER LEVEL	RCS FLOW	OTSG LEVEL(2)	OTSG PRESSURE	EFW FLOW	MFW FLOW	T_{cold}	230 kV BUS VOLTS	1D AND 1E BUS VOLTS	DIESEL GENERATOR VOLTS AND FREQUENCY	ALARMS(3)	ALARMS(4)	
1210-1 REACTOR/TURBINE TRIP	ON	ON					U	(X)	(U)				(D)	X	X		(D)	X	(0%)					(
1210-2 LOSS OF SCM			D					D		U														
1210-3 EXCESSIVE COOLING(13)															(D)			(D)						
1210-4 LACK OF PSHX(14)													0%		U									
1210-5 SGTR			D		U									U										
1210-6 SMALL BREAK LOCA COOLDOWN			0%					U	U					X	D			D						
1201-7 LARGE BREAK LOCA COOLDOWN									U		D													
1210-8 RCS SUPERHEATED										U														
1210-9 HPI COOLING			U									U	0%	(X)	U	0%	0%							
1210-10 ATOG RULES(15)															U	0%	0%							
1202-2 LOSS OF OFFSITE																			(0%)	X	U			
1202-2A BLACKOUT																			0%	0%	0%			
1202-9A LOSS OF "A" DC																						ON		
1202-17 LOSS OF ICCW																							ON	
1202-26 PARTIAL LOFW								U						D			D							
1202-29 PRESSURIZER SYSTEM FAIL			D			D	U	X				X							0%					
1202-30 EARTHQUAKE																								
1202-31 FIRE				ON																				
1202-35 LOSS OF DHR								U										U						
1202-36 LOSS OF INSTRUMENT AIR																			(0%)					
1202-37 COOLDOWN OUTSIDE CONTROL ROOM				ON																				
1202-38 NSRW FAIL																								
1202-40 ICS POWER FAIL																								
1203-19 RIVER WATER SYSTEM FAIL																								
1203-20 NSCCS FAIL																								
1203-21 SSCCS FAIL																								
1203-24 STEAM LEAK							U	D	U			D			D			D						
1203-34 CONTAINMENT BUILDING VENTILATION FAIL(16)									(U)										(0%)					
1102-11 COOLDOWN				ON																				
1102-16 NATURAL CIRCULATION COOLDOWN								U										U	0%					

*SEE SHEET 2 OF 2 FOR FOOTNOTES.

LEGEND:

ON – INITIATION OF A SYSTEM OR ALARM
OFF – INDICATION IS LOST
U – INDICATION GOES UPSCALE
D – INDICATION GOES DOWNSCALE
0% – INDICATION OF 0% OF MEASURED PARAMETER
X – INDICATION MAY GO UPSCAL[E] BUT WILL DEVIATE FROM TH[E]
( ) – THIS INDICATION ALONE TEL[LS] TO ENTER THE REFERENCED

	DELTA T_{cold}	FEEDWATER VALVE INDICATOR	ALARMS(5)	ALARMS(6)	ALARMS(7)	SECONDARY RIVER SYSTEM PRESSURE	RMA-1 ALARM	AIR INTAKE ALARM	SEISMIC ALARM	ALARMS(8)	ALARMS(9)	AC LIGHTING OFF(10)	ALARMS(11)	ALARMS(12)	REACTOR BUILDING SUMP LEVEL	REACTOR BUILDING RADIATION LEVEL
)																
															U	U
															U	U
												OFF				
	U	D														
									ON							
														ON		
			(ON)													
				ON												
					ON											
						D				ON						
											ON					
													ON			
								ON								
									ON							
			ON													

OR DOWNSCALE,
NORMAL VALUE
S THE OPERATOR
ROCEDURE

TABLE 3-9. PROCEDURE ENTRY INDICATIONS

8806210078-04

1. The grouping of alarms are as defined in the footnotes for Table 3-8.

2. If OTSG level is upscale and cannot be restored due to excessive cooling, then this indication alone, in Procedure 1210-3, would tell the operator to enter the HPI cooling Procedure 1210-9.

3. Loss of "A" DC Distribution Alarms

- A-2-7 Battery Charger A/C/E Trouble
- A-1-7 Battery 1A Ground
- D-2-5 Battery Discharging
- C-2-2 4-kV Bus Trouble
- C-1-2 7-kV Bus Trouble
- C-3-2 480V Bus Trouble
- A-3-7 A/C/E Inverter System Trouble
- A-4-2 Control Building Battery Charger A Damper Trouble, Fire-Smoke

4. Loss of Intermediate Closed Cooling System (1202-17) Alarms

- IC Pump Discharge Pressure Low Alarm
- IC System Flow Low Alarm
- IC System CRD Cooling Flow Low Alarm
- IC System CRD Cooling Outlet Temperature High Alarm
- IC Surge Tank High/Low Alarm
- IC Surge Tank High/Low Alarm-Bailey Computer
- IC Surge Tank High/Low Alarm
- IC Cooler Outlet Temperature High Alarm
- CRD Stator Temperature High Alarm
- IC Reactor Coolant Pump Cooling Outlet Temperature High Alarm

5. Loss of Instrument Air (1202-36) Alarms

- Instrument Air Low Pressure Alarms
  - Turbine Building
  - Auxiliary Building
  - Service Air Low Pressure
- Low Pressure on IA/SA Pressure Indicators

6. Nuclear Service River Water System Failure (1202-38) Alarms

- Screen House Pump Water Lubrication Delta Pressure Low Alarm
- River Water Pump Strainer Delta Pressure High Alarm
- Nuclear Service Heat Exchanger Outlet Temperature High Alarm
- IC Cooler Outlet Temperature High Alarm
- Loss of Pressure in NSRW (PI-217)
- Increasing IC Outlet Temperature (IC6-TI)

7 ICS Power Failure (1202-40) Alarms

- All ICS/NNI Hand/Automatic Stations Fail to Midscale
- All ICS/NNI Hand/Automatic Stations Hand/Automatic Lights Go Off
- ATA Power Lost Alarm
- ICS System Power Transfer Alarm
- Loss of ICS/NNI Feed Alarm
- ICS/NNI Subfeed Lights on Panel PCL Deenergize

8. River Water System Failure (1203-19) (DR/SR) Alarms

- River Water Pump Strainer Differential Pressure High Alarm
- 480V Engineered Safeguards Motor Overload Alarm
- 480V Engineered Safeguards Motor Trip Alarm
- 480V Motor Overload Alarm
- 480V Motor Trip Alarm

9. Loss of Nuclear Services Closed Cooling System (1203-20) Alarms

- Nuclear Services Surge Tank Pressure Low Alarm
- Nuclear Services Cooling Pump Discharge Pressure Low Alarm
- Nuclear Services Surge Tank Low-Level Alarm
- Nuclear Services Heat Exchanger Outlet Temperature High Alarm
- Components Cooled by NSCCW High Temperature Alarms

10. AC Lighting Off. After a blackout event, the only lights on in the plant will be the circuits supplied from batteries.

11. Secondary Services Closed Cooling System Failure (1203-21) Alarms

- SSCCW Pump Discharge Pressure Low Alarm
- SSCCW Surge Tank Level High/Low Alarm
- Components Cooled by SSCCW High Temperature Alarms

12. Loss of Decay Heat Removal System (1203-35) Alarms

- Increasing RCS Temperature when on DHR
- Decay Heat Removal 1A/B Flow Low Alarm
- Decay Heat Out Decay Heat Removal Cooler A/B Temperature High Alarm
- Pressurizer Level High/Low Alarm
- 4-kV Engineered Safeguards Motor Trip Alarm
- Increasing RCS Pressure
- Decay Heat Removal System Valve Closed or Partially Closed

13. Excessive primary to secondary heat transfer is defined as:

- OTSG Pressure Lower than Normal
- RCS T_{cold} Lower than Normal

14. Lack of primary to secondary heat transfer is defined as OTSG pressure higher than normal for the RCS T_{cold}.

15. The status of primary to secondary heat transfer recognition is determined by consideration of:

- OTSG Level and Pressure Control
- RCS T_{cold} Controlled by OTSG Pressure
- Forced or Natural RCS Circulation

16. The entry conditions for Procedure 1203-34 (control building ventilation failure) are only those to instruct the operator to align the system to recirculation to prevent contaminants from entering the control room. Other indications would tell the operator to enter this procedure to instruct the operator in recovering the system to protect against room heatups.

TABLE 3-9 (continued)

TABLE 3-10. ORDER OF PROCEDURES FOLLOWED FOR EACH INITIATOR[1]

INITIATING EVENTS[2] \ PROCEDURES[3]	1210-1 REACTOR/TURBINE TRIP	1210-2 LOSS OF SCM	1210-3 EXCESSIVE COOLING	1210-4 LACK OF PSHX	1210-5 SGTR	1210-6 SMALL BREAK LOCA COOLDOWN	1201-7 LARGE BREAK LOCA COOLDOWN	1210-8 RCS SUPERHEATED	1210-9 HPI COOLING	1210-10 ATOG RULES	1202-2 LOSS OF OFFSITE	1202-2A BLACKOUT	1202-9A LOSS OF "A" DC	1202-17 LOSS OF ICCW	1202-26 PARTIAL LOFW	1202-29 PRESSURIZER SYSTEM FAIL	1202-30 EARTHQUAKE	1202-31 FIRE	1202-35 LOSS OF DHR	1202-36 LOSS OF INSTRUMENT AIR	1202-37 COOLDOWN OUTSIDE CONTROL ROOM	1202-38 NSRW FAIL	1202-40 ICS POWER FAIL	1203-19 RIVER WATER SYSTEM FAIL	1203-20 NSCCS FAIL	1203-21 SSCCS FAIL	1203-24 STEAM LEAK	1203-34 CONTAINMENT BUILDING VENTILATION FAIL	1102-11 COOLDOWN	1102-16 NATURAL CIRCULATION COOLDOWN
ICS MALFUNCTION (ATA LOSS)	1																						2						3	
LOSS OF RIVER WATER	3																					1		2						4
LOSS OF MAIN FEED	1																													
LOSS OF OFFSITE POWER	1									3	2					5														4
STEAM GENERATOR TUBE RUPTURE	1				2																									
REACTOR TRIP	1																												2	
TURBINE TRIP	1																												2	
LOSS OF CONTAINMENT BUILDING VENTILATION																												1		
EXCESSIVE FEEDWATER	1		2																											
LOSS OF DC TRAIN A	[illegible]												2																3	
V-SEQUENCE	1	2					3																							
LOSS OF INSTRUMENT AIR	2																			1										
LARGE LOCA	1	2					3																							
MEDIUM LOCA	1	2					3																							
SMALL LOCA	1	2				3																								
VERY SMALL LOCA	1	[illegible]				3																								
TURBINE BUILDING SLB	1		2																											
INTERMEDIATE BUILDING SLB	1		2																											
TOXIC CHEMICAL RELEASE																														
STATION BLACKOUT	1											2																		
FIRE AT 1P OR 1S																		1												
SEISMIC DC LOSS	1												2				3												4	
NSCCW FAILURE																									1					
INADVERTENT HPI																														
MSLB IN REACTOR BUILDING	1		2																											
ATWS	1																													

NOTES:

1. THE NUMBERS IN THE TABLE IDENTIFY THE EXPECTED ORDER IN WHICH THE PROCEDURES SHOULD BE IMPLEMENTED FOR EACH INITIATOR
2. REMARKS ON THE INITIATORS ARE PROVIDED IN THE FOOTNOTES TO TABLE 3-8
3. REMARKS ON THE PROCEDURES ARE PROVIDED IN THE FOOTNOTES TO TABLE 3-9

(INTENTIONALLY BLANK)

TABLE 4-1 (continued)


```
HSR1- SWITCHOVER TO SUMP FOLLOWING LARGE LOCA

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                       RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                 AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                       GRAVE
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =          FAIR
    TYPE OF HUMAN ACTION TASK IS =                          PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =            SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =           YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                   ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =        FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =          5.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                       POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)      MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 36.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 1.78E-03
            BEST ESTIMATE= 1.78E-02
            UPPER BOUND= 1.78E-01
         BEST ESTIMATE TIME DEPENDENT= 1.68E-02
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.78E-02
```

TABLE 4-1 (continued)


```
HSR2- RECIRCULATION SWITCHOVER FOLLOWING SMALL LOCA

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                       RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                 AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                       POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =          FAIR
    TYPE OF HUMAN ACTION TASK IS =                          PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =            SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =           YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                   ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =        FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =          0.200  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                       POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)      HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 12.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 4.76E-06
            BEST ESTIMATE= 4.76E-05
            UPPER BOUND= 4.76E-04
         BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-05
```

```
HSR3- SWITCHOVER TO SUMP FOLLOWING MEDIUM LOCA

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                         RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                   AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                         GRAVE
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =            FAIR
    TYPE OF HUMAN ACTION TASK IS =                            PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =              SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =             YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                     ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =          FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =            5.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                         POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)        MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 55.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

           FAILURE FREQUENCY RANGE
              LOWER BOUND= 2.71E-04
              BEST ESTIMATE= 2.71E-03
              UPPER BOUND= 2.71E-02
           BEST ESTIMATE TIME DEPENDENT= 1.71E-03
           BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
           TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.71E-03
```

```
HSV1- CLOSE SUMP DRAIN VALVES,AUTO FAILS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           BACKUP AUTO. ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           2.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =   9.500  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 2.91E-04
           BEST ESTIMATE= 2.91E-03
           UPPER BOUND= 2.91E-02
        BEST ESTIMATE TIME DEPENDENT= 1.91E-03
        BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.91E-03
```

```
HTB1A-INITIATE TURBINE COOLING,SGTR OR VSB,CD SUCCESS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                       KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                 AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                       OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =          FAIR
    TYPE OF HUMAN ACTION TASK IS =                          CAUSE EXTENDED OUTAGE
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =            FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =           YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                   MEDIUM
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =         HCD4
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =        SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =          1.000  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                       POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)      HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  6.000  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 7.37E-03
            BEST ESTIMATE= 3.69E-02
            UPPER BOUND= 1.84E-01
         BEST ESTIMATE TIME DEPENDENT= 3.30E-02
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.30E-02
```

```
HTB1B-INITIATE TURBINE COOLING,SGTR OR VSB,CD FAILURE

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                      KNOWLEDGE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                      POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =         FAIR
    TYPE OF HUMAN ACTION TASK IS =                         CAUSE EXTENDED OUTAGE
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =           FULL SUPPORT
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =          YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                  MEDIUM
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =        HCD4
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =       FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =         1.000  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                      POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)     HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 10.500  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 5.07E-02
            BEST ESTIMATE= 1.61E-01
            UPPER BOUND= 5.11E-01
         BEST ESTIMATE TIME DEPENDENT= 1.10E-02
         BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=2.10E-02
```

```
HTC1- LOCALLY ISOLATE SG FOLLOWING SGTR

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           FAIR
    TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    MEDIUM
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =          HID1
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           0.100  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =  4.700  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 4.09E-06
           BEST ESTIMATE= 4.09E-05
           UPPER BOUND= 4.09E-04
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.77E-05
```

```
HTC2- CLOSE TD EFW SUPPLY VALVES,MF+ FAILED

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             RECOVER FAILED SYSTEM
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             0.100  HOURS
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         HOURS
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =       4.700  HOURS
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 4.76E-05
           BEST ESTIMATE= 4.76E-04
           UPPER BOUND= 4.76E-03
        BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE
        BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04
```

```
HTH1- THROTTLE HPI USING MUV 217, NO ESAS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                          SKILL
    EXPERIENCE LEVEL OF OPERATING CREW IS =                    AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                          OPTIMAL CONDITIONS
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =             FAIR
    TYPE OF HUMAN ACTION TASK IS =                             PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =               SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =              YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                      LOW
    TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS =            NONAME
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =           SUCCEEDED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =             3.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                          POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)         MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 17.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

         FAILURE FREQUENCY RANGE
            LOWER BOUND= 5.10E-06
            BEST ESTIMATE= 5.10E-05
            UPPER BOUND= 5.10E-04
         BEST ESTIMATE TIME DEPENDENT= 5.95E-06
         BEST ESTIMATE TIME INDEPENDENT = 4.76E-05
         TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=5.36E-05
```

```
HTH2- THROTTLE HPI USING MUV-16S,AFTER ESAS

  INPUT ECHO:

    TYPE OF COGNITIVE PROCESSING IS =                        RULE
    EXPERIENCE LEVEL OF OPERATING CREW IS =                  AVERAGE
    STRESS LEVEL IN CONTROL ROOM IS =                        POTENTIAL EMERGENCY
    QUALITY OF PLANT INTERFACE WITH OPERATORS IS =           GOOD
    TYPE OF HUMAN ACTION TASK IS =                           PLANNED MANUAL ACTION
    ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =             SHIFT SUPERVISOR
    ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =            YES
    TYPE OF DEPENDENCY BETWEEN TASKS IS =                    ZERO
    STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =         FAILED
    THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =           3.000  MINUTES
    ESTIMATES OF TIME AVAILABLE ARE =                        POINT ESTIMATE
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)       MINUTES
    BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS = 14.000  MINUTES
    (UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)

  RESULTS:

        FAILURE FREQUENCY RANGE
           LOWER BOUND= 1.45E-03
           BEST ESTIMATE= 1.45E-02
           UPPER BOUND= 1.45E-01
        BEST ESTIMATE TIME DEPENDENT= 1.35E-02
        BEST ESTIMATE TIME INDEPENDENT = 1.00E-03
        TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.45E-02
```

HTH3- THROTTLE HPI AFTER ESAS AND GA FAILS

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	POTENTIAL EMERGENCY
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	GOOD
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	NO
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	3.000 MINUTES
ESTIMATES OF TIME AVAILABLE ARE =	POINT ESTIMATE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	MINUTES
BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS =	8.000 MINUTES
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 2.30E-02
BEST ESTIMATE= 1.15E-01
UPPER BOUND= 5.74E-01
BEST ESTIMATE TIME DEPENDENT= 1.05E-01
BEST ESTIMATE TIME INDEPENDENT = 1.00E-02
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=1.15E-01

HVB1- TRANSFER INSTRUMENT BUS TO INVERTER 1E

INPUT ECHO:

TYPE OF COGNITIVE PROCESSING IS =	RULE
EXPERIENCE LEVEL OF OPERATING CREW IS =	AVERAGE
STRESS LEVEL IN CONTROL ROOM IS =	OPTIMAL CONDITIONS
QUALITY OF PLANT INTERFACE WITH OPERATORS IS =	FAIR
TYPE OF HUMAN ACTION TASK IS =	RECOVER FAILED SYSTEM
ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =	SHIFT SUPERVISOR
ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =	YES
TYPE OF DEPENDENCY BETWEEN TASKS IS =	ZERO
STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS =	FAILED
THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS =	0.100 HOURS
ESTIMATES OF TIME AVAILABLE ARE =	VARIABLE
(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)	HOURS

DISTRIBUTION FOR TIMES ALLOWED

5.00	6.00	11.00	24.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION

0.10	0.40	0.30	0.20	0.00	0.00	0.00	0.00	0.00	0.00

DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED

1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION

1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

INTERMEDIATE RESULTS:

TIME ALLOWED	TIME TO RESPOND	ESTIMATED ERROR FREQUENCY	PROBABILITY
5.00E+00	1.00E+00	4.76E-04	1.00E-01
6.00E+00	1.00E+00	4.76E-04	4.00E-01
1.10E+01	1.00E+00	4.76E-04	3.00E-01
2.40E+01	1.00E+00	4.76E-04	2.00E-01

RESULTS:

FAILURE FREQUENCY RANGE
LOWER BOUND= 4.76E-05
BEST ESTIMATE= 4.76E-04
UPPER BOUND= 4.76E-03
BEST ESTIMATE TIME DEPENDENT= NEGLIGIBLE
BEST ESTIMATE TIME INDEPENDENT = 4.76E-04
TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS=4.76E-04

TABLE 4-2. ACCIDENT SCENARIOS WITH DEPENDENT DYNAMIC HUMAN ACTIONS MODELED

Scenario Description	Human Actions Involved
1. Loss of River Water due to Screen Plugging	HRE4 (fails) → HRE6A HRE4 (fails) → HRE6B HRE4 (fails) → HRE6C HRE6A (fails) → HRE2 HRE6 (fails) → HCF1 HRE6 (succeeds) → HBW3
2. Reactor Trip Failure	HRT7 (fails) → HRT8
3. HPI Cooling Required (loss of secondary cooling)	HBW1 (succeeds) → HPO1
4. Throttle HPI	
a. After Manual Initiation	Open MU-V217 (succeeds) → HTH1 HTH1 (fails) → HRC2
b. After ESAS Initiation	HTH2 (succeeds) → HMR1 HTH3 (succeeds) → HMR1 HTH2 (fails) → HRC2
5. Reactor Building Purge in Progress	HCA2(fails) → HCS5
6. Loss of Instrument Air	HAM1 (fails) → HINJ4
7. Cooldown and Depressurization of RCS	
a. Without Steam Generator Tube Rupture	HCD1 (fails) → HLT1B HCD1 (succeeds) → HHL1A HCD1 (succeeds) → HHL1B HCD2 (fails) → HLT1B
b. Following Steam Generator Tube Rupture	HID1 (succeeds) → HTC1 HCD4 (succeeds) → HHL1A HID1 (succeeds) → HCD3 HID1 (succeeds) → HCD4 HID2 (succeeds) → HCD5 HCD4 (fails) → HLT2
8. Loss of Offsite Power with Both Vital Buses Available	HAM2 (fails) → HINJ4 HAM2 (fails) → HEF1 HCD1 (success) → HCD2

Scenario Description	Human Actions Involved
9. Loss of Offsite Power with One Vital Bus Failed	HCD1 (succeeds) → HHL1B HCD1 (succeeds) → HCD2 HAM2 (fails) → HEF1 HAM2 (fails) → HINJ4
10. Loss of All AC	
a. With EFW Success	HEF4 (succeeds) → HRE1
b. With EFW Failed	HEF4 (fails) → HRE3
11. Failure of Normal DHR Cooling	
a. With Cooldown to DHR Entry Successful	HCD4 (succeeds) → HTB1A
b. With Failure of Cooldown to DHR Entry	HCD4 (fails) → HTB1B
c. Like (a), but One DC Train Fails and 12 Hours Available	HCD1 (success) → HRE12A
d. Like (a), but One DC Train Fails and 12 Hours Available	HCD1 (success) → HRE12B
e. Like (a), but One DC Train Fails and 24 Hours Available	HCD1 (success) → HRE12C

TABLE 4-3. TMI-1 OPERATOR-PLANT STATUS CONFUSION MATRIX

INITIATING EVENT \ POTENTIAL CONFUSION WITH	ICS MALFUNCTION (ATA LOSS)	LOSS OF RIVER WATER	LOSS OF MAIN FEED	LOSS OF OFFSITE POWER	STEAM GENERATOR TUBE RUPTURE	REACTOR TRIP	TURBINE TRIP	LOSS OF CONTAINMENT BUILDING VENTILATION	EXCESSIVE FEEDWATER	LOSS OF DC TRAIN A	V-SEQUENCE	LOSS OF INSTRUMENT AIR	LARGE LOCA	MEDIUM LOCA	SMALL LOCA	VERY SMALL LOCA	TURBINE BUILDING SLB	INTERMEDIATE BUILDING SLB	TOXIC CHEMICAL RELEASE	STATION BLACKOUT	FIRE AT 1P OR 1S	SEISMIC DC LOSS	NSCCW FAILURE	INADVERTENT HPI ACTUATION	MSLB IN REACTOR BUILDING	ATWS (MFW LOSS)
ICS MALFUNCTION (ATA LOSS)	–								L/N																	
LOSS OF RIVER WATER		–																								
LOSS OF MAIN FEED			–																							
LOSS OF OFFSITE POWER				–																						
STEAM GENERATOR TUBE RUPTURE					–										L/R											
REACTOR TRIP						–	H/N																			
TURBINE TRIP						H/N	–																			
LOSS OF CONTAINMENT BUILDING VENTILATION								–																		
EXCESSIVE FEEDWATER	L/N								–								M/N	M/N								
LOSS OF DC TRAIN A										–																
V-SEQUENCE					L/N						–			M/N	M/N											
LOSS OF INSTRUMENT AIR												–														
LARGE LOCA													–	L/N												
MEDIUM LOCA													L/N	–												
SMALL LOCA					L/N										–											
VERY SMALL LOCA																–										
TURBINE BUILDING SLB									M/N								–	M/N								
INTERMEDIATE BUILDING SLB									M/N								M/N	–								
TOXIC CHEMICAL RELEASE																			–							
STATION BLACKOUT																				–						
FIRE AT 1P OR 1S																					–					
SEISMIC DC LOSS																						–				
NSCCW FAILURE																							–			
INADVERTENT HPI ACTUATION															L/R									–		
MSLB IN REACTOR BUILDING														H/R	H/R										–	
ATWS (MFW LOSS)																										–

LEGEND:

CONFUSION LEVEL

H – HIGH
M – MEDIUM
L – LOW
BLANK – NEGLIGIBLE

SUBSEQUENT ACTION

N – NEGLIGIBLE IMPACT ON SUBSEQUENT OPERATOR ACTIONS
R – IMPACTS SUBSEQUENT OPERATOR ACTIONS (REDIAGNOSIS REQUIRED)

TABLE 4-4. DISPOSITION OF POTENTIAL SLIPS/NONVIABLE OPERATOR ACTIONS

Sheet 1 of 3

Human Action Identifier	Slips/Nonviable Action Descriptions	Comments
HBW1	Throttle HPI when mistakenly believing that primary to secondary heat transfer has been restored.	This event actually occurred during the TMI-2 accident. Since that time, the procedures have been revised to incorporate new HPI throttling criteria; i.e., AP-1210-1a, rule 1.3. Now, the operator is not to throttle HPI unless 25°F subcooling margin exists and pressurizer level is more than 0 inches. Despite the expected low frequency of a repeat of this error, for historical reasons, this event is quantified in the model.
HCF1	Continue to attempt recovery of river water and not try to establish containment cooling with industrial coolers	To reestablish industrial cooling would require violation of the containment boundary. A low dependence on the failure to recover river water is assumed to account for the possible fixation on that action. This possibility is considered in quantifying the nonresponse error frequency for HCF1.
HFW4	Manipulate the valves on the wrong steam generator while trying to manually control feedwater flow, given a stuck open steam generator relief valve.	He may grab the controls for MFW valves rather than the startup flow control valves. These valves would be ineffective because the block valves (FW-V-5)are closed. Operator would soon notice the reduced level in the wrong steam generator and recognize his error. Since he would likely then take the correct action, this potential slip is not quantified.
HIC1	Manipulate the wrong valves when trying to control feedwater flow following loss of the integrated control system after a plant trip.	As discussed for HFW4, he may grab the main feedwater valves (FW-V-17), but they would be ineffective at controlling feed. Both steam generators would be affected. Operator would notice level increasing even if he focused on only one steam generator initially. This potential slip is not quantified. Adequate time to realize the mistake and manipulate the correct valves is assumed.

TABLE 4-4 (continued)

Sheet 2 of 3

Human Action Identifier	Slips/Nonviable Action Descriptons	Comments
HID1/HID2	Isolate the wrong steam generator following a tube rupture event.	Operator would recognize feedwater level continuing to rise on the other steam generator. Assume operator would reestablish feedwater to the intact steam generator rather than proceeding to HPI cooling. This action is therefore not quantified.
HINJ1	Start makeup pump A without suction from makeup tank.	An off-normal lineup may have pump C aligned to the makeup tank. Operator may then start pump A, which is the normal response. Only a small fraction of time would the system be aligned for suction to pump C. Assume the product of the frequency of the off-normal alignment and the error frequency for starting pump A anyway is small relative to the pump failure to start frequency.
HINJ2	Operator restores RCP seal cooling too fast using the makeup pump C, thereby shocking the seals and causing them to fail.	Makeup pumps A and B have failed. Potential for incorrectly establishing cooling is modeled as another way of failing HINJ2 Although the timing of the seal failure is much quicker for this error, the long-term effect is the same as a nonresponse; i.e. RCP seal failure.
HRT8	When attempting to interrupt power to the reactor trip breakers, operator selects the wrong pistol grip switches.	Similar switches interrupt power to only nonvital heating and ventilation buses; i.e., not needed for main feedwater. This nonvital action is not quantified because it has no adverse impact and the correct action could still be taken subsequently.
HSI2	In attempting to isolate a main steam break upstream of the MSIVs, the operator isolates the wrong steam generator.	Switches to operate the EFW valves are relatively close together in the control room. By isolating the intact steam generator, there may not be enough pressure in the failed steam generator to allow the turbine-driven EFW pump to operate. This action would not fail the EFW pump, but would prevent its operation. However,this error is not quantified because the operator would discover the error, isolate the correct steam generator, then reestablish feed to the intact steam generator and then reinitiate the turbine-driven EFW pump. The combination of these human errors is believed small relative to the other pump failure modes and is therefore neglected.

Sheet 3 of 3

Human Action Identifier	Slips/Nonviable Action Descriptons	Comments
HSR1	Misposition the DHR pump suction valves when attempting to switch over to recirculation following a LOCA. Operator may attempt to close the BWST suction valves and open the containment sump valves at the same time. The BWST suction valves have a faster str[illegible].	The BWST suction valves close faster than the sump valves open. The DHR pumps should survive even with minimal flow. For large LOCAs ,therefore,this action has no impact because these pumps are so rugged. For smaller LOCAs, the amount of flow through the sump valves should be sufficient to protect the makeup and spray pumps. This nonviable action was therefore not quantified separately from the nonresponse probability (HSR1)
HTC1	Operator isolates the wrong steam generator following a tube rupture by isolating the wrong supply valve to the EFW turbine-driven pump.	See the comments indicated above for the nonviable action under HSI2.

TABLE 4-5. FORCED LINE OUTAGE DURATION DATA
230-kV LINES AND 500-kV LINES (1979-1983)

Outage Duration (hours)	Fraction of Events (including momentary outages of duration less than 5 minutes)	Fraction of Events (excluding momentary outages of duration less than 5 minutes)
0 to 0.25	.78	.24
0.25 to 0.50	.03	.09
0.50 to 0.75	.01	.05
0.75 to 1.0	.03	.09
1.0 to 1.5	.01	.05
1.5 to 2.0	.03	.09
2.0 to 4.0	.08	.24
4.0 to 8.0	.01	.05
8.0 to 16.0	.01	.05
16.0 to 24.0	.01	.05
> 24.0	0	0

TABLE 4-6. TIME WINDOW BASED ON PLANT THERMAL HYDRAULICS

Time* at which EFW Is Lost (hours)	Time* to Core Uncovery (hours)	
	With Seal Leak	Without Seal Leak
0	1	1
2	3.7	3.7
4	6.0	6.0
6	7.7	8.2
8	9.1	10.4
10	9.1	10.4
12	9.1	10.4

*Times are time after loss of all AC power.

TABLE 4-7. TMI DHR AND DHCCW PUMP RECOVERY

PART 1: FAILURE EVENT DATA

Plant Name	Failure Events	Maintenance Events
TMI	3	44
Pilgrim	1	--
Farley	6	--
Beznau	12	--
Oconee	3	--

PART 2: CATEGORIZED EVENT DATA

Duration	Failure Events	Probability that Repair Cannot be Made	Maintenance Events	Probability that Repair Cannot be Made
0 to 6 Hours	15	0.40	28	0.36
6 to 12 Hours	3	0.28	10	0.14
12 to 24 Hours	0	0.28	5	0.02
> 24 Hours	7	--	1	--
Total Events	25	--	44	--

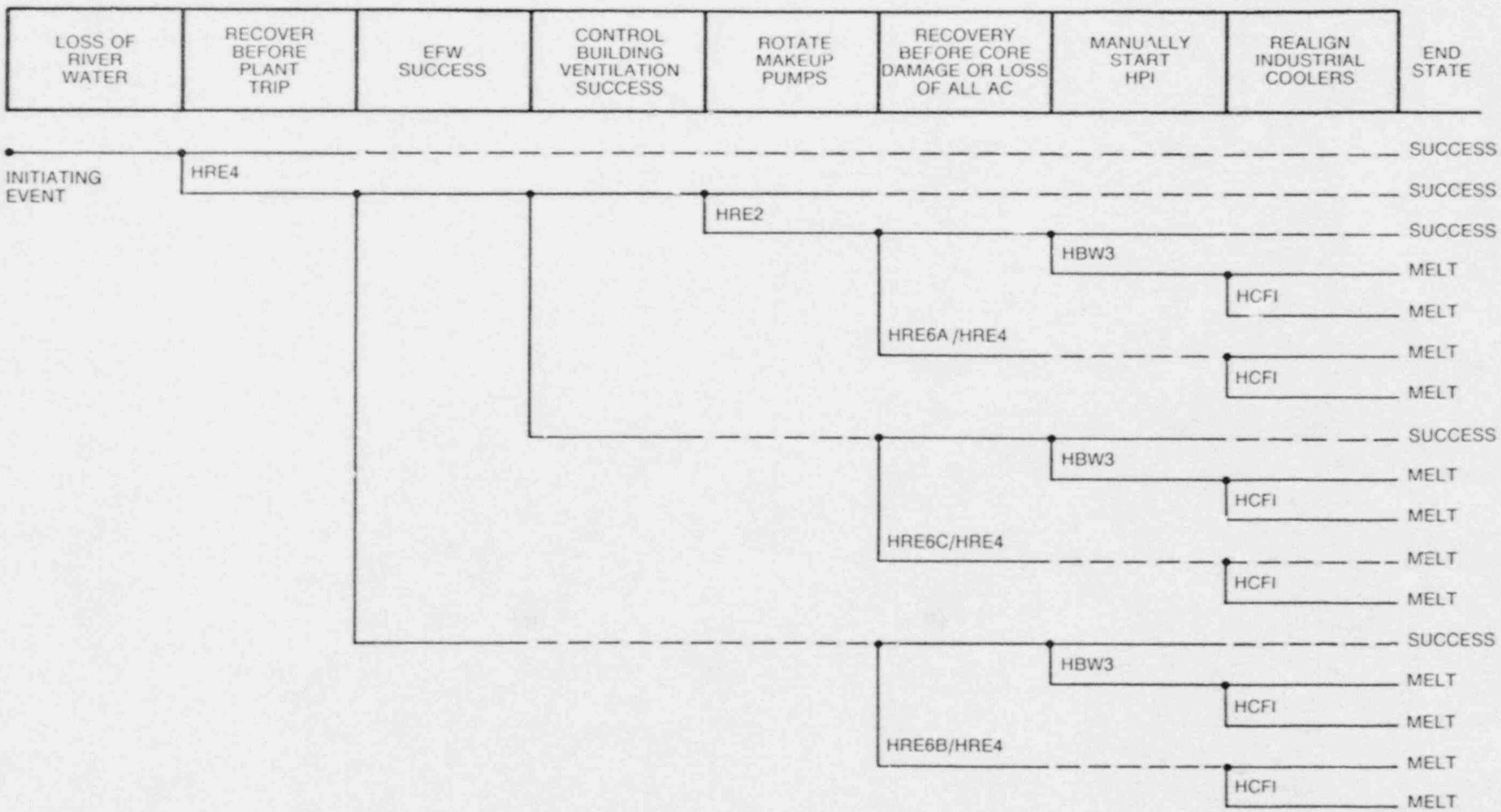


FIGURE 4-1. RECOVERY SEQUENCES FOR LOSS OF RIVER WATER

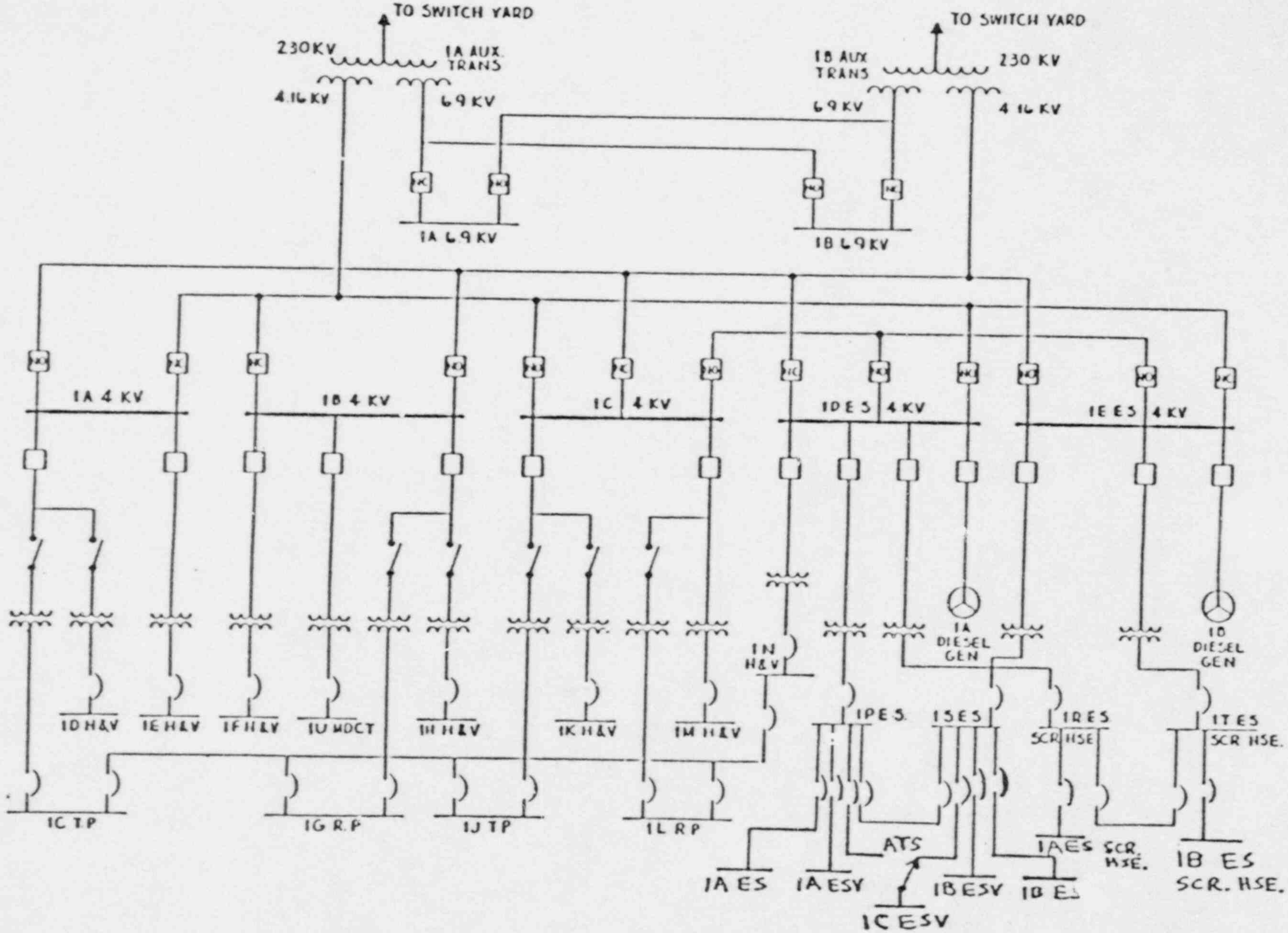


FIGURE 4-2. TMI UNIT 1 PLANT ELECTRICAL DISTRIBUTION

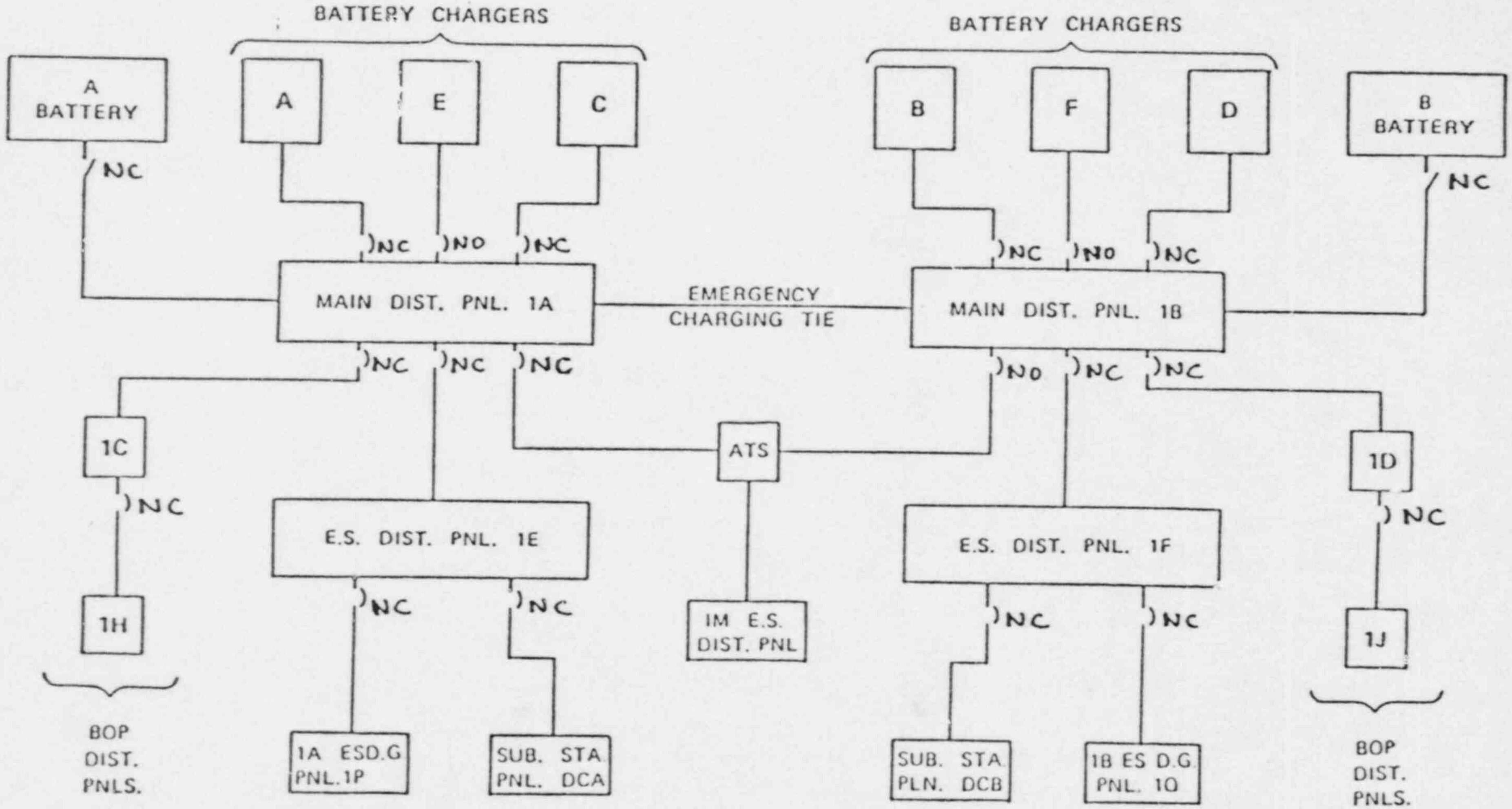


FIGURE 4-3. DC SYSTEM

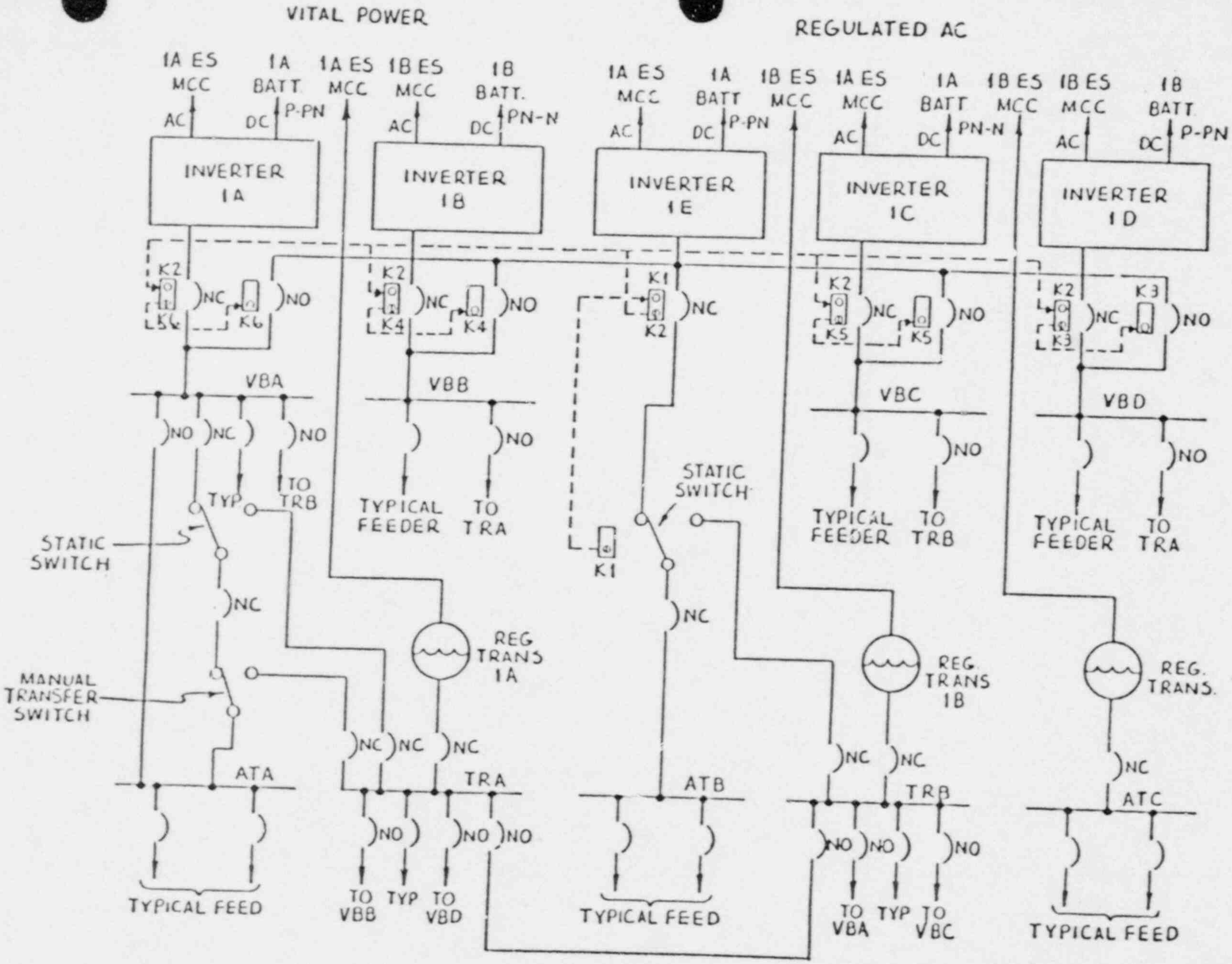


FIGURE 4-4. VITAL AC DISTRIBUTION

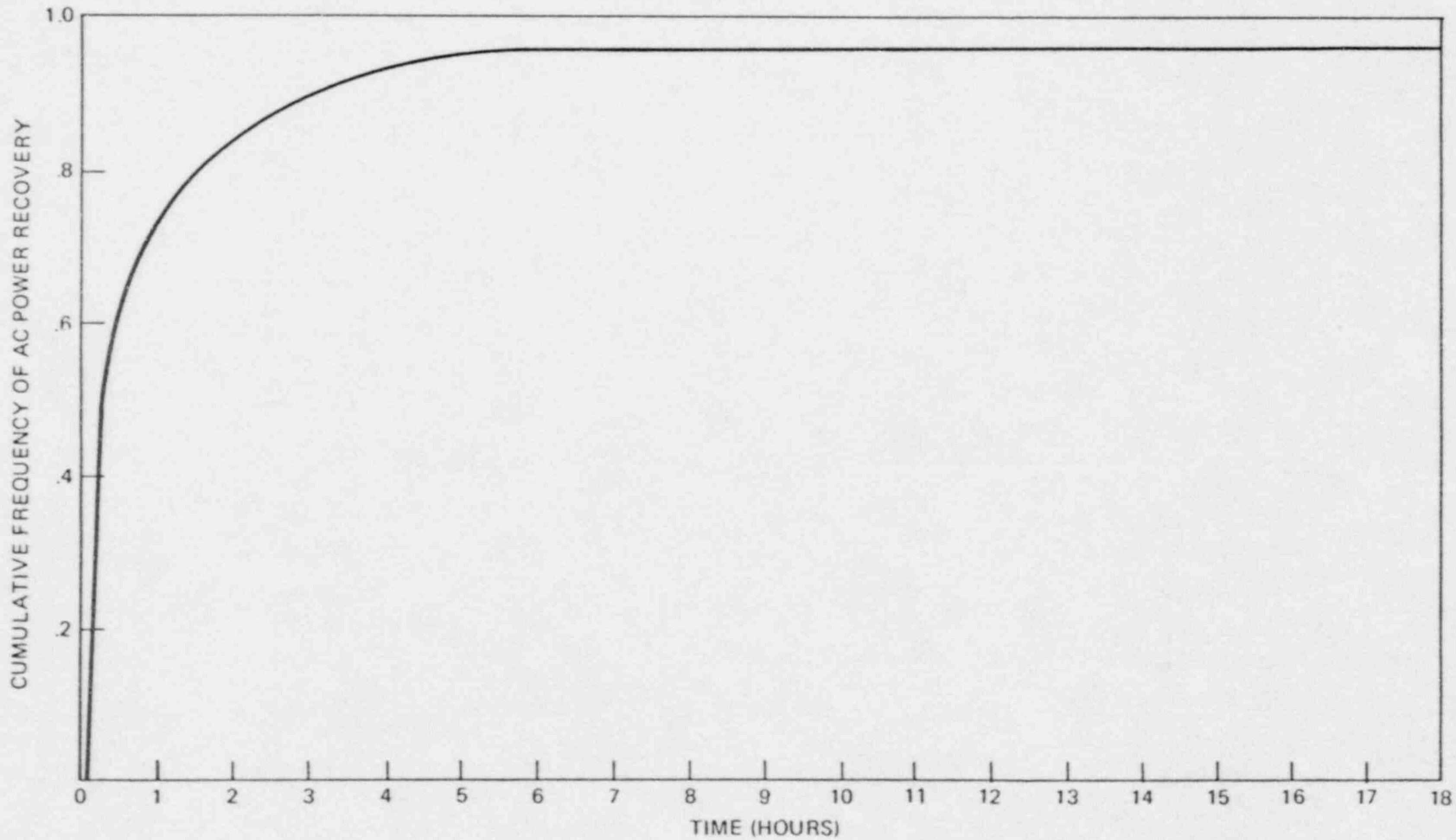


FIGURE 4-5. TIME TO RECOVER ELECTRIC POWER FROM ANY SOURCE

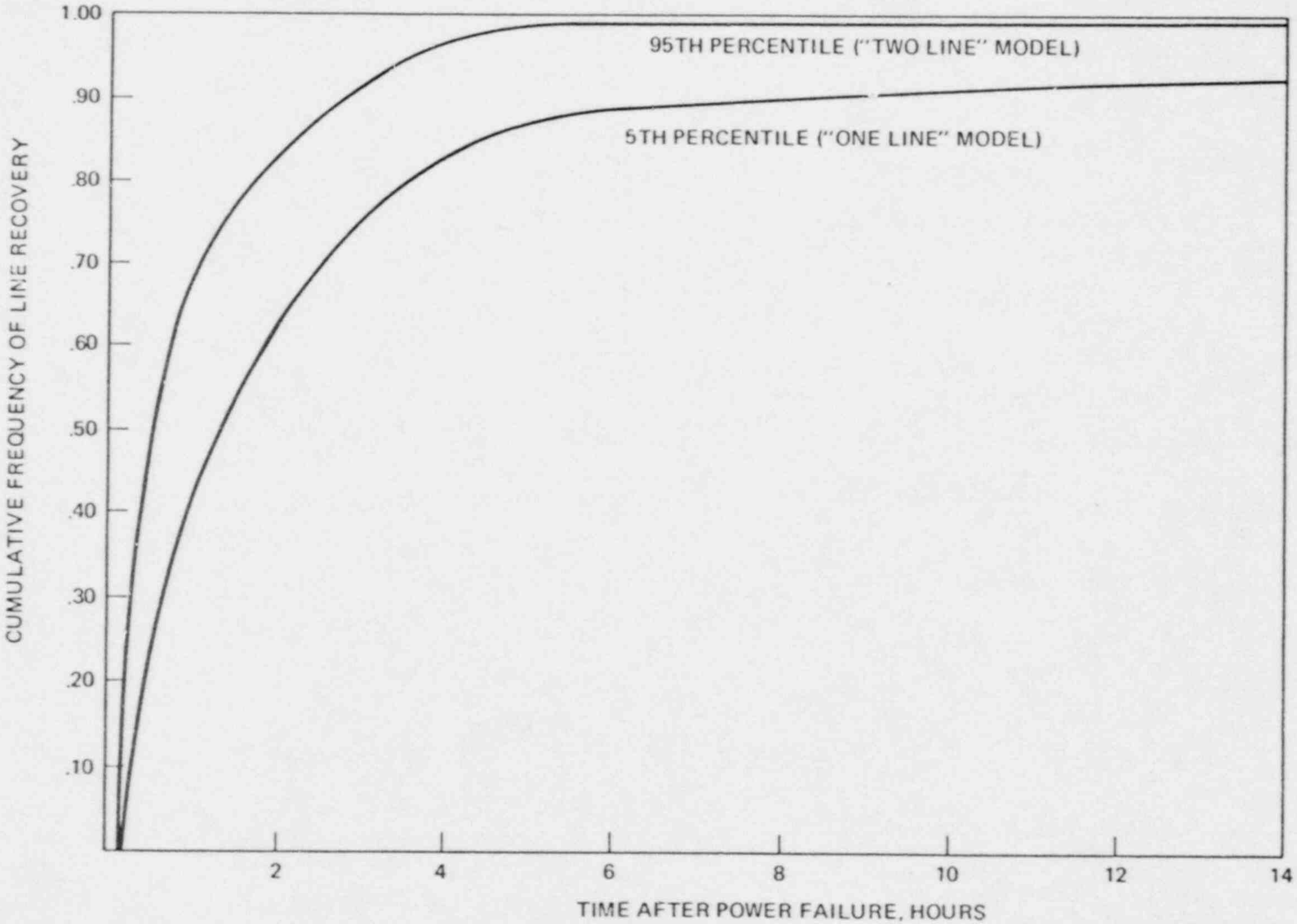
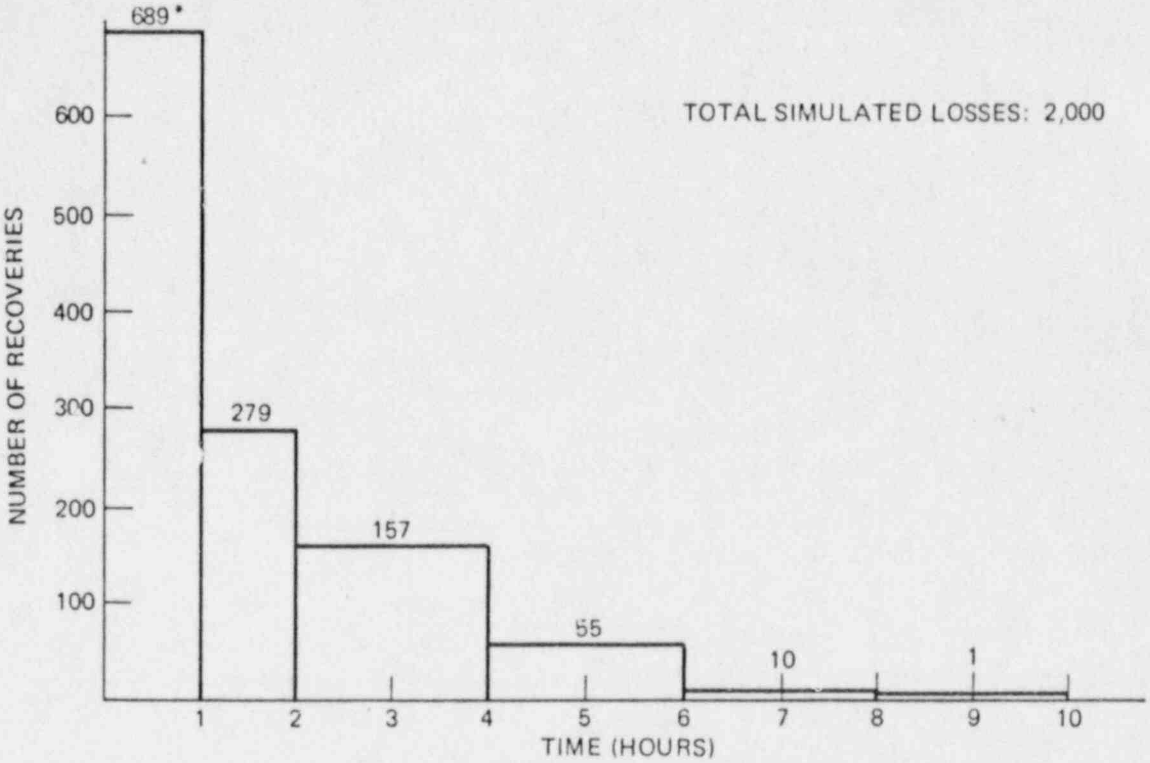
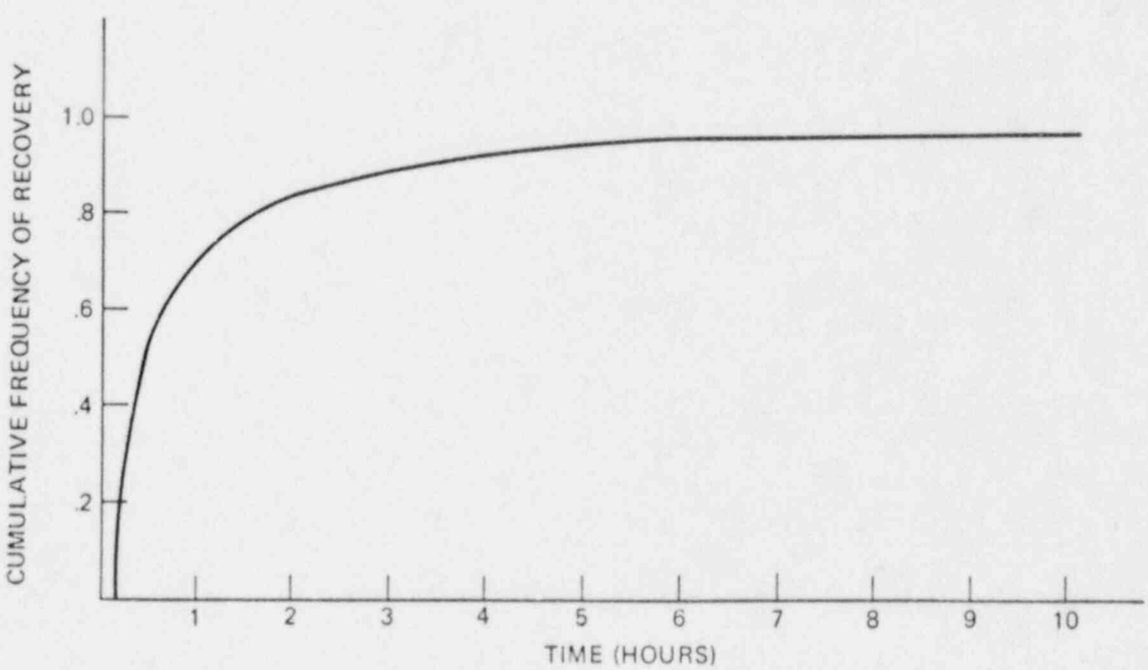


FIGURE 4-6. TMI OFFSITE TRANSMISSION LINE RECOVERY MODEL



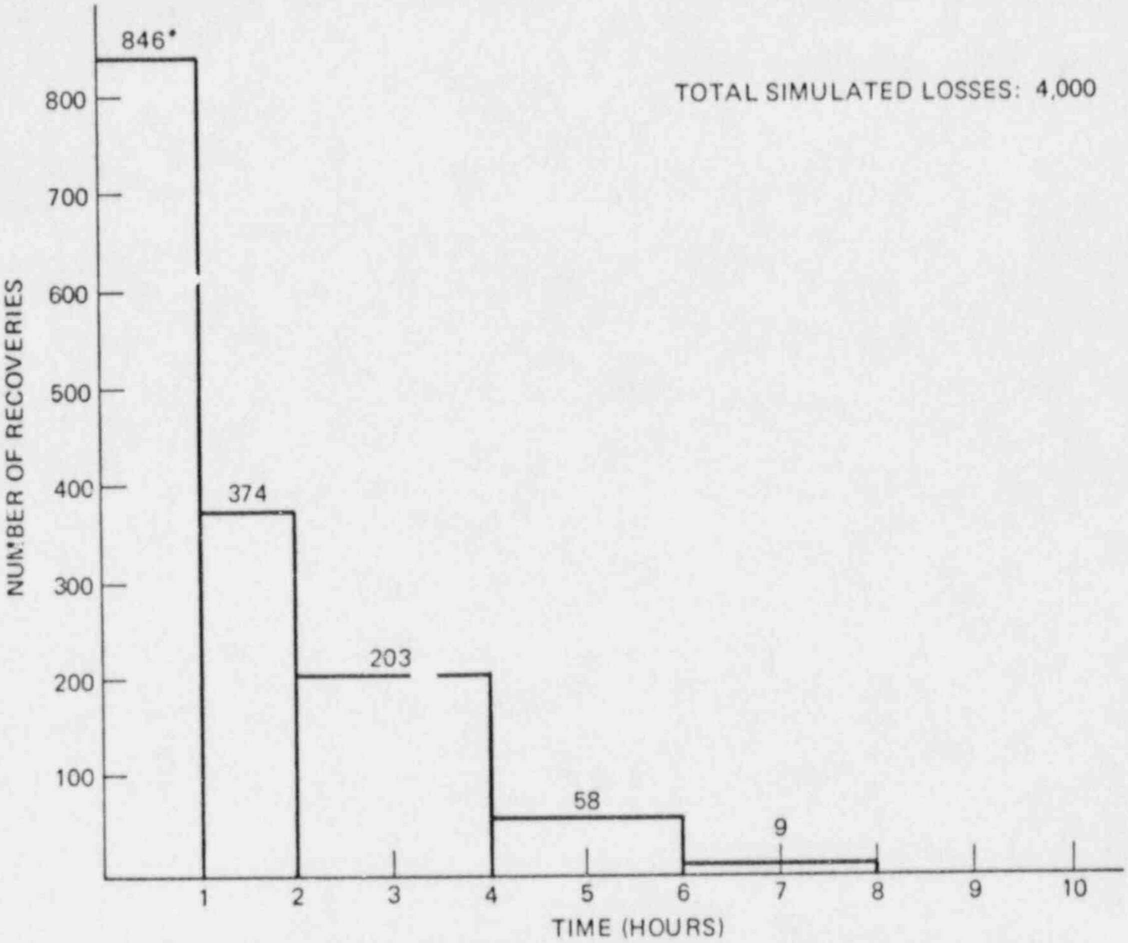
(a) HISTOGRAM OF RECOVERY FREQUENCY

*DOES NOT INCLUDE THE NUMBER OF TIMES AC POWER IS NEVER LOST



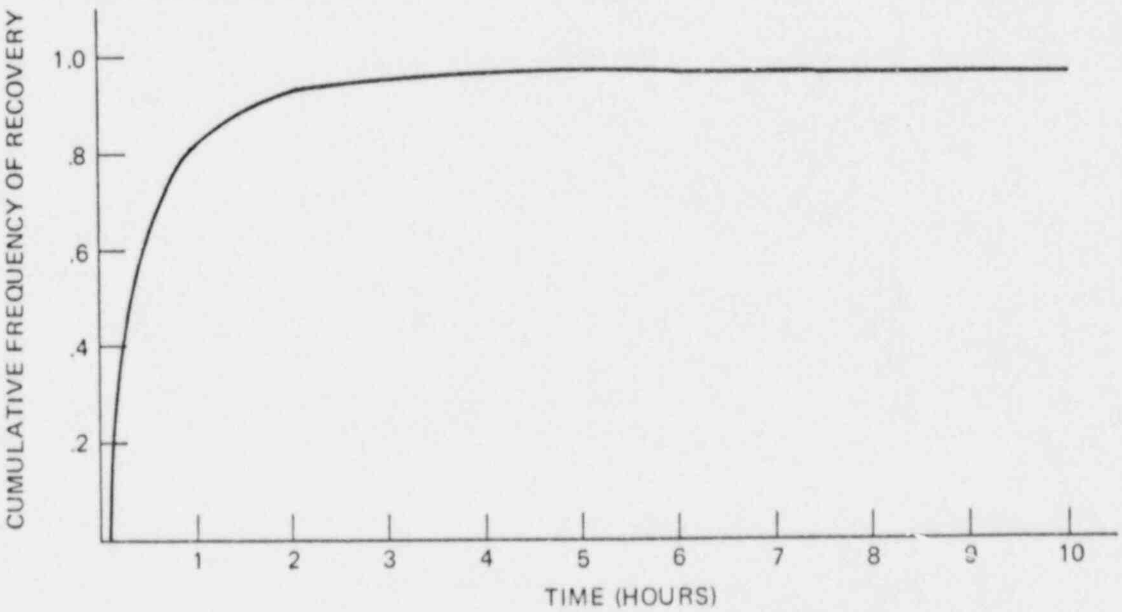
(b) CUMULATIVE FREQUENCY OF RECOVERY (NORMALIZED)

FIGURE 4-7. SINGLE DIESEL GENERATOR RECOVERY DISTRIBUTION



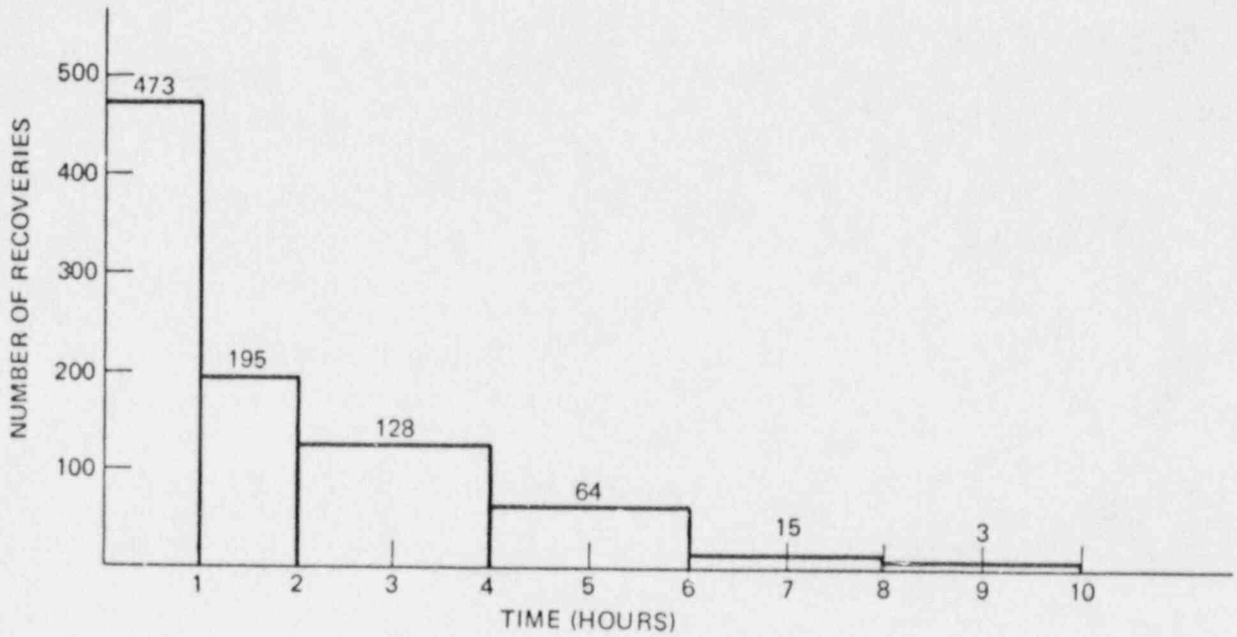
(a) HISTOGRAM OF RECOVERY FREQUENCY

*DOES NOT INCLUDE THE NUMBER OF TIMES AC POWER IS NEVER LOST

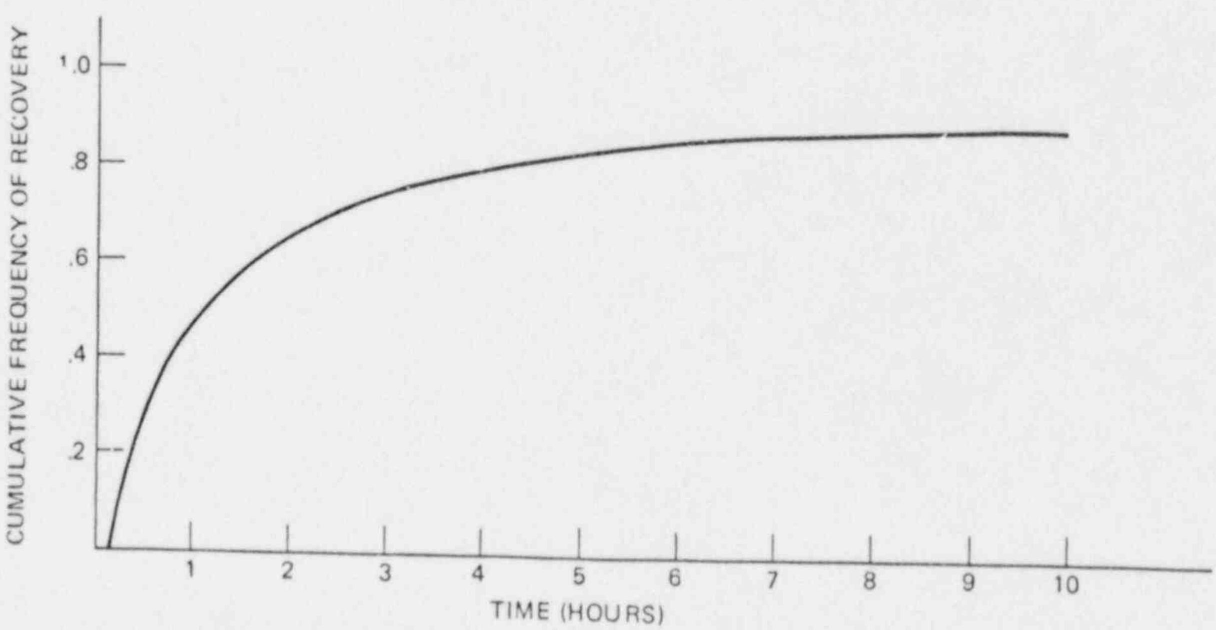


(b) CUMULATIVE FREQUENCY OF RECOVERY (NORMALIZED)

FIGURE 4-8. DUAL DIESEL GENERATOR RECOVERY DISTRIBUTION



(a) HISTOGRAM OF RECOVERY FREQUENCY



(b) CUMULATIVE FREQUENCY OF RECOVERY

FIGURE 4-9. OFFSITE (NO DIESEL GENERATOR) RECOVERY DISTRIBUTION

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Three Mile Island Unit 1 Probabilistic Risk Assessment

HUMAN ACTIONS ANALYSIS REPORT

Project Director
B. John Garrick

Project Manager
Douglas C. Iden

Principal Investigator
Frank R. Hubbard

Task Leaders
Mardyros Kazarians
Ali Mosleh
Harold F. Perla
Martin B. Sattison
Donald J. Wakefield

Prepared for
GPU NUCLEAR CORPORATION
Parsippany, New Jersey
November 1987

Pickard, Lowe and Garrick, Inc.
Engineers • Applied Scientists • Management Consultants
Newport Beach, CA Washington, DC

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HUMAN ACTIONS ANALYSIS REPORT

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LIST OF ACRONYMS

Abbreviation	Definition
ACR	air-cooled reactor
ADV	atmospheric dump valve
AOV	air-operated valve
ATOG	abnormal transient operational guidelines
ATWS	anticipated transient without scram
BOP	balance of plant
Btu	British thermal unit
BWR	boiling water reactor
BWST	borated water storage tank
CARS	condenser air removal system
CAS	chemical addition system
CBVS	control building ventilation system
CCF	common cause failure
CFT	core flooding tank
CIV	containment isolation valve
CSF	conditional split fraction
CST	condensate storage tank
CRO	control room operator
CWS	circulating water system
DHCCW	decay heat closed cooling water
DHR	decay heat removal
DHRS	decay heat removal system
DHRW	decay heat river water
EFW	emergency feedwater
EOF	emergency operations facility
EPRI	Electric Power Research Institute
ESD	event sequence diagram
ESAS	engineered safeguards actuation system
ETC	event tree code
FSAR	Final Safety Analysis Report
FTAP	Fault Tree Analysis Program
GCR	gas-cooled reactor
GPUN	GPU Nuclear Corporation
HCR	human cognitive reliability
HPI	high pressure injection
HPIS	high pressure injection system
HVAC	heating, ventilating, and air conditioning
ICCS	intermediate closed cooling system
ICCW	intermediate closed cooling water
ICS	integrated control system

LIST OF ACRONYMS (continued)

Abbreviation	Definition
LBIS	line break isolation system
LCO	limiting condition for operation
LER	Licensee Event Report
LOCA	loss of coolant accident
LOFW	loss of main feedwater
LONS	loss of nuclear services
LORI	loss of reactor coolant system inventory
LORW	loss of river water
LOSP	loss of offsite power
LPI	low pressure injection
LPIS	low pressure injection system
LSS	low speed stop
MCC	motor control center
MFPT	main feedwater pump trip
MFW	main feedwater
MGL	multiple Greek letter
MOV	motor-operated valve
MSIV	main steam isolation valve
MSLB	main steam line break
MSS	main steam system
MSSV	main steam safety valve
MSV	main steam valve
MUP	makeup and purification
NPE	Nuclear Power Experience
NRC	U.S. Nuclear Regulatory Commission
NSCCS	nuclear services closed cooling system
NSCCW	nuclear services closed cooling water
NSRW	nuclear services river water
NSSS	nuclear steam supply system
OPM	Operations Plant Manual
OTSG	once-through steam generator
PCL	panel center left
PCR	panel center right
PDS	plant damage state
PLF	panel left front
PLG	Pickard, Lowe and Garrick, Inc.
P&ID	piping and instrumentation drawing
PORV	power-operated relief valve
PRA	probabilistic risk assessment
PRF	panel right front
PSHX	primary to secondary heat transfer
PSV	pressurizer safety valve
PWR	pressurized water reactor

LIST OF ACRONYMS (continued)

Abbreviation	Definition
RBCU	reactor building cooler unit
RBEC	reactor building emergency cooling
RBD	reliability block diagram
RBS	reactor building spray
RBSS	reactor building spray system
RCDT	reactor coolant drain tank
RCP	reactor coolant pump
RCS	reactor coolant system
RPS	reactor protection system
SCCW	secondary closed cooling water
SCM	subcooled margin
SGTR	steam generator tube rupture
SLB	steam line break
SLRDS	steam line rupture detection system
SRO	senior reactor operator
SRW	secondary river water
SSCCS	secondary services closed cooling system
SSE	safe shutdown earthquake
SSS	support state system
STA	shift technical advisor
TBV	turbine bypass valve
TMI-1	Three Mile Island Nuclear Generating Station, Unit 1
ULD	unit load demand

APPENDIX A

DYNAMIC HUMAN ACTIONS PROGRAM

A FORTRAN computer program (Table A-1) was written to perform the calculations described in Sections 2.3.2, 2.3.5, and 2.3.6. This program uses the judgments documented in the dynamic human actions questionnaire to compute the best estimate and an uncertainty range for nonresponse error frequencies. Both time-dependent and time-independent error contributions are determined.

In Table A-2, the input variables required for this program are defined, and the values they may take on are identified and their meanings described.

The completed human action questionnaires are provided in Appendix B.

TABLE A-1. CHARACTER*21 TITLE, COGNIT, EXPER, STRESS, INTER, SWITCH, TYPES, CREW

Sheet 1 of 6

```
      CHARACTER*21 TITLE, COGNIT, EXPER, STRESS, INTER, SWITCH, TYPET,CREW
     1,FEED,DEPEN,STATUS,VART,RNAME,UNITS
      CHARACTER*6 DPTASK
      CHARACTER*2 POIN2
      DIMENSION POIN2(200)
       DIMENSION RESULT(200),RNAME(200)
C          TO RUN TYPE: R H HUMAN,INPUTFILE,OUTPUTFILE
      DIMENSION TITLE(7),COGNIT(3),EXPER(3),STRESS(4),INTER(5),SWITCH(2)
     1,TYPET(5),CREW(3),FEED(2),DEPEN(5),STATUS(2),VART(2)
      DIMENSION TASKT(5),R1(3),R2(2),R3(3),UNITS(2)
      DIMENSION TAL(10),PTAL(10),TRESP(10),PTRESP(10)
      NAMELIST/DAT1/NCOG,K1,K2,K3,NTDEP,TALLOW,TMED,NTASK,NR1,NR2
     1 ,NDEP,NPREV,NPOINT,POINT,NUNITS,DPTASK
      NAMELIST/TABLE/NTAL,NTRESP,TAL,PTAL,TRESP,PTRESP
      DATA UNITS/'  MINUTES ',' HOURS   '/
      DATA TASKT/1.E-3,3.E-2,1.E-2,1.E-3,1.E-2/
      DATA R1/1.,.333,.5/
      DATA R2/1.,.143/
      DATA R3/1.0,3.0,7.0/
      DATA COGNIT/'SKILL','RULE','KNOWLEDGE'/
      DATA EXPER/'EXPERT','AVERAGE','MINIMUM'/
      DATA STRESS/'GRAVE','POTENTIAL EMERGENCY','OPTIMAL CONDITIONS',
     1'LOW VIGILANCE'/
      DATA INTER/'EXCELLENT','GOOD','FAIR','POOR','VERY POOR'/
      DATA SWITCH/'POINT ESTIMATE','VARIABLE'/
      DATA TYPET/'BACKUP AUTO. ACTION','DETRACT FROM ES','RECOVER FAILED
     2 SYSTEM','PLANNED MANUAL ACTION',
     1'CAUSE EXTENDED OUTAGE'/
      DATA CREW/'NO ADDITIONAL','SHIFT SUPERVISOR','FULL SUPPORT'/
      DATA FEED/'NO','YES'/
      DATA DEPEN/'ZERO','LOW','MEDIUM','HIGH','COMPLETE'/
      DATA STATUS/'SUCCEEDED','FAILED'/
      DATA VART/'YES','NO'/
      N=1
      READ(5,102)NACT
      WRITE(6,*)NACT
  102 FORMAT(I3)
   70 CONTINUE
      WRITE(6,420)
  420 FORMAT(1H1)
      READ(5,100) TITLE
  100 FORMAT(1H1,7A10)
      WRITE(6,101)TITLE
  101 FORMAT (/,1X,7A10,/)
      NPOINT=0
      POINT=0.0
      NUNITS=2
      READ(5,DAT1)
C         NPOINT=1 IF HUMAN ERROR RATE IS READ VIA INPUT
C         POINT IS THE VALUE OF THE HUMAN ERROR RATE IF READ THRU INPUT
C         NUNITS= 1 IF TIME IS READ IN MINUTES,=2 IF READ IN HOURS,
C                   DEFAULT UNITS IS HOURS
      IF(NPOINT.EQ.0)GO TO 440
      WRITE(6,441)POINT
  441 FORMAT(/,10X,'POINT VALUE IS =',1PE8.2)
      RESULT(N)=POINT
      RNAME(N)=TITLE(1)
      POIN2(N)='**'
      N=N+1
      GO TO 70
  440 CONTINUE
      WRITE(6 421)
  421 FORMAT(3X,'INPUT ECHO:')
      WRITE(6,400) COGNIT(NCOG)
  400 FORMAT(/,5X,'TYPE OF COGNITIVE PROCESSING IS =',21X,A21)
      WRITE(6,401) EXPER(K1)
```

TABLE A-1 (continued)

Sheet 2 of 6

```
 401 FORMAT(5X,'EXPERIENCE LEVEL OF OPERATING CREW IS =',15X,A21)
     WRITE(6,402) STRESS(K2)
  402 FORMAT(5X,'STRESS LEVEL IN CONTROL ROOM IS = ',20X,A21)
     WRITE(6,403) INTER(K3)
 403 FORMAT(5X,'QUALITY OF PLANT INTERFACE WITH OPERATORS IS =',8X,A21)
     WRITE(6,405) TYPET(NTASK)
 405 FORMAT(5X,'TYPE OF HUMAN ACTION TASK IS =',24X,A21)
     WRITE(6,406) CREW(NR1)
 406 FORMAT(5X,'ADDITIONAL CREW AVAILABLE FOR DIAGNOSIS IS =',10X,A21)
     WRITE(6,407) FEED(NR2)
 407 FORMAT(5X,'ADDITIONAL PLANT FEEDBACK TO ALERT OPERATOR =',9X,A21)
     WRITE(6,408) DEPEN(NDEP)
 408 FORMAT(5X,'TYPE OF DEPENDENCY BETWEEN TASKS IS =',17X,A21)
     IF(NDEP.NE.1)WRITE(6,601)DPTASK
 601 FORMAT(5X,'TITLE OF TASK WHICH THIS ACTION DEPENDS ON IS = '
    1,6X,A6)
     WRITE(6,409) STATUS(NPREV)
 409 FORMAT(5X,'STATUS OF TASK WHICH THIS ACTION DEPENDS ON IS ='
    1,6X,A21)
     NTDEPP=NTDEP+1
     WRITE(6,415)TMED,UNITS(NUNITS)
 415 FORMAT(5X,'THE MEDIAN ESTIMATE OF THE TIME TO DIAGNOSE IS ='
    1,6X,F7.3,A21)
     WRITE(6,404) SWITCH(NTDEPP),UNITS(NUNITS)
 404 FORMAT(5X,'ESTIMATES OF TIME AVAILABLE ARE =',21X,A21
    1,/,5X,'(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIME)',2X,
    1A21 )
     IF(NTDEPP.EQ.1)WRITE(6,414)TALLOW,UNITS(NUNITS)
 414 FORMAT(5X,'BEST ESTIMATE OF THE TIME AVAILABLE FOR DIAGNOSIS IS ='
    1,F7.3,A21,/,5X,'(UNITS FOR TIME ARE THE SAME AS FOR THE MEDIAN TIM
    2E)',/)
C
C
C          TIME DEPENDENT PART CALCULATED FIRST
C      NCOG GIVES THE TYPE OF COGNITIVE PROCESSING
C           1=SKILL,2=RULE,3=KNOWLEDGE
      GO TO (10,20,30),NCOG
   10 C1=.7
      C2=.407
      C3=1.2
      GO TO 40
   20 C1=.6
      C2=.601
      C3=.9
      GO TO 40
   30 C1=.5
      C2=.791
      C3=.8
   40 CONTINUE
C     RK1= OPERATOR EXPERIENCE(EXPERT(1),AVERAGE(2),MINIMUM(3))
C     RK2= STRESS LEVEL(GRAVE(1),POTENTIAL EMERG(2),NO EMERG(3),LOW ACTIVITY(4)
C     RK3= PLANT INTERFACE QUALITY(EXCELLENT(1),GOOD(2),FAIR(3),POOR(4),
C           EXTREMELY POOR(5))
C
C     K1= OPERATOR EXPERIENCE LEVEL
      GO TO (11,21,31),K1
   11 RK1=-.22
      GO TO 41
   21 RK1=0.0
      GO TO 41
   31 RK1=.44
   41 CONTINUE
C
C     K2= STRESS LEVEL
      GO TO (12,22,32,42),K2
```

Sheet 3 of 6

```
   12 RK2=.44
      GO TO 52
   22 RK2=.28
      GO TO 52
   32 RK2=0.0
      GO TO 52
   42 RK2=.28
   52 CONTINUE
C
C     K3= PLANT INTERFACE
      GO TO (13,23,33,43,53),K3
   13 RK3=-.22
      GO TO 63
   23 RK3=0.0
      GO TO 63
   33 RK3=.44
      GO TO 63
   43 RK3=.78
      GO TO 63
   53 RK3=.92
   63 CONTINUE
C     NTDEP= SWITCH TO DETERMINE IF VARIABLE  ESTIMATES OF THE
C            TIME AVAILABLE FOR DIAGNOSIS MUST BE INPUT BECAUSE
C            THE ALLOWABLE TIME FOR RECOVERY OR  THE ESTIMATED
C            TIME FOR PERFORMING THE ACTION ARE UNCERTAIN
C            NTDEP=0(VARIABLE ESTIMATES NOT USED)
C            NTDEP=1(VARIABLE ESTIMATES USED)
      NTAL=1
      NTRESP=1
      PROB=1.0
      CSUM=0.
      CTOTAL=0.
      CFT=0.
      CFIND=0.
      IF(NTDEP.EQ.0)GO TO 71
      READ(5,TABLE)
C                   NTAL= NUMBER OF POINTS IN TIME ALLOWED DISTRIBUTION
C                   NTRESP= NUMBER OF POINTS IN TIME TO  RESPOND DISTRIBUTION
C                   TAL=   TIMES IN TIME ALLOWED DISTRIBUTION
C                   PTAL= PROBABILITIES IN TIME ALLOWED DISTRIBUTION
C                   TRESP=TIMES IN TIME TO RESPOND DISTRIBUTION
C                   PTRESP= PROBABILITIES IN TIME TO RESPOND DISTRIBUTION
      IF(NTDEPP.EQ.2) WRITE(6,410)TAL
  410 FORMAT(/,15X,'DISTRIBUTION FOR TIMES ALLOWED',/,10F7.2,/)
      IF(NTDEPP.EQ.2) WRITE(6,411)PTAL
  411 FORMAT(15X,'PROBABILITIES FOR TIMES ALLOWED DISTRIBUTION',/,
     1 10F7.2,/)
      IF(NTDEPP.EQ.2)WRITE(6,412)TRESP
  412 FORMAT(15X,'DISTRIBUTION FOR TIMES TO RESPOND ONCE DIAGNOSED',/,
     110F7.2,/)
      IF(NTDEPP.EQ.2)WRITE(6,413)PTRESP
  413 FORMAT(15X,'PROBABILITIES FOR TIME TO RESPOND DISTRIBUTION',
     1 /,10F7.2,/)
   71 CONTINUE
      DO 72 I=1,NTAL
      DO 72 J=1,NTRESP
      IF(NTDEP.EQ.0) GO TO 73
      IF(I.EQ.1.AND.J.EQ.1) WRITE(6,418)
  418 FORMAT(/,3X,'INTERMEDIATE RESULTS:'/,4X,'TIME ALLOWED     TIME TO R
     1ESPOND     ESTIMATED ERROR FREQUENCY     PROBABILITY',/)
      TALLOW= TAL(I)-TRESP(J)
      IF(TALLOW.LE.0.)TALLOW=0.
      PROB= PTAL(I)*PTRESP(J)
   73 CONTINUE
```

```
C
C     TALLOW= ALLOWABLE DIAGNOSIS,RESPONSE TIME FROM TIME OF INDICATIONS
C     TMED= MEDIAN ESTIMATE OF ACTUAL DIAGNOSIS TIME MEASURED FROM INDICATIONS
C          TO COMPLETION OF DIAGNOSIS
      RNUM=TALLOW/TMED/(1.+RK1)/(1.+RK2)/(1.+RK3)-C1
      IF(RNUM.LE.0.0) RNUM=1.E-6
      FT= EXP(-(RNUM/C2)**C3)
C     FT= TIME DEPENDENT ERROR PROBABILITY
C

C          TIME INDEPENDENT CALCULATION
C     NTASK= TYPE OF DYNAMIC HUMAN ACTION
C         1= BACKUP TO AUTO. ACTION
C         2= DETRACT FROM AN ESAS RESPONSE
C         3= RECOVER A FAILED SYSYTEM
C         4= PLANNED MANUAL ACTION
C         5= ACTION WILL LEAD TO AN EXTENDED OUTAGE
C     NR1= ADDITIONAL CREW INPUT( 1=NONE,2= SHIFT SUP. ARRIVES, 3= ONSITE
C         EMERG SUPPORT TEAM ARRIVES)
C     NR2= ADDITIONAL PLANT FEEDBACK (1=NONE,2=YES;MUST ALSO HAVE
C         SUFFICIENT TIME AVAILABLE)
      IF(NCOG.EQ.3.AND.NR1.EQ.2)NR1=1
      IF(NCOG.NE.3.AND.NR1.EQ.3)NR1=2
C
C     NR3= TIME-INDEPENDENT FAILURE PENALTY FOR POOR OR VERY POOR
C         PLANT INTERFACE
      NR3=1
      IF(K3.EQ.4) NR3=2
      IF(K3.EQ.5) NR3=3
      FIND=TASKT(NTASK)*R3(NR3)*R1(NR1)*R2(NR2)
      IF(FT.GE.FIND)NR1=1
      IF(FT.GE.FIND)NR2=1
      FIND=TASKT(NTASK)*R1(NR1)*R2(NR2)*R3(NR3)
C
C        ACCOUNT FOR DEPENDENCE BETWEEN OTHER TASKS
C     NDEP= TYPE OF DEPENDENCE BETWEEN TASKS(1=ZERO,2=LOW,3=MEDIUM,
C          4=HIGH,5=COMPLETE)
      SUM  =FT+FIND
      IF(SUM.GE.1.0)SUM=1.0
C     NPREV= DID PREVIOUS TASK SUCCEED OR FAIL(1=SUCCEED,2=FAIL)
C           USE NPREV = FAIL IF ZERO DEPENDENCE MODELED
      IF(NPREV.EQ.1)SUM=1.-SUM
      GO TO (15,25,35,45,55)NDEP
   15  TOTAL=SUM
      GO TO 65
   25  TOTAL=(1.+19.*SUM)/20.
      GO TO 65
   35 TOTAL= (1.+6.*SUM)/7.
      GO TO 65
   45 TOTAL= (1.+SUM)/2.
      GO TO 65
   55 TOTAL=1.0
   65 CONTINUE
C     CHANGE SUCCESS PROBABILITY TO FAILURE PROBABILITY IF PREVIOUS TASK
C     WAS SUCCESSFUL
      IF(NPREV.EQ.1)TOTAL=1.-TOTAL
      CTOTAL=CTOTAL+TOTAL*PROB
      IF(NTDEP.NE.0)WRITE(6,417) TAL(I),TRESP(J),SUM,PROB
  417 FORMAT( 4X,1PE8.2,8X,1PE8.2,11X,1PE8.2,21X,1PE8.2)
      CSUM=CSUM+SUM*PROB
      IF(NPREV.EQ.1)CSUM=CSUM-SUM*PROB+(1.-SUM)*PROB
      CFT=CFT+FT*PROB
      CFIND=CFIND+FIND*PROB
   72 CONTINUE
```

```
C
C     COMPLETION OF LOOP ON VARIABLE TIME AVAILABLE FOR DIAGNOSIS
C
C
C     BEGIN CALCULATION OF UPPER AND LOWER BOUND ESTIMATES
C
      RF=10.
      IF(CSUM.GT..03)RF=5.
      IF(NDEP.NE.1.AND.NPREV.EQ.2) GO TO 200
      CTOTH=CTOTAL*RF
      IF(CTOTH.GE.1.0) CTOTH=1.0
      CTOTL=CTOTAL/RF
      GO TO 203
  200 CONTINUE
      IF(NDEP.NE.5) GO TO 201
      CTOTH=1.0
      CTOTL=1.0
      GO TO 203
  201 CONTINUE
      NDEP=NDEP+1
      IF(NPREV.EQ.1)NDEP=NDEP-2
C     USER LOWER DEPENDENCY FOR UPPER BOUND IF PREVIOUS TASK WAS SUCCESSFULL
      PROB=1.0
      CTOTH=0.
      DO 82 I=1,NTAL
      DO 82 J=1,NTRESP
      IF(NTDEP.EQ.0) GO TO 81
      TALLOW= TAL(I)-TRESP(J)
      IF(TALLOW.LE.0.)TALLOW=0.
      PROB= PTAL(I)*PTRESP(J)
   81 CONTINUE
C
C     TALLOW= ALLOWABLE DIAGNOSIS,RESPONSE TIME FROM TIME OF INDICATIONS
C     TMED= MEDIAN ESTIMATE OF ACTUAL DIAGNOSIS TIME MEASURED FROM INDICATIONS
C           TO COMPLETION OF DIAGNOSIS
      RNUM=TALLOW/TMED/(1.+RK1)/(1.+RK2)/(1.+RK3)-C1
      IF(RNUM.LE.0.) RNUM=1.E-5
      FT= EXP(-(RNUM/C2)**C3)
C     FT= TIME DEPENDENT ERROR PROBABILITY
C
C           TIME INDEPENDENT CALCULATION
C     NTASK= TYPE OF DYNAMIC HUMAN ACTION
C         1= BACKUP TO AUTO. ACTION
C         2= DETRACT FROM AN ESAS RESPONSE
C         3= RECOVER A FAILED SYSYTEM
C         4= PLANNED MANUAL ACTION
C         5= ACTION WILL LEAD TO AN EXTENDED OUTAGE
C     NR1= ADDITIONAL CREW INPUT( 1=NONE,2= SHIFT SUP. ARRIVES, 3= ONSITE
C          EMERG SUPPORT TEAM ARRIVES)
C     NR2= ADDITIONAL PLANT FEEDBACK (1=NONE,2=YES;MUST ALSO HAVE
C          SUFFICIENT TIME AVAILABLE)
      IF(NCOG.EQ.3.AND.NR1.EQ.2)NR1=1
      IF(NCOG.NE.3.AND.NR1.EQ.3)NR1=2
C
C     NR3= TIME-INDEPENDENT FAILURE PENALTY FOR POOR OR VERY POOR
C          PLANT INTERFACE
      NR3=1
      IF(K3.EQ.4) NR3=2
      IF(K3.EQ.5) NR3=3
      FIND=TASKT(NTASK)*R3(NR3)*R2(NR2)*R1(NR1)
      IF(FT.GE.FIND)NR1=1
      IF(FT.GE.FIND)NR2=1
      FIND=TASKT(NTASK)*R1(NR1)*R2(NR2)*R3(NR3)
C
C        ACCOUNT FOR DEPENDENCE BETWEEN OTHER TASKS
```

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```
C     NDEP= TYPE OF DEPENDENCE BETWEEN TASKS(1=ZERO,2=LOW,3=MEDIUM,
C           4=HIGH,5=COMPLETE)
      SUM  =FT+FIND
      IF(SUM.GE.1.0) SUM=1.0
C     NPREV= DID PREVIOUS TASK SUCCEED OR FAIL(1=SUCCEED,2=FAIL)
C            USE NPREV = FAIL IF ZERO DEPENDENCE MODELED
      IF(NPREV.EQ.1) SUM=1.-SUM
      GO TO (86,87,88,89,90)NDEP
   86  TOTAL=SUM
      GO TO 85
   87  TOTAL=(1.+19.*SUM)/20.
      GO TO 85
   88 TOTAL= (1.+6.*SUM)/7.
      GO TO 85
   89 TOTAL= (1.+SUM)/2.
      GO TO 85
   90 TOTAL=1.0
   85 CONTINUE
      IF(TOTAL.GE.1.0) TOTAL=1.0
C     CHANGE SUCCESS PROBABILITY TO FAILURE PROBABILITY IF PREVIOUS TASK
C     WAS SUCCESSFUL
      IF(NPREV.EQ.1)TOTAL=1.-TOTAL
      CTOTH=CTOTH+TOTAL*PROB
   82 CONTINUE
      CTOTL=(CTOTAL**2)/CTOTH
C
C     COMPLETION OF LOOP ON VARIABLE TIME AVAILABLE FOR DIAGNOSIS
C
  203 CONTINUE
      WRITE(6,422)
  422 FORMAT(3X,'RESULTS:')
      IF(CFT.LE..000001) WRITE(6,600)CTOTL,CTOTAL,CTOTH,CFIND,CSUM
      IF(CFT.GT..000001)WRITE(6,104)CTOTL,CTOTAL,CTOTH,CFT,CFIND,CSUM
  104 FORMAT(/,10X,'FAILURE FREQUENCY RANGE',/,13X,'LOWER BOUND= ',
     61PE8.2,
     1  /,13X,'BEST ESTIMATE= ',1PE8.2,/,13X,'UPPER BOUND= ',1PE8.2,
     2  /,10X,'BEST ESTIMATE TIME DEPENDENT= ',
     3 1PE8.2,/,10X,'BEST ESTIMATE TIME INDEPENDENT = ',1PE8.2,/
     4 ,10X,'TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS='
     5 ,1PE8.2,/)
  600 FORMAT(/,10X,'FAILURE FREQUENCY RANGE',/,13X,'LOWER BOUND= ',
     61PE8.2,
     1  /,13X,'BEST ESTIMATE= ',1PE8.2,/,13X,'UPPER BOUND= ',1PE8.2,
     2  /,10X,'BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE',
     3 /,10X,'BEST ESTIMATE TIME INDEPENDENT = ',1PE8.2,/
     4 ,10X,'TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS='
     5 ,1PE8.2,/)
      RESULT(N)=CTOTAL
      RNAME(N)=TITLE(1)
      POIN2(N)='  '
      N=N+1
      IF(N.LE.NACT)GOTO 70
      WRITE(6,432)
  432 FORMAT(1H1,10X,'SUMMARY OF BEST ESTIMATE RESULTS',/)
      DO 431 J=1,NACT
      WRITE(6,430)RNAME(J),RESULT(J),POIN2(J)
  430 FORMAT(10X,A6,5X,1PE8.2,A2)
  431 CONTINUE
      WRITE(6,451)
  451 FORMAT(10X,'** INDICATES THAT POINT VALUES WERE READ AS INPUT')
      STOP
      END
```

```
C     NDEP= TYPE OF DEPENDENCE BETWEEN TASKS(1=ZERO,2=LOW,3=MEDIUM,
C           4=HIGH,5=COMPLETE)
      SUM  =FT+FIND
      IF(SUM.GE.1.0) SUM=1.0
C     NPREV= DID PREVIOUS TASK SUCCEED OR FAIL(1=SUCCEED,2=FAIL)
C            USE NPREV = FAIL IF ZERO DEPENDENCE MODELED
      IF(NPREV.EQ.1)SUM=1.-SUM
      GO TO (86,87,88,89,90)NDEP
   86  TOTAL=SUM
      GO TO 85
   87  TOTAL=(1.+19.*SUM)/20.
      GO TO 85
   88 TOTAL= (1.+6.*SUM)/7.
      GO TO 85
   89 TOTAL= (1.+SUM)/2.
      GO TO 85
   90 TOTAL=1.0
   85 CONTINUE
      IF(TOTAL.GE.1.0) TOTAL=1.0
C     CHANGE SUCCESS PROBABILITY TO FAILURE PROBABILITY IF PREVIOUS TASK
C     WAS SUCCESSFUL
      IF(NPREV.EQ.1)TOTAL=1.-TOTAL
      CTOTH=CTOTH+TOTAL*PROB
   82 CONTINUE
      CTOTL=(CTOTAL**2)/CTOTH
C
C     COMPLETION OF LOOP ON VARIABLE TIME AVAILABLE FOR DIAGNOSIS
C
  203 CONTINUE
      WRITE(6,422)
  422 FORMAT(3X,'RESULTS:')
      IF(CFT.LE..000001) WRITE(6,600)CTOTL,CTOTAL,CTOTH,CFIND,CSUM
      IF(CFT.GT..000001)WRITE(6,104)CTOTL,CTOTAL,CTOTH,CFT,CFIND,CSUM
  104 FORMAT(/,10X,'FAILURE FREQUENCY RANGE',/,13X,'LOWER BOUND= ',
     61PE8.2,
     1  /,13X,'BEST ESTIMATE= ',1PE8.2,/,13X,'UPPER BOUND= ',1PE8.2,
     2  /,10X,'BEST ESTIMATE TIME DEPENDENT= ',
     3 1PE8.2,/,10X,'BEST ESTIMATE TIME INDEPENDENT = ',1PE8.2,/
     4 ,10X,'TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS='
     5 ,1PE8.2,/)
  600 FORMAT(/,10X,'FAILURE FREQUENCY RANGE',/,13X,'LOWER BOUND= ',
     61PE8.2,
     1  /,13X,'BEST ESTIMATE= ',1PE8.2,/,13X,'UPPER BOUND= ',1PE8.2,
     2  /,10X,'BEST ESTIMATE TIME DEPENDENT=  NEGLIGIBLE',
     3 /,10X,'BEST ESTIMATE TIME INDEPENDENT = ',1PE8.2,/
     4 ,10X,'TOTAL BEFORE ACCOUNTING FOR DEPENDENCY BETWEEN TASKS='
     5 ,1PE8.2,/)
      RESULT(N)=CTOTAL
      RNAME(N)=TITLE(1)
      POIN2(N)='  '
      N=N+1
      IF(N.LE.NACT)GOTO 70
      WRITE(6,432)
  432 FORMAT(1H1,10X,'SUMMARY OF BEST ESTIMATE RESULTS',/)
      DO 431 J=1,NACT
      WRITE(6,430)RNAME(J),RESULT(J),POIN2(J)
  430 FORMAT(10X,A6,5X,1PE8.2,A2)
  431 CONTINUE
      WRITE(6,451)
  451 FORMAT(10X,'** INDICATES THAT POINT VALUES WERE READ AS INPUT')
      STOP
      END
```

TABLE A-2. DYNAMIC HUMAN ERROR CALCULATION INPUT VARIABLES

The number of dynamic human errors to be calculated is first read as input variable NACT. The variable is read according to (I3) format.

For each dynamic error to be calculated the following input is provided.

Title:
A title record is input for each action. It is read according to (7A10) format.

NAMELIST DAT1:

*NCOG	= Type of cognitive processing (skill = 1, rule = 2, knowledge = 3)
*K1	= Crew experience level (expert = 1, average = 2, minimum = 3)
*K2	= Stress level (grave = 1,potential emergency = 2, optimal conditions = 3,low vigilance = 4)
*K3	= Plant interface (excellent = 1, good = 2, fair = 3, poor = 4, very poor = 5)
*NTDEP	= Estimates of times allowed and times to respond (variable =1, point values = 0)
*TALLOW	= Time available for diagnosis
*TMED	= Best estimate of time to complete diagnosis (same units as for TALLOW
*NTASK	= Type of task (Backup Auto. Action = 1,Detract from ES = 2, Recover Failed System = 3, Planned Manual Action = 4, Cause Extended Outage = 5)
*NR1	= Feedback from additional crew (none = 1,Shift Supervisor Arrives = 2, Full Support from Offsite Team = 3)
*NR2	= Feedback from additional plant indications (no =1, yes =2)
*NDEP	= Dependency between tasks (zero = 1,low = 2,medium = 3, high = 4, complete = 5)
*NPREV	= Status of task dependent on (succeeded = 1, failed = 2)
*DPTASK	= Identifier for task dependent on. (Format is (A6))
*NUNITS	= Time units for TALLOW and TMED (minutes = 1, hours = 2)
*NPOINT	= Type of quantification (full dynamic error calculation = 0, echo point value read as input = 1,default = 0)
*NTAL	= Number of points in variable time allowed distribution.
*NTRESP	= Number of points in variable time to respond distribution
*TAL	= Times in variable times allowed distribution (supply 10 times)
*PTAL	= Frequencies for variable time allowed (supply 10 frequencies)
*TRESP	= Times in variable time to respond distribution (supply 10 times)
*PTRESP	= Frequencies for variable time to respond (supply 10 times)

APPENDIX B

COMPLETED HUMAN ACTION QUESTIONNAIRES

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HAM1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to bypass the instrument air dryer transfer valve in the event it sticks between dryers restricting flow to both flow paths. It takes about 10 minutes for the air pressure to drop to low levels. After loss of air pressure, reserve bottles on the seal injection and intermediate cooling air-operated valves maintain their position for about another 10 minutes. The bypass must be established before these valves fail closed.

2. List split fractions that include this human action.

AmA ; Am-1
AmB ; Am-1 ($\overline{OP}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

In 10-15 minutes the air pressure decays off.

Approximately 20 minutes from initiation of event available until seal injection and intermediate closed cooling valves go closed.

At ≈45# in the air system PP-V-144 opens and vents off the air

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Human Action Identifier: HAM1 Sheet 2 of 11

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (yes, no) (3) yes

2) If yes, by what means? (procedures, training, frequent performance) classroom training and frequent performance

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no) no

4) Is this action included in simulator training? (yes, no) no

5) Frequency of action reviewed? annually

Check those applicable descriptions of actions:

Skill-Based

- ___ Routine action, procedure not required.
- ___ Routine action, procedure required, but personnel well trained in procedure.
- X Action not routine, but unambiguous and well understood by operators who are well trained.
- ___ Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- ___ Routine action, but procedure required; operators not well trained, or procedure does not cover.
- A.O. X Not routine, action unambiguous and well understood, but not well practiced.
- C.R.O. X Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- ___ Not routine, action ambiguous.
- ___ Not routine, procedure does not cover.
- ___ Not routine, procedure not well understood.
- ___ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ~~Skill~~ Rule

~~[Use logic tree (from HCR report, Figure 8-3) if helpful.]~~

Human Action Identifier: HAM1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
Instrument Air Dryer Trouble alarm — alarm response procedure
Low instrument air pressure indicator

Are displays directly visible? yes

2. Alarms (name, location, audible, visual):
Instrument Air dryer Alarms
Low Instrument Air Pressure alarms
In control room, VISUAL and audible

DISTRACTING ALARMS — Valves changing position could cause distrac

3. From where will action first be attempted? (control room, other - specify) Locally at the instrument air dryer in the intermed building.

4. Is special coordination between operators required? (yes, no) No

5. Is there corroboration among indications? (very good, some, none) Very good

6. How specific is the guidance for action? good

Check most applicable description of plant interface:

- [x] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

7.

Human Action Identifier: HAM 1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no) No

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response) Recovery

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) NO

4. Are there any system failures that complicate this action? (none, one, multiple) None

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) NO

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. HAM1	Potential Emergency	
B.		
C.		
D.		

Human Action Identifier: HAM1 Sheet 5 of 11

E. <u>Experience Level of Operating Team</u>
(specific team member who would perform the action)

___ Expert, Well Trained. Licensed with more than 5 years experience.

X Average Knowledge, Training. Licensed with more than 6 months experience.

___ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HAM1

F. Response Time Available

1. What is the timing of the first indications for the operator action? Immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
Within 5 minutes the auxiliary operator should be at the valve and have it transferred or bypassed and isolated.
The diagnose time best estimate is 1 minute.

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 20 minutes
or as time since first indications 20 minutes

4. Estimate the median time to carry out the action, once decided to pursue. 3-4 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 20-4 = 16 minutes

TABLE 2-7 (continued)

Human Action Identifier: HAM1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

Valves would transfer position if didn't have backup bottles

— Low air pressure alarms

— Visual inspection by Auxiliary Operator at the air dryer

— Noise of air escaping at the valve.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? Yes

Within the first 10 ~~one - two~~ minutes of the event.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) Yes

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Remote Emergency Response Team]

S.S. or Shift Foreman

4a. At What point will the following ~~scenario~~ events be declared alert ______ site area emergency ______

- Should additional credit be given because of additional plant feedback? (yes, no) Yes - additional low pressure alarms alert the operator to a possible total system failure
- Should additional credit be given because of newly arriving crew members? (yes, no) ~~No~~ Yes

(also some other less important valves may change state

TABLE 2-7 (continued)

Human Action Identifier: HAM1 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   NO

2. How much influence do previous human errors have on this action? (significant, same, none) N/A

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   NO

3 A. Are there enough personnel available to carry out necessary actions? Yes

Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HAM1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ______ Identify by number Alarm Response.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) N/A

3. Which initiating events may lead to a need for this action? Loss of power could cause valve to hang up. This is an initiating event caused by valve failure.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) ______ If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures ~~only~~ by parameters not normally keyed on by the operator? (yes, no) ______ If yes, identify ______.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ______

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ______

8A Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low? ______

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) ______ Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to: N/A

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ______
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? None.

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Human Action Identifier: HAM1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ________ Identify:

4. Is more than one option pursued in parallel? (yes, no) ________

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) N/A Identify:

5A If the correct action were taken prematurely, would the action still be successful? Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) ________ Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ~~N/A~~ very low

TABLE 2-7 (continued)

Human Action Identifier: HAM1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Good

From D. Expected stress level for each scenario group?

Group A Potential Emergency → mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 16 minutes
Best Estimate of time to diagnose 1 minute

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Yes Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group? No

Group A
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? unlikely

From J. Potential for selection of nonviable option? very low

Recover Failed Systems

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..)' :

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HAM2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to manually reload the instrument air compressors following a loss of offsite power. One train of vital electric power is also assumed failed.

2. List split fractions that include this human action.

AMB ; AM-1 (OP)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Offsite power lost, one train of GA or GB down

A- With diesel 'A' failed, requires the operator to go to the 1E bus to select the 'B' Makeup pump for ES in order to restart it.

B- With 'B' diesel failed, the operator can start the 'A' makeup pump from the Control room.

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TABLE 2-7 (continued)

Human Action Identifier: HAM 2 Sheet 2 of 11

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar

2) If yes, by what means? (procedures, training, frequent performance) SIMULATOR TRAINING, CLASS ROOM TRAINING

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)

5) How frequently are these actions reviewed in training? once every 2 yrs minimum

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip. 1202-2

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: ______ Sheet 3 of 11

C. Operator/Plant Interface (. which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   1202-2 step 4 STATION BLACKOUT
   INSTRUMENT AIR PRESSURE, INDICATOR decreasing

   1a. Are displays directly visible. (yes/no)
   yes

2. Alarms (name, location, audible, visual):
   LOW INSTRUMENT AIR PRESSURE ALARMS
   AUDIBLE, VISUAL

3. From where will action first be attempted? (control room, other - specify) C.R.

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HAM2

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) — depends on which Diesel Fails.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. 'A' diesel	MILD	(slightly higher than 'B' due to Makeup pump problems
B. 'B' diesel	MILD	
C.		
D.		

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TABLE 2-7 (continued)

Human Action Identifier: HAM2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HAM 2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 20 seconds (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
5 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event ______
or as time since first indications 20 MINUTES

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~~10 MINUTES~~ 19 minutes

	Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservative
A	'A' D.G. failed	20m		5 min	1-2m.	
B	'B' D.G. failed	20m.		5 min	<1 min	

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TABLE 2-7 (continued)

Human Action Identifier: HAM2 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

He could have not initially recognized that one diesel was not running and tried to start an air compressor that had no power. He would then go to the second compressor and attempt to start it.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

approximately one minute after failure of first option.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

Shift supervisor

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team]

S.F. assisting CRO

4a. At what point would the following be declared:

ALERT —

GENERAL —

SITE AREA —

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SF or procedure reader should help Locate procedure step.

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
A	NO	Yes	FAILURE OF 'A' DIESEL CREATES ADDITIONAL WORK
B	NO	Yes	

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Human Action Identifier: HAM2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   NO

2. How much influence do previous human errors have on this action? (significant, same, none) ______

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   Recovery of makeup pump — parallel
   Recovery of offsite power
   Recovery of CBU
   Recovery of failed diesel
   Stopping DC motors which can be replaced by AC motors.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HAM 2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1202-2.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? LOSS OF OFFSITE POWER

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1202-2A.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number UNLIKELY.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HAM2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful?
NO - The diesel may not be on line yet

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

Low air pressure alarms

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

yes - He could initially try to start the wrong air compressor.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

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Human Action Identifier: HAM7

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential emergency, mild
* Group B " " "
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 19 minutes
Best Estimate of Time To Diagnose 3 minutes

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
* Group B No
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? Very low.

* Scenario groups results do not really differ.

Planned manual Action

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HBW1

 5.0-2

A. <u>Description of Human Action</u>

1. Objective (task to be performed and failure criteria):

   Operator fails to start the HPI pumps and to open the MU-V14s (used in BW-2).

   for HPI cooling in time to prevent core uncovery

2. List split fractions that include this human action.

   BWB; BW-2

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   HPI cooling required, (no secondary cooling available)
   (not just used to maintain level in pressurizer)
   If normally running MU pump continues, the MU tank may go dry before core uncovery and cause a loss of suction to that pump. Since it only effects one pump, this time period is not assumed to be limiting.

Human Action Identifier: HBW1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 3
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule SKILL

TABLE 2-7 (continued)

Human Action Identifier: HBW1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): 1210-1 STEP 2.6

PRZR LEVEL AT 20"

Subcooled margin less than 25°F

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

PRESSURIZER LOW LEVEL ALARM - C.R. - AUDIBLE, VISUAL

3. From where will action first be attempted? (control room, other - specify) ________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HBW1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Contaminate containment Loss of power or valve failure could prevent action.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HBW1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HBW1 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2 minutes (to reestablish pressurizer level)
15 minutes (before deciding EFW will not be restored)

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 30 min. without EFW
or as time since first indications ~28 min.

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 28 minutes
?

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
only 1	25 min		3 min.	1 min	

TABLE 2-7 (continued)

Human Action Identifier: HBW1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

Subcooling Margin less than 25°F; assume also indicated within about 5 minutes

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

after the pressurizer empties, PRIOR to core DAMAGE

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

ALERT RCS ≥ 620°F GENERAL N/A

SITE AREA RCS > 700°F on 2 operable incore thermocouples

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HBW1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   No

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   Serially - opening MUV 217 or MUV 16 A/B/C/D

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?
   No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HBW1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1 STEP 2.6 and 1210-4 Step 1.5

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) N/A

3. Which initiating events may lead to a need for this action? Excessive cooling, Steamline Break, LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-2, 1210-4, 1210-6, 1210-7, 1210-8

- Loss of 25° SCM
- Lack of P-S H. Transfer
- Small Break LOCA Cooldown
- Large Break LOCA Cooldown
- RCS Superheated.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HBW1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) NA Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:
NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:
Good labeling, separation of components by train

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HBW1

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis ~~action~~ 30-2-1 = 27 min.
Best Estimate of time to diagnose = 3 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Action Type = extended range

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HBW3 2 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Like HBW1, but after recovery from ~~station~~ blackout with no emergency feedwater available. (used in BW-4)

2. List split fractions that include this human action.

BWC; BW-4.3

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Offsite power and both diesel generators failed but recovered within time to prevent core damage. Allowed time for recovery must be split between power recovery time and HPI start time.

EFW fails - 2 hours available

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Human Act on Identifier: HBW3[2] Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? yearly

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL Rule

Human Action Identifier: HBW3 2

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable): 1210-1 STEP 2.6

   PRESSURIZER level at 20".
   Subcooled margin less than 25°F

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

   Pressurizer low level alarm - C.R - audible, visual

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HBW3

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Valve, pump failures could prevent satisfactory completion of action

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HBW3[2]

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HBWS

Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 min (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
After power is restored + 2 minutes
~~Assume power is restored in 20 minutes~~

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 30 min. without EFW
or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. after power restoration + 1 minute

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 30-2-1 = 27 minutes

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
Only 1	30 min		5 minutes	1 min	

Human Action Identifier: HBW3[2]

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   subcooling margin less than 25°F.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   Prior to core damage, after the pressurizer empties.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

   ALERT RCS ≥ 620°F GENERAL

   SITE AREA RCS > 700°F on 2 operable incore thermocouples

- A Should additional credit be given because of additional plant feedback? (yes no)

- B Should additional credit be given because of newly arriving crew members? (yes no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HBW3

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   NO errors,
   but power is successfully recovered.
   Assume offsite crew recovered offsite power so that dependency is zero. Onsite team did not recover the power

2. How much influence do previous errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   Parallel Recovery of offsite power, diesel generators
   Serially EFW recovery

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for? ~~Yes~~ No - recovery of power, assume zero dependence

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HBW3~ Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1 STEP 2.6

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) N/A

3. Which initiating events may lead to a need for this action? Excessive cooling, steamline break, LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-2, 4, 6, 7, 8.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________________

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TABLE 2-7 (continued)

Human Action Identifier: HBW3 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes (No if tried prior to recovery of power)

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:
NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

good labeling, separation of components by train.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HBW3~ Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis & action 31-2-1 min = 27 min.
Best estimate of time to diagnose 5 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Sup.

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

~~[illegible]~~
Recover failed systems

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HBW~~1~~3

A. Description of Human Action

1. Objective (task to be performed and failure criteria): loss of river water

Like HBW1, but after recovery from ~~station~~ blackout, (used in BW-~~2~~4). Emergency feedwater is available.

2. List split fractions that include this human action.

BWD; BW-~~3~~4

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Offsite power and both diesel generators failed but recovered within time to prevent core damage.

Allowed time for recovery must be split between power-recovery time and HPI start time.

EFW WORKS - 6 hours AVAILABLE

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Human Action Identifier: HBW2[3]

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? yearly

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL rule

Human Action Identifier: HBWX3 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable): 1210-1 STEP 2.6
PRESSURIZER LEVEL at 20"

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
PRESSURIZER LOW LEVEL ALARM - CR - AUDIBLE, VISUAL

3. From where will action first be attempted? (control room, other - specify) ________ ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HBW 2³ Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) FAILURE OF equipment TO START

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HBW03 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HBWL3

F. Response Time Available

1. What is the timing of the first indications for the operator action? ~~2 minutes~~ SHFT (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2 minutes ~~6 hours, assume electric power first recovered in 2 hours.~~

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 6 hours
or as time since first indications 6 hours

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 5 minutes

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
only 1	6 hours		5 minutes	1 min.	

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Human Action Identifier: HBWZ[3] Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Subcooling margin less than 25 °F.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   prior to core uncovery, damage

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

   ALERT RCS ≥ 620 °F   GENERAL

   SITE AREA RCS ~ 700 °F on 2 operable incore thermocouples.

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: ~~HBW2~~ HBW3

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No, river water recovery known to be successful ~~but may be established by offsite repair team~~

2. How much influence do previous human errors have on this action? (significant, some, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Serially - opening MU-V-217 or MU-V16 A/B/C/D.

3a. Are there enough personnel available to carry out necessary actions? (yes/no) yes

Must a specific dependence with another human action be accounted for?

Yes Recovery of ~~Power~~ river water

Scenario Group	(Yes/No)	Comments
A.	Yes	low dependence on success of river water recovery (RE-2)
B.		
C.		
D.		

0394G011386

Human Action Identifier: HBW7 3 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) N/A

3. Which initiating events may lead to a need for this action? EXCESSIVE COOLING, STEAMLINE BREAK, LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______ ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-2,4,6,7,8

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NO.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ______

☒ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______

0394G011386

Human Action Identifier: HBWX3 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurely would the action still be successful? yes (NO, if tried prior to power recovery)

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

   NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain: GOOD LABELING, SEPARATION of components, plenty of time.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HBW03

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 6hrs. - 1min ≈ 6 hours
Best Estimate of time to diagnose 5 min, < 1 hr

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? SS + Emerg. Response Team

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low dependence on success of HRE2
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recover failed system

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HC3 1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to isolate seal return (MU-V25, MU-V26) using a push-button in the control room for containment isolation purposes, given that the 30-psig reactor building pressure actuation system fails. A severe core damage sequence is assumed in progress. The action must be complated before the containment failure pressure is reached.

2. List split fractions that include this human action.

C3A ; C3-1
C3B ; C3-1(GA)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

- Response time could be short, ~10 min., with very high stress level
- melt pressure rising in RB,

Human Action Identifier: HCS1

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 2
1=unfamiliar 5=very familiar

2) If yes, by what means? (procedures, training, frequent performance)

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)

5) How frequently are these actions reviewed in training? 2 years

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip. 1210-1 step 2.7

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? skill

Human Action Identifier: HC31 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
1210-1 step 7 RB pressure ≥ 30 psig

1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
D-1-6 RB Press 30 # A & V

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HC31 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☒ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HC31

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HC31 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? ~10 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
10 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event ________
or as time since first indications 10-.5 = 9.5 min.

4. Estimate the median time to carry out the action, once decided to pursue. 30 seconds

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ________

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
	10 min.		2 min.	0.5 min	

Human Action Identifier: HC31 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

None

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address ~~the problem~~? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

ALERT

SITE AREA failure of auto actuation

GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

TABLE 2-7 (continued)

Human Action Identifier: HC31 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

No

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if ~~necessary to~~ describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HC3 1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
   LL, ML, YS

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to: NA

    - [ ] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify ________
    - [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HC31

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) NA Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues: unknown - probably yes

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: Could push wrong actuation pushbutton thus failing to close valves. Could push wrong valve pushbutton if closing only MU-V-25 and MU-V-26.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HC31

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Grave
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 10-.5 = 9.5 min
Best estimate of time to diagnose 2 min

From G. Additional credit to rediagnosis due to plant feedback?
No Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? Low
may push wrong button

Backup to Auto action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCA2 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to manually actuate the reactor building\4-psig containment isolation signal, given that the reactor building is unisolated.

2. List split fractions that include this human action.

CAB, CA-2

~~CBC, CB-2~~

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

- Purge in progress prior to event
- LOCA or SLB in RB
- Early core melt resulting in high stress w/ short time limit
- ten minutes from start of event until operator has to shut valves. is assumed.

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Human Action Identifier: HCA2 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? annually

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HCA2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   RB pressure indicator (<4# but > normal)
   ATP 1210-1 verification of ES actuation component status

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
   ES Actuation, control room A & V

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HCA2 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [x] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HCA2

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HCA2 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 10 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
≤ 2 minutes

3. When is the last time allowed for the operator to take action and be successful?
10 minutes

Measured as median time since initiating event ______
or as time since first indications 10 minutes

4. Estimate the median time to carry out the action, once decided to pursue. 2.5 - 3.5 minutes

Estimate the median time availa[illegible] for the operator to decide to perform the correct action. Meas[illegible]re the time available from when he would first turn his att[illegible]tion to the indications until the last time available. 2 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
Only 1	10 min		2 minutes	3 min	

Human Action Identifier: HCH2 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   radiation alarms in RB (~6)
   high RB sump level indication
   CFT low level
   high condensate in RB cooler alarm
   high radiation in Aux Bldg & F.H. bldg

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes ≤ 10 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT < 10 min
   SITE AREA < 10 min
   GENERAL < 10 min.

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

TABLE 2-7 (continued)

Human Action Identifier: HCA2 Sheet 8 of 11

H. Dependence with Other Human Actions initial in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   yes - failure of initiate verification of ES component status is possible

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? No.

Scenario Group	(Yes/No)	Comments
A.	No	Verification of ES component status is not credited. Credit for this action may be taken later, but it need not be considered as failed
B.		
C.		
D.		

Human Action Identifier: HCA2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ATP 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action? [redacted],

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator NA.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HCA2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) NA Identify:

4. Is more than one option pursued in parallel? (yes, no) NA

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes.

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:
Radiation alarms

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HCA2

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Grave Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 10-3 = 7 minutes
Best estimate of time to diagnose 2 minutes

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A N/a
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Back auto actuation

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCD1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to initiate coodcwn and depressurization if the ADVs and pressurizer spray are available. Also includes the manual action to open the low pressure injection valves (DH-V-4A,B). and start the DHR pumps. (used in CD-1,CD-1(OP))

2. List split fractions that include this human action.

CDA CD-1
CDB CD-1 (OP)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

After RT, operator fails to initiate cooldown.

TABLE 2-7 (continued)

Human Action Identifier: HCD1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 5
1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? 6 WKS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [x] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HCD1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   1210-1 3.16 None

   1a. Are displays directly visible. (yes/no)
   NA

2. Alarms (name, location, audible, visual):
   None

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)
   NA

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

NA

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HCD1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Actual control problems could complicate the action

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HCD1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HC01

F. Response Time Available

1. What is the timing of the first indications for the operator action? 30 minutes (in time since initiating event)
AT end of RT procedure

2. When may the operator first act? (in time from initiating event)
45 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 5 hours — FROM system model section 12.3. 12 hours ... TA ... Ca...
or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. 0,5 hours

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 4 hours

$5 - .5 - .5 = 4$

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	4.5hrs		0.25 hrs.	0.5 hrs	

Human Action Identifier: HCD1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
PLANT MANAGEMENT determining that a cooldown is needed. - RCS inventory loss calculation (2 hours)
   - decreasing MU tank level
   - increasing MU feed with stable pressurizer level
   - radiation indications

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   1-1.5 hours

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team] Operations department management

4a. At what point would the following be declared:
ALERT
SITE AREA
GENERAL
N/A

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HC01

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) ______

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   NOT for just turbine/Reactor trip transients except for the root cause determination as to why the reactor tripped.

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HC01 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1102-11.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
Any reactor trip.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator
a normal trip that is determined to not be a serious event.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

[x] Not do any related action?

[ ] Perform an action that makes things worse? Identify ______

[ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______

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Human Action Identifier: HCD1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful? Possibly not (if the operator opened the TBV's at the wrong time he could create an overcooling event)

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

This is a normal action, performed under low stress, the controls are well laid out.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HCD1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 4 hours
Best estimate of time to diagnose 0.25 hours

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned manual action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCD2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to perform a slow cooldown and depressurization given that he originally decided to attempt the cooldown but the usual equipment (RCPs, spray valve, or ADVs) were not available. This action may include local control of the ADVs if they originally fail to respond, or locally opening the DH-V-4A, B valves if they fail. (used in CD-1, CD-1(OP))

2. List split fractions that include this human action.

CDA CD-1

CDB CD-1(OP)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, normal cooldown
RCP's, sprayer & ADV remote control not available.

0394G01138t

Human Action Identifier: HC02

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip. 1210-1, step 3.16

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HCD2

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable): 1210-1 step 3.16 (Reactor /Turbine Trip)

   slow loss of RCS inventory indicated by decreasing makeup tank level and increasing MU flow with stable pressurizer level

   ~~NONE~~

   1a. Are displays directly visible. (yes/no) — Flow and pressure indications are available to determine if DH-V4's don't open or ADVs not responding to ~~that~~ attempts to reduce Steam generator pressure.

   N/A

2. Alarms (name, location, audible, visual):

   NONE

3. From where will action first be attempted? (control room, other - specify) Local at ADV's if they are known to have a remote control failure

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none) indications of need for cooldown would be equipment problem

6. How specific is guidance given by procedure (very specific, not too specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

N/A ☐ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HC02 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) ADV remote control, DH-V4A,B, RCPs, pressurizer spray [illegible] of above

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HCD2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HC02

F. Response Time Available

1. What is the timing of the first indications for the operator action? 30 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event) at the end of the reactor trip procedure
1 hour

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 12 hours
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 6 hours

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 5.5 hours

$$12-6-0.5=5.5$$

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	11.5 hrs		15 minutes	6 hours	

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TABLE 2-7 (continued)

Human Action Identifier: HC02   Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Plant management determining that a cooldown is needed
   - decreasing MU tank level
   - increasing MU feed with stable pressurizer level
   - RCS leakrate calculation at 2 hours
   - radiation indication

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   1 – 1.5 hours

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team] — OPERATION Department Management

4a. At what point would the following be declared:

   ALERT
   SITE AREA N/A
   GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

TABLE 2-7 (continued)

Human Action Identifier: HC02 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO, but operator has previously decided to perform cooldown & depressurization

2. How much influence do previous human errors have on this action? (significant, same, none) ______

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Try to determine cause and correct the problem of loss of control of valves.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

   ~~NO~~ Yes

Scenario Group	(Yes/No)	Comments
A.	Yes	High dependence on success of HCD1 which decided to attempt cooldown & depressurization
B.		
C.		
D.		

Human Action Identifier: HC02 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1102-16.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
Any reactor trip with power failures

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ____________ NA
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________

Human Action Identifier: HC02 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

The valves are well labelled, the operator's training stresses the location and operation of these valves.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HC02 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 5.5 hours
Best estimate of time to diagnose 15 min = .25 hours

From G. Additional credit to rediagnosis due to plant feedback?
~~No~~ Yes Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A ~~No~~ Yes, High dependence on success of HC01
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recovery of failed system

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCD3 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to take action to cooldown and depressurize by using ADVs and pressurizer spray and opens the DH-V4s for DHR cooling when vital bus ATA is not available. Operator must use the backup manual loader [used for CD-2\(AA)]. A steam generator tube rupture sequence is assumed to have occurred.

2. List split fractions that include this human action.

CD-2($\overline{AA}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Steam generator tube rupture, Loss of ICS power.
The ADV backup manual loader must be used.

Human Action Identifier: HC03 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? yearly

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

Human Action Identifier: HC03

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): 1210-5 (SGTR)

   None, except the requirement to cooldown due to the SGTR.

   See HI01, HI02

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

   See HI01, HI02

3. From where will action first be attempted? (control room, other - specify) ______________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HC03

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes. possible offsite release

4. Are there any system failures that complicate this action? (none, one, multiple) valve power (BACKUP for ADU's) could fail, the valve themselves could fail.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HC03

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HC03 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event) 15 minute

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 4 hours
   or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. 30 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 3.46 hours

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT.
			.25 hours	.5 hrs.	

Human Action Identifier: HC03 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
SG levels and flow rates not responding as the should after a reactor trip
Radiation monitors RM-G-26, 27 alarms

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
Variable depending on size of rupture, should be within 10 minutes.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT — RMA-5 Hi. GENERAL
SITE AREA RMA-5 Hi-Hi

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HC03

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
Possible yes HI01

2. How much influence do previous human errors have on this action?
(significant, same, none) ______________

3. Are other actions being performed serially or in parallel?
(Attach operator time line if necessary to describe.)
serially

3a. Are there enough personnel available to carry out necessary actions?
(yes/no)

Must a specific dependence with another human action be accounted for? yes HI01

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HC03

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-5.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
SGTR, SBLOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator SBLOCA.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
1210-6 except for Radiation alarms in secondary system
(Small LOCA)

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify __________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
Identify by number __________.

10. If the incorrect procedure is entered, does it direct the operator to:

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify __________
- ☒ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? __________

Human Action Identifier: HC03

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

The valves are well labelled, the operators training stresses the location and operation of these valves.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HC03

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 3.5 hours
Best estimate of time to diagnose .25 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, medium dependence, success of HID1
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Low but perform correct action anyway.

From J. Potential for selection of nonviable option? Very low

Planned manual action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCD4

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Like HCD1 except for steam generator tube rupture events. The decision to initiate cooldown and depressurization must be accomplished in time to allow it to be accomplished within 12 hours of the tube rupture. (used in CD-2, ~~CD-2(OP)~~)

2. List split fractions that include this human action.

CD-2
~~CD-2(OP)~~

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Like HCD1 except a steam generator tube rupture has occurred and decision must be made to accomplish cooldown within 12 hours. The operator has 4 hours to make the decision.

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Human Action Identifier: HC04

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6 wks

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [x] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

Human Action Identifier: HC04

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
   Requirement to cooldown due to SGTR
   see HI01 HI02

   1a. Are displays directly visible. (yes/no) yes

2. Alarms (name, location, audible, visual):

   See HI01, HI02

3. From where will action first be attempted? (control room, other - specify) control room

4. Is special coordination between operators required? (yes, no) no

5. Is there corroboration among indications? (very good, some, none) some

6. How specific is guidance given by procedure (very specific, not to specific, very general) very specific

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HC04

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes. possible offsite release

4. Are there any system failures that complicate this action? (none, one, multiple) valve power could fail, the valves themselves could fail

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HC04 Sheet 5 of 11

E. Experience Level of Operating Team (specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HC04

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event) 15 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 4 hours
   or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. 0.5 hours

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 3.46 hours

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat

Human Action Identifier: HC04

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   SG levels and flow rates not responding as the should after a reactor trip.
   Radiation Monitors RM-G-26, 27 alarm

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   within 10 minutes depending on the size of the SGTR.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), STS, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT – RM-A-5 Hi
   SITE AREA RM-A5 Hi-Hi
   GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HCD4

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   Possible yes HID1

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   serially

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? HID1 success

Scenario Group	(Yes/No)	Comments
A.	Yes	HID1 success, medium
B.		
C.		
D.		

Human Action Identifier: HC04 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-5.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
SGTR, SBLOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator SBLOCA.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-6 except for secondary system radiation alarms

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HC04

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

These valves are well labelled, the operators training stresses the location and operations of these valves.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HCD4

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 3.5 hours
Best estimate of time to diagnose 0.25 hours

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, medium dependence on success of HSD1
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Low (better perform correct action anyway)

From J. Potential for selection of nonviable option? Very low

Planned manual action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCD5

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to initiate cooldown and depressurization using pressurizer vents and the PORV following a steam generator tube rupture and a loss of offsite power which precludes pressurizer spray.

2. List split fractions that include this human action.

CD-2 (OP)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Steam generator tube rupture occurred coincident with a loss of offsite power.

Human Action Identifier: HCD5

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip. 1210-5 step 3.8, 4.0.6

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ~~Skill~~ Rule

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Human Action Identifier: HC05 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
Requirement to cooldown due to SGTR

See HI01 HI02

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

See HI01, HI02

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HC05 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.
Venting the pressurizer could cause RCDT rupture disc to break and contaminate the R.B
4. Are there any system failures that complicate this action? (none, one, multiple) Vent or PORV could stick open

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)
The cooldown without RCP's doesn't tell the operator to open the pressurizer vents or PORV, but 1210-5 does allow this to be done

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Humar Action Identifier: HC05 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licen-ed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HCD5

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
25 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 4 hours
   or as time since first indications ____

4. Estimate the median time to carry out the action, once decided to pursue. 0.5 hours

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 3.46 hours

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	4hrs.		.25 hrs.	.5 hrs.	

TABLE 2-7 (continued)

Human Action Identifier: HCD5 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

SG levels and flow rates are not responding as they should after a reactor trip.

Radiation monitors RM-G-26, 27 alarm

Pressurizer level lost.

BWST level at 21 feet, procedure tells him to isolate steam generator

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

within 10 minutes depending on the size of the SGTR.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

ALERT RM-G-25 Hi GENERAL

SITE AREA RM-G-25 Hi-Hi

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HCD5

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   , HID2

2. How much influence do previous human errors have on this action? (significant, same, none) ____________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   serially

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? HID2

Scenario Group	(Yes/No)	Comments
A.	Yes	High dep. on success of HID2
B.		
C.		
D.		

Human Action Identifier: HC05

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-5 step 3.8 (SGTR)

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? SBLOCA, SGTR

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator SBLOCA.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-6 (Small LOCA) except for secondary system radiation alarms

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☒ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

TABLE 2-7 (continued)

Human Action Identifier: HC05 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

The pressurize vents ~~is~~ not normally used for this function and could create some confusion in the operator mind as to the success of using it to cooldown

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HC05

K. Summary Sheet

From B. What type of behavior is required? ~~Knowledge~~ Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action [illegible] 3.5 hours
Best estimate [illegible] .25 hours

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Emer. Response Team

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, high dependence on success of HI02
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? very Low
[illegible]

~~[illegible]~~
Extended Outage if perform action (3-7 days)

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRR3- HCF1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to establish Reactor Building cooling after loss of river water using the industrial coolers

2. List split fractions that include this human action.

CFC ; CF-2

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Loss of river water and it is not recovered in time so that the sequence progresses to a core damage event.

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Human Action Identifier: ~~HRR3~~ HcF1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar /

2. If yes, by what means? (procedures, training, frequent performance) NO

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? ______

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [x] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

Human Action Identifier: ~~HRR3~~ HCF1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
   High RB air temp.
   High RB pressure

   1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
   RB air temp alarm high - CR - audible-visual
   RB high pressure alarm — CR - audible - visual

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☐ Fair. Displays human engineered, but require operator to integrate information.

☒ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: ~~HRR3~~ HCFI

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) The RB isol. must be bypassed to reopen the Industrial cooler valves.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

Generally the industrial coolers would not be used during an emergency.

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [x] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: ~~HRR3~~ HCF1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HRR3 HCF1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 hours (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2.5 hours

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 3 hours
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 0.5 hours (no procedure to help the operator perform steps)

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 0.5 hours

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	1 hour		0.5 hours	0.5 hours	

Human Action Identifier: HRR3 HCF1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
continuously increasing R.B. temp. and pressure.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
prior to containment failure

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT >4# in RB.
SITE AREA >30# in RB
GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HRR3 HCF1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
possible HRR1

2. How much influence do previous human errors have on this action? (significant, same, none) ______

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
Recovery of RW, alternating makeup pumps to prevent support system heatup problems

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?
~~no.~~ yes

Scenario Group	(Yes/No)	Comments
A.	yes	medium dependence on failure of HRE2 (fail to recover river water or rotate MU pumps
B.		
C.		
D.		

Human Action Identifier: ~~HRR3~~ HCF1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number __________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
   Loss of River Water

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator
   NA.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
   None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
   Identify by number NA.

10. If the incorrect procedure is entered, does it direct the operator to:

    - [x] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify __________
    - [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? CF.

Human Action Identifier: ~~HRR3~~ HCF1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

The operator may try to regain the operability of the RR system

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

the RR system

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: ~~HRR3~~ HCF1

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A Grave
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 0.5 hours
Best estimate of time to diagnose 0.1 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Full Support

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, medium dependence on failure of HRE2
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? medium, operator may persist trying to reestablish river water to establish fan cooling

During ESAS response to isolate industrial coolers

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRRT HCF2

A. Description of Human Action

1 Objective (task to be performed and failure criteria):

Operator fails to manually regulate RBEC water pressure, given failure of RR-V6. The accident sequence evaluated is assumed to result in core damage and a continually rising containment pressure. Ten minutes is assumed available for action before the pumps would fail.

2. List split fractions that include this human action.

CFA ; CF-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

- HPI actuation has occurred
- 4# RBI & C has actuated
- LOOP with 1 diesel failed
- Core melt has occurred
- Time available before RR pump failure ~10 minutes
- Pressure indication will be higher than required resulting in operator not realizing valve has failed

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TABLE 2-7 (continued)

Human Action Identifier: ~~HRR1~~ HCF2

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1 = unfamiliar 5 = very familiar ___1___
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? ________

Check those applicable descriptions of actions:

Skill-Based

- ☐ Routine action, procedure not required.
- ☐ Routine action, procedure required, but personnel well trained in procedure.
- ☐ Action not routine, but unambiguous and well understood by operators who are well trained.
- ☐ Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- ☐ Routine action, but procedure required; operators not well trained, or procedure does not cover.
- ☐ Not routine, action unambiguous and well understood, but not well practiced.
- ☐ Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- ☒ Not routine, action ambiguous.
- ☐ Not routine, procedure does not cover.
- ☐ Not routine, procedure not well understood.
- ☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

TABLE 2-7 (continued)

Human Action Identifier: ~~HRR1~~ HCF2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
   none

1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
   none

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general) none

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [x] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HRR1 HCF2 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☒ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HRR1 HCF2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: ~~HRR1~~ HCF2

F. Response Time Available

1. What is the timing of the first indications for the operator action? no indications until pump fails (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   10 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 10 minutes
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. <1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 10 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
Only one	11 min.		10 min.	1 min.	

Human Action Identifier: ~~HRE1~~ HCF2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   none

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to ~~address the problem~~? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA NA
   GENERAL

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (~~yes~~, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HRR1 HCF-2 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

Scenario Group	(Yes/No)	Comments
A.	No	
B.		
C.		
D.		

HCF2

Human Action Identifier: ~~HRR1~~

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for th s ac ion?

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ________.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, o. very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

    [X] Not do any related action?

    [ ] Perform an action that makes things worse? Identify ________

    [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: ~~H2R1~~ HCF2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) NO Procedure asks operator to verify ES equipment status but instruments limited to detect any problem.

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: control is single pushbutton located near pressure indication

8. Is the potential ~~for~~ selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: ~~HRRT~~ HCF2 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Extremely Poor

From D. Expected stress level for each scenario group?

Group A Grave Emerg.
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 91 min.
Best estimate of time to diagnose 10 min

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? very low

Recover Failed System

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCS4 5 6

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

FREQUENCY OF THE OPERATOR FAILING TO ACTUATE THE CONTAINMENT SPRAY SYSTEM. THE 30# ACTUATION SIGNAL DOES NOT OCCUR BECAUSE A CONTAINMENT PURGE WAS IN PROGRESS AT THE TIME OF THE ACCIDENT AND IT is NOT SUBSEQUENTLY ISOLATED. A CORE DAMAGE SEQUENCE IS ASSUMED TO HAVE OCCURRED.

2. List split fractions that include this human action.

CSE CS-3

CSF CS-3($\overline{SL}$)

CSH CS-4

CSI CS-4($\overline{RA}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

- Prior to 30# in RB because auto signal not reached due to purge valves being open after LOCA
- Vering response times
- Operator starts RB spray to minimize offsite doses when he sees high radiation level in RB after core damage.
- Assume large LOCA occurs and goes unmitigated

Human Action Identifier: HCS45

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? annually

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [x] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

Human Action Identifier: HCS 4, 5, 6 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   High radiation in RB (~6)

1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
   High radiation in RB - 1 audible, ~6 visual
   various ES actuation, RT induced alarms

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [x] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HCS4.5 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response) in advance of automatic action which won't be received

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) purge valves failing to close on RT isolation & 4# ESAS

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☒ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HCS45 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HCS 4.5

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2-10 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event) 2-10 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 10 minutes
   or as time since first indications [illegible]

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 2 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVATIVE
Only 1	10 min		2 minutes	1 min.	

Human Action Identifier: HCS 4 5

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   NA - indications are there initially but decision to take action may not come until rediagnosis of same indications

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT initially
   SITE AREA 2-5 minutes
   GENERAL >10 minutes

●A Should additional credit be given because of additional plant feedback? [redacted] no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HCS4 9 5 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
no
yes, operators failed to isolate the purge line

2. How much influence do previous human errors have on this action? (significant, same, none) NA
significant

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? failure to perform initial verification correctly

Scenario Group	(Yes/No)	Comments
A.	Yes	fail to isolate purge line (HCS2) incline
B.		
C.		
D.		

Human Action Identifier: HCS4

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action? LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☒ Perform the correct action anyway? – directs to correct procedure

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HCS4 5

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, nc)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain: controls are blocked out by demarkation lines.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HCS4 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A Grave Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 10-2-1 = 7 minutes
Best Estimate of Time to Diagnose 2 minutes

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, ~~high~~ medium, failure to isolate purge line, HCA2
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Type of human action - backup to automatic action ~~outage~~

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to realign the system to the normal (once-thru) alignment in the event that the recirculation damper (AH-D-36) fails to open following an ESAS actuation or in the event chilled water is lost so that outside air is needed to limit the circulating air temperature.

2. List split fractions that include this human action.

   ECR2

   CVA ; CV-1

   CVB ; CV-1($\overline{OP}$)

   CVC ; CV-1($\overline{GA}$)

   CVD ; CV-1($\overline{NS}$)

   CVG ; CV-1($\overline{OP \cdot GA \cdot NS}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   ES Actuation places CBV on recirc.

   ES actuation increases confusion in CR.

   Because of inadequate damper position indication operator ~~is~~ may be unable to determine that AH-D-36 is closed. *

* Per conversation with Ray Rusnowski of plant engineering this failure will not result in duct failure.

TABLE 2-7 (continued)

Human Action Identifier: HCV1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? procedures, training, frequent performance
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? every 2 years

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

0304C013335

Human Action Identifier: HCV1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
group damper position indication light on PCR and H&V panel
CBV flow recorder on H&V panel
1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
H&V panel flow alarms, audible & visual

3. From where will action first be attempted? (control room, other - specify) ____________________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

[ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.

[ ] Good. Displays carefully integrated with SPDS to help operator.

[X] Fair. Displays human engineered, but require operator to integrate information.

[ ] Poor. Displays available, but not human engineered.

[ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HCV1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) POTENTIAL Explain if yes. potential if airborne activity outside of control bldg, otherwise no

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no). Procedures require CB envelope be maintained and operator is trained to maintain envelope.

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.

- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.

- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. —	Potential Emergency	
B.		
C.		
D.		

Human Action Identifier: HCV1

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Trained. Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HCV1 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? initial verification (in time since initiating event)
≤ 2 minutes

2. When may the operator first act? (in time from initiating event)

30 to 60 minutes

3. When is the last time allowed for the operator to take action and be successful? to be determined by CBV study, estimate 5 to 24 hours

Measured as median time since initiating event ______

or as time since first indications same

4. Estimate the median time to carry out the action, once decided to pursue. 5 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. to be determined by CBV study

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
—	5 hours	24 hours	30 minutes	5 minutes	

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Human Action Identifier: HCV1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   if initially operator only observed indicator light as verification he may later verify inadequate flow in system using flow recorder
   - high control room temperature
   - Room high temp. alarms at 125°F (likely isolate)
   - Erratic instrumentation responses
   - high temperature in control room
2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes - aprox 30 minutes
3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)
4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA NA
GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)
- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
–	Yes	Yes	Would see loss of flow as some [illegible]
			indication after only 30 minutes [illegible]
			[illegible]
			[illegible]

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HCV1 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

No

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

parallel - ES recovery, RT recovery, CBV recovery

3a. Are there enough personnel available to carry out necessary actions? (Yes/No)

Must a specific dependence with another human action be accounted for?

Scenario Group	(Yes/No)	Comments
A.	No	
B.		
C.		
D.		

Human Action Identifier: HCV1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
HSCC failure, NR failure, LOCA, steam line rupture in RB.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

NA ☐ Perform an action that makes things worse? Identify ________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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TABLE 2-7 (continued)

Human Action Identifier: HCV1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) normal system operating procedure

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   if high airborne activity exists outside the control bldg envelope

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful?

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

   high activity alarm/indication on RM-A-1

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

   No

8. Is the potential ~~for~~ selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HCV1

K. Summary Sheet

From B. What type of behavior is required? ~~Skill~~ Rule

From C. Description of plant interface? ~~Fair~~ Poor

From D. Expected stress level for each scenario group?

Group A Potential Emerg.
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 2-8 hours, Best estimate = 3 hours.
Best Estimate of Time To Diagnose 45 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? low

From J. Potential for selection of nonviable option? Very low *

* Concern if high radiation detected.

Time to perform action = 5 minutes or 0.1 hours

$P_{prob} = 1.0$

$P_{time} = .1$

Time Allowed Distribution:

Times = 5., 6., 11., 24

Probabilities = .1, .4, .3, .2

Recover Failed System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to start a standby train of fans or chilled water in the event that the operating train fails. Offsite power is assumed available.

2. List split fractions that include this human action.

   CVP ; LOCV

   CVA ; CV-1

   CVD ; CV-1 (NJ)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   OFFSITE power AVAILABLE
   Equipment FAILURE within the system itself.

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TABLE 2-7 (continued)

Human Action Identifier: HCV2 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? every 2 years

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HCV2

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Chiller, chilled water pumps, fans show breaker status mismatch
Total CBV flow at or near zero.
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
CR - motor trip alarm
Audible, visual

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HCV2

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) multiple

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [x] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. —	Vigilance Problem	[illegible]
B.		
C.		
D.		

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TABLE 2-7 (continued)

Human Action Identifier: HCV2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HCV2

F. Response Time Available

1. What is the timing of the first indications for the operator action? Immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
<1 minute

3. When is the last time allowed for the operator to take action and be successful?

   5-24 hours estimated

   Measured as median time since initiating event TBD by CBU study
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 8 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. TBD by CBU evaluation
   5-24 hours estimated

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
(1)	5	24	5 min.	.1	—

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Human Action Identifier: HCV2 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

He could try to start the wrong train of fans.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

When room temperature alarms come in.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team] SF, SS

4a. At what point would the following be declared:
ALERT N/A GENERAL
SITE AREA

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HCV2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   no

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?
   no

Scenario Group	(Yes/No)	Comments
A.	No	
B.		
C.		
D.		

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Human Act'on Identifier: HCV2 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsi ccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1104-19.

2. If no procedures applv, is the operator trained to perform the specific action? yes no) N/A

3. Which initiating events may lead to a need for this action?
LOSS OF CONTROL Bldg VENT. LOSS OF OFFSITE powe

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ________ NO

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, o. very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

N/A ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? CV, GA, GB, VITAL POWER ATR, DA, DB

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Human Action Identifier: HCV2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful?
Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:
Control Room temperature Rising
Possible high Temperature Alarms in other rooms

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:
No
Controls are clearly marked.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

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TABLE 2-7 (continued)

Human Action Identifier: HCV2 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Vigilance Problem
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 2-8 hours
Best Estimate of [illegible] 5 minutes

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Time To Perform Action
Probability = 1.0, Time = 5 minutes [illegible] .1 hour
Time Allowed Distribution
Times = 5, 6, 11, 24
Probability = .1, .4, .3, .2

Recover Failed System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV4 — Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Similar to HCV8 except that no ESAS signal is present. Operators fail to establish alternative cooling for the control building given an initial loss of ventilation. Used for the LOCV initiating event.

2. List split fractions that include this human action.

FBIC10

CVP; LOCV

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of CBV, normal system found to be not recoverable.

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Human Action Identifier: HCV4 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 2
1 = unfamiliar 5 = very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? every 2 years

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Procedure

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Human Action Identifier: HCV4

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
VENTILATION FANS OFF, CHILLERS OFF, WON'T RESTART

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
CBV FAN MOTOR TRIP. AUDIBLE, VISUAL IN C.R.
CBV LOW FLOW "

3. From where will action first be attempted? (control room, other - specify) LOCALLY AT CONT. BLDG HOT ROOMS

4. Is special coordination between operators required? (yes, no) SECURITY NEED TO OPEN DOORS.

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not too specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HCV4 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.
COULD POSSIBLY CAUSE AREA CONTAMINATION

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HCV4

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine   Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HCV4 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? > 15 minutes because (in time since initiating event). the operator tries to recover normal ventilation first.

2. When may the operator first act? (in time from initiating event) 15 minutes

3. When is the last time allowed for the operator to take action and be successful? more estimate

   Measured as median time since initiating event TBD by CBU study
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 1 hour

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. Variable (5 - 1/4 - 1) = 3.75 hours ~ (24 - 1/4 - 1) = 22.75 hours

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
—	5 hrs	24 hrs	15 minutes	1 hour	–

Human Action Identifier: HCV4

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   Room temp. alarms

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes - prior to equipment failure times developed in CBU study.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team] → SF, SS, ER

4a. At what point would the following be declared:
   ALERT → Due to plant status ambiguity, but would likely arrive too late
   SITE AREA
   GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given be[illegible] of newly arriving crew members? (yes, no)
   Shift Supervisor only

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
Jah, I			

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Human Action Identifier: HCV4 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   No

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   No

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.	No	
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HCV4 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number to be WRITTEN

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
LOSS OF CBV

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ________
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? GA, GB, VITAL POWER, OP, DA, OB

TABLE 2-7 (continued)

Human Action Identifier: HCV4 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) He MAY TRY to RECOVER NORM CBV OPERATI

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematuri y would the action still be successful?
yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Expla :

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HCV4

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 2-8 hours
Best Estimate of Time To Diagnosis 15 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? very low

Time To Perform Action
Probability = .2, .6, .2 , Times to respond = .5, .75, 1.0 hours
Time Allowed Distribution
Times = 5., 3., 11., 24.
Probability = .1, .4, .3, .2

Recover Failed System

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV5

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Failure of operator to manually open a single control building ventilation damper, which transferred closed, prior to overheating of equipment in the affected room. All support systems are assumed available. A plant trip is assumed to have occurred

2. List split fractions that include this human action.

   CVA ; CV-1
   CVB ; CV-1(OP)
   CVC ; CV-1(GA)
   CVD ; CV-1(NS)
   CVG ; CV-1 (OP, GA, NS)
   CVP ; LOCV

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Reactor trip has occurred
   All support systems are available
   Single damper transfered closed isolating cooling to one or more rooms
   Flow alarms come in
   Possible high fan outlet temperature alarm

Human Action Identifier: H CV 5

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar

2. If yes, by what means? procedures, training, frequent performance

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? very infrequent

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

Human Action Identifier: HCV5 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
decreased flow on CBV flow recorder or low fan flow alarms (HVA 2-5, 3-5, 3-8 etc.)
observation of AO touring control tower - min. once per shift

1a. Are displays directly visible. (yes/no)
Individual room damper trouble alarms (HVA 1-2, 1-4, 2-2 etc.)

2. Alarms (name, location, audible, visual):
low flow alarm H&V panel audible & visual
damper closing alarms

3. From where will action first be attempted? (control room, other - specify) locally at individual damper failed

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

0394G011386

Human Action Identifier: HCV5

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☒ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. O.L.1		
B.		
C.		
D.		

0394G011386

Human Action Identifier: HCV5 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HCV5 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? to be determined by CBV study (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
5-10 minutes if no alarms

3. When is the last time allowed for the operator to take action and be successful? to be determined by CBV study

   Measured as median time since initiating event estimate 5-24 hours
   or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. 15 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. see CBV study
(5 hours - 15 minutes - 15 minutes) : 4.50 hours.

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
—	5	24 hr	15 min.	15 minutes	

0394G011386

Human Action Identifier: HCV5

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   high temperature alarms in other rooms

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes - see CBV study

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S Emergency Response Team]

4a. At what point would the following be declared:

   ALERT GENERAL

   SITE AREA none required

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

Human Action Identifier: HCV5

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   yes - recovery from reactor trip

3a. Are there enough personnel available to carry out necessary actions? (yes / no)

Must a specific dependence with another human action be accounted for?

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HCV5

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action? (GA/GB), ATA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number AP 1203-34.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) currently Identify by number ___; (AP 1203-34). procedure does not cover scenario
(Ventilation loss procedure)

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☒ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

0394G011386

Human Action Identifier: HCV 5 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)
   AP 1203-34 available but does not provide guidance
2. .s discretion given to the control room team as to the proper option among several to be selected? (yes, no)
   Non-proceduralized options
3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, ~~are~~ there other plausible options that are nonviable? (yes, no) Identify:

5a If the action were taken prematurily would the action still be successful?
   yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) NA
   Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: no

8. Is the potential for selection of a nonviable option high, medium, low, or very low? NA

Human Action Identifier: HCV5

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? ~~Fair~~ Poor

From D. Expected stress level for each scenario group?

Group A Vigilance Problem
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 2.4 hours*
Best estimate [illegible] Time To Diagnose 15 minutes

From G. Additional credit to rediagnosis due to plant feedback?
~~Yes~~ No Arriving crew members? [illegible]

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? [illegible]

From J. Potential for selection of nonviable option? Very low

* Time To Perform Action
Probability = 1.0, Time = 0.25 hours
Time Allowed Distribution
. Times = 5, 6, 16, 24
Probability = .1, .4, .3, .2
Recover Failed System

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV6 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to restart the control building ventilation fans and chilled water train following a loss of offsite power. A failure of one train of engineered safeguards power is also assumed lost.

2. List split fractions that include this human action.

CVB ; CV-1(OP)

CVC ; CV-1($\overline{GA}$)

CVF ; CV-1($\overline{GB}$)

CVG ; CV-1($\overline{OP.GA.NS}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

LOOP with one train of diesel supplied power failed ($\overline{GA}$/$\overline{GB}$)

CBV fans and chilled water off.

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TABLE 2-7 (continued)

Human Action Identifier: HCV6 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? annually

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

6

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Base

- [ ] Not rou...e, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

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Human Action Identifier: HCV6 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
zero flow for CBV flow recorder
EP 1202-2 step 10
1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
many ventilation alarms on H&V panel:
- motor trip
- low flow

3. From where will action first be attempted? (control room, other - specify) locally at chiller

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, ~~[illegible]~~ specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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TABLE 2-7 (continued)

Human Action Identifier: HCV6 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HCV6 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HCV6

F. Response Time Available

1. What is the timing of the first indications for the operator action? immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   15-20 minutes

3. When is the last time allowed for the operator to take action and be successful? see CBV study determination

   Measured as median time since initiating event 5-24 was estimated

   or as time since first indications

4. Estimate the median time to carry out the action, once decided to pursue. 15 minutes Anti-recycle interlock:

   if chiller was running at initiation of event it cannot be started for 30 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 5 - .25 = 4.75 hours

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
only 1	5 hours	24 hours	15 minutes	15 minutes	

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Human Action Identifier: HCV6 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   none

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to ~~address the~~ problem? [e.g., None, Shift Technical Advisor (STA), S/S Emergency Response Team]

4a. At what point would the following be declared:
ALERT none declared GENERAL
SITE AREA

●A Should additional credit be given because of additional plant feedback? (~~yes~~, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
—	[illegible]	[illegible]	

Human Action Identifier: HCV6 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   recovery of offsite power
   recovery of failed diesel
   control of EFW for natural circulation cooling.
   restart of AC equipment as power is made available

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? no

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HCV6

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number EP 1202-2 .

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
LOOP with GA/GB

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ____________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number AP 1203-34 .

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ____________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, o. very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.
1210-1 directs to 1202-2 directs to ventilation procedure

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

NA ☐ Perform an action that makes things worse? Identify ____________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________

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Human Action Identifier: HCV6

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control ~~room team~~ as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify: NA

5a. If the action were taken prematurily would the action still be successful: Potential exists that prematurely starting ventilation can overload diesel,

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) NA Identify cues:

7. Is th[illegible] plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

8. Is the potential ~~for sele~~ction of a nonviable option high, medium, low, or very low?

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Human Action Identifier: HCV6 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A [illegible] Emerg.
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action [illegible]
Best Estimate of Time To Diagnose 15 minutes

From G. Additional credit to rediagnosis due to plant feedback?
No Arriving crew members? Shift [illegible]

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? low
([illegible] Operation)

Time To Perform Action
Probability 1.0, Time .25 hours
Time Allowed Distribution
Times = 5., 6., 11., 24.
Probability = .1, .4, .3, .2

Planned manual Action.

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV7

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to align the control building ventilation system to the recirculation mode when no ESAS signal is present. One of AH-D-5, 37 or 39 is assumed to have transferred closed. It is assumed that the event occurs during the time of year when the system is primarily on outside air.

2. List split fractions that include this human action.

CVP, LOCV

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

- Loss of CBV as an initiator at time of year when on outside air
- The operator has to notice the problem is a shutting of one of the major dampers and determine corrective action is to go on recirc.

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Human Action Identifier: HCV7 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1
   1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance) NA

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? not specifically

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [x] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ~~Rule~~ Knowledge

0394G011386

Human Action Identifier: HCV7

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
flow recorder for CBV on HSV panel decreases pressure in control building

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
low flow alarms for various rooms is possible

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not ~~to specific~~, very general) none

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☐ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☒ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

displays for actual damper position do not exist. Dampers are grouped to one light. Limit switch on AHD5 actuates alarm but none on 37 or 39.

0394G011386

Human Action Identifier: HCV 7

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. only 1		
B.		
C.		
D.		

Human Action Identifier: HCV7

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HCV7 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 10 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
10 minutes

3. When is the last time allowed for the operator to take action and be successful? to be determined by CBV study
Measured as median time since initiating event 5-24 estimated
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 15 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______
to be determined by CBV study
(5 .75) = 4.50 hours
-.75

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
—	5	24	15 minutes	15	minutes

Human Action Identifier: HCV7

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   - input from people passing thru doors having large differential pressure

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes - within 30 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA none declared
GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

Human Action Identifier: HCV 7

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   no

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

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TABLE 2-7 (continued)

Human Action Identifier: HCV7 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ______.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
LOOP with ($\overline{GA}$/$\overline{GB}$)

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator
no specific procedure to deal with single damper failure

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
NA.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ______

Not Applicable

☒ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______

Human Action Identifier: HCV7

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:
   He may try shifting to the non operating fan train which will not correct problem but is essential part of troubleshooting process

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:
   see 3 above

5a. If the action were taken prematurily would the action still be successful?
   Yes.

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:
   alarm remain activated, rooms remain pressurized, flow does not return to normal

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:
   controls are adequately marked with good seperation

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HCV7

K. Summary Sheet

From B. What type of behavior is required? ~~Rule~~ Knowledge

From C. Description of plant interface? Extremely Poor

From D. Expected stress level for each scenario group?

Group A Vigilance Problem
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 2-8 hours *
Best Estimate & Time to Diagnose Terminate a .2 hours

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

* Time to Perform Action
Probability = 1.0, Time = .25 hours

Time Allowed Distribution
Times: 5., 6., 11., 24.
Probability = .1, .4, .3, .2

Recover Failed System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV8

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to establish alternative control building ventilation using portable fans (or hallway fans) and elephant trunks to direct the flow. Ventilation is assumed lost initially. An ESAS signal is assumed present. Two to eight hours are assumed available to establish the alternate ventilation.

2. List split fractions that include this human action.

   CVA; CV-1
   CVB; CV-1 ($\overline{OP}$)
   CVC; CV-1 ($\overline{GA}$)
   CVD; CV-1 ($\overline{HE}$)
   CVE; CV-1 ($\overline{VE}$)
   CVF; CV-1 ($\overline{OP.GB.IC}$)
   CVG; CV-1 ($\overline{OP.GA.HE}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   CBV lost (no FANS OPERABLE)
   RT, ESAS SIGNALS PRESENT

TABLE 2-7 (continued)

Human Action Identifier: HCV8 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 2
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is requir Rule

Human Action Identifier: HCV8

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   CBV FLOW ZERO, NO FANS RUNNING

1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
   FAN MOTOR TRIP ALARMS
   CBV LOW FLOW ALARMS

3. From where will action first be attempted? (control room, other · specify) LOCALLY

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

0394G011386

Human Action Identifier: HCV8 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) . Explain if yes.
POSSIBLE SPREAD OF AIRBORNE RADIATION if use outside air

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. only 1		
B.		
C.		
D.		

Human Action Identifier: HCV8

E. <u>Experience Level of Operating Team</u>
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HCV8

F. Response Time Available

1. What is the timing of the first indications for the operator action? Immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   30 minutes

3. When is the last time allowed for the operator to take action and be successful?
   Possible TBD (~~2-8~~ 5-24 hours) based on CBU study
   Measured as median time since initiating event ________
   or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. 30 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~~1.5-7.5~~ hours
   4.5 - 23.5

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
—	5	24	15 minutes	30 minutes	

Human Action Identifier: HCV8 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Room high Temperature ALARMS

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   upon reaching ALARM setpoints probably within 2-6 hours.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team] SS, STA, Re

4a. At what point would the following be declared:
   ALERT INITIALLY GENERAL
   SITE AREA

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no) The new members could direct their attention to different issues than the original members

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HCV8

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) NONE

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   OTHER RECOVERY ACTIONS COULD be ATTEMPTED depending ON REASON FOR LOSS OF CBV.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A. [illegible]	No	
B.		
C.		
D.		

Human Action Identifier: HCV8 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number To be written

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
CBV Failure

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?
Very Low

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to: N/A

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? GA, GB Vital Buses, ATA

Human Action Identifier: HCV8

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? N/A

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) N/A
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: No

8. Is the potential for selection of a nonviable option high, medium, low, or very low? NA

TABLE 2-7 (continued)

Human Action Identifier: HCV8 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action estimated 7-8 hours & Best Estimate of Time To Diagnose 15 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

* Time To Perform Action
Probability = .2, .6, .2 Time to respond = .5, .75, 1.0 hrs.

Time Allowed Distribution
Times = 5., 6., 11., 24
Probability = .1, .4, .3, .2

Recover Tripped System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HCV9

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Similar to HCV8 except that ventilation is lost only after an initial period of 2 hours. During the first 2 hours, DC power supplies the vital instrument buses which hold the room dampers open even though engineered safeguards electric power train B is assumed failed. An ESAS signal is assumed present.

2. List split fractions that include this human action.

   CIF ; CV-1 (OP.GB.IC)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Inverters "B+D" fail after 2 hours causing the 2nd + 3rd Floor dampers to go closed.

ESAS signal present

0394G011386

Human Action Identifier: HCV9

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 2
   1= unfamiliar 5= very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2 YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HCV9 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
CBV Flow zero, no fans running

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
Fan motor trip alarms
CBV low flow alarms

3. From where will action first be attempted? (control room, other - specify) Locally

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

0394G011386

Human Action Identifier: HCV9

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.
POSSIBLE SPREAD OF AIRBORNE RADIATION

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HCV9 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HCV9

F. Response Time Available

1. What is the timing of the first indications for the operator action? Immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
~30 minutes

3. When is the last time allowed for the operator to take action and be successful? 5-24 +2 hours for batteries
Possible (~~2-8~~ hours) TBD based on CBV STUDY
Measured as median time since initiating event ______
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 30 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~~1.5 - 7.5 hours~~
4.5 - 23.5

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVATIVE
–	5	24	15 minutes	30 minutes	

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HCV9 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Room high Temp ALARMS

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   upon reaching ALARM setpoints probably within 2-6 hours

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team] (SS, STA ERT)

4a. At what point would the following be declared:
ALERT INITIALLY
SITE AREA
GENERAL

A Should additional credit be given because of additional plant feedback? (yes, no)

B Should additional credit be given because of newly arriving crew members? (yes, no) The new members could direct their attention to different issues than the original members.

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
A,L,I			

Human Action Identifier: HCV9

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) None

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Other recovery actions could be attempted depending on the reason for loss of CBV.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

Scenario Group	(Yes/No)	Comments
A. —	No	
B.		
C.		
D.		

Human Action Identifier: HCV9

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number To be WRITTEN

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?

   CBV failure

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NONE.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify N/A.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis ~~leading to an~~ operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to: N/A

    ☐ Not do any related action?

    ☐ Perform an action that makes things worse? Identify ________

    ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? GA, GB, VITAL BUSES, ATA

0394G011386

Human Action Identifier: HCV9 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? N/A

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) N/A
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: NO

8. Is the potential for selection of a nonviable option high, medium, low, or very low? N/A

Human Action Identifier: HCV9

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action + 2.8 hours estimated after demands close
Best Estimate of time to diagnose ≈15 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Pot ıtial for selection of nonviable option? Very low

# Time to Complete Action
Probability = .2, .6, .2 Times to respond (hr) = .5, .75, 1.0

Time Allowed Distribution
Times = 5., 6., 11., 24.
Probability = .1, .4, .3, .2

Recover Failed System

0394G011386

TABLE 2-8. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action identifier: HDH1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator turns off the affected DHR pump when DHCCW fails following ESAS actuation in time to prevent pump failure.

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Small Break LOCA with the DHCCW pump failed.

HDH1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) 5
   Rank on scale of 1 to 5, with 3 being average and 5 most familiar. _____

2. If yes, by what means? (procedures, training, frequent performance, or walk-throughs) ________________
   Give procedure number if applicable ____________.

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) NO

4. Is this action included in simulator training? (yes, no) _______

5. How frequently are these actions reviewed by the operators? 2yrs

Check descriptions that apply to this action:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) _______.

HDH1 Sheet 3 of 13

Knowledge-Based

☐ Not routine, action ambiguous.

☐ Not routine, procedure does not cover.

☐ Not routine, procedure not well understood.

☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

HDH1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): see alarms below

   Are displays directly visible? yes

2. Alarms (name, location, audible, visual): (Delayed (100°F) see sheet 8 G.1. D-1-3 DHCC Temp Hi ALARM.
D-3-3 DH Closed Cycle Flow Low, computer alarms on DHR pump temps.

   Will there be many other alarms to distract the operator? (Describe.)

3. From where will action first be attempted? (control room, other--specify)

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)

6. How specific is the guidance for action? (component numbers, timing) The alarm procedures direct the operator to shift to the other train of DHR.

Check most applicable description of plant interface.

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human-engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human-engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

HDH 1 Sheet 5 of 13

D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) Yes

2. Why is this action needed? (_____ to an automatic action, planned _____ action, Recovery of failed system, _____ ESAS response) __________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) No (Explain if yes.)

4. Are there any system failures that complicate this action? (none, one, multiple) if the other train fails the operator may continue running the present one while trying to recover the other train or this one sooner.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

A.

B.

C.

D.

HDH1

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, well trained. Licensed with more than 5 years experience.
- [x] Average knowledge, training. Licensed with more than 6 months experience.
- [ ] Novice, minimum training. Licensed with less than 6 months experience.

HDH 2 — Sheet 7 of 13

F. Response Time Available

1. What is the timing of the first indications for the operator action? (in time since initiating event) D-3-3 alarm, immediate; D-1-3 alarm, delayed

2. When may the operator first act? (in time from initiating event)

   2 minutes first alarm is immediately (est 15 min for high bearing temp alarm)

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event, 20 min*
   or as time since first indications ?

4. Estimate the median time to carry out the action, once decided to pursue. ½ min

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available.

Assess timing for each scenario group.

Scenario Group	Allowed Best	Time Available Conservative	Time to Diagnose Best Estimate	Time to Perform Best Conservative
A.				
B.				
C.				
D.				

* Ref. letter of Nov 3, 1986 (5430-86-102) from E.G. Pidcock to C.D. Adams (i.e. not less than 15 minutes)

HDH1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   alarm D-1-3 at 100°F in DHCCW possible, but not probable if the DC pumps are not on.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NO

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e.. Is the error rate essentially time independent?) (yes, no) ______

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., none, shift technical advisor (STA), remote emergency response team] ______

   At what point would the following events be declared?

   - Alert (onsite response team called) >50gpm Leak
   - Site Area Emergency (offsite response team called) >4# in RB or <1600# RCS
   - General Emergency (potential evacuation) ______

5. Should additional credit be given because of additional plant feedback? (yes, no)______

6. Should additional credit be given because of newly arriving crew members? (yes, no) ______

HDH1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
no

2. How much influence do previous human errors have on this action? (significant, some, none) ____________
NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

4. Are there enough personnel available to carry out the necessary actions? yes

5. Must a specific dependence with another human action be accounted for? yes HRE11

Scenario Group	Yes/No	Comments
A.		
B.		
C.		
D.		

HDH2

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ______ Identify by number alarms. D1 3, D3 7

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
any LOCA or SLB large enough to result in 4 PSIG in RB, coincident with DHCCW failure

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) ______ If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NA.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) NA If yes, identify ______.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ______

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ______

   Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low? ______

9. What is the likelihood of the operator initially ~~entering~~ the wrong procedure? (likely, somewhat likely, unlikely) ______ Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ______.
- ☒ Perform the correct action anyway?

TABLE 2-8 (continued)

HDH1 Sheet 11 of 13

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? DH, LP, SASB

HOH2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) yes

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ______

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ______ Identify:

4. Is more than one option pursued in parallel? (yes, no) ______

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) ______ Identify ______ NA

   If the correct action were taken prematurely, would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) yes
   Identify cues:
   high DHR pump bearing temperature alarms, 3 per pump.

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes, no) ______ Explain:
   well labeled controls on the console.

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ______

Human Action Identifier: HDH1

K. Summary Sheet

From B. What type of behavior is required? SKILL

From C. Description of plant interface? FAIR

From D. Expected stress level for each scenario group?

Group A High WORKLOAD/ POTENTIAL EMERGENCY
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average.

From F. Time available to perform correct action 20min.
Best estimate of time to diagnose 2min.

From G. Additional credit for rediagnosis due to plant feedback?
Yes Arriving crew members? Yes

From H. Need to account for dependence with other actions for each scenario group?

Group A ~~HRE11~~ no. DW
Group B
Group C
Group D

From I. Potential for incorrect diagnosis leading to failure?
Low

From J. Potential for selection of nonviable option? Very Low

Type of human action

- [ ] Backup to an automatic action
- [ ] Detract from an ESAS response
- [x] Recovery of a failed system via realignment
- [ ] Planned manual action
- [ ] Action may lead to an extended outage; e.g., due to contamination.

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HDT1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to take action to prevent boron concentration effects, following a LOCA when the plant is in recirculation from the containment sump.

2. List split fractions that include this human action.

   DTA ; DT-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   - Response time 24 hours
   - LOCA with DH removal on sump recirculation

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Human Action Identifier: HDT1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1
   1 = unfamiliar, 5 = very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2 yrs

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HDT1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   None

1a. Are displays directly visible. (yes/no)

   NA

2. Alarms (name, location, audible, visual):

   NA

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

   NA

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface: NA

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HDT 1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HDT1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HDT I

F. Response Time Available

1. What is the timing of the first indications for the operator action? << 24 hours (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
< 24 hours

3. When is the last time allowed for the operator to take action and be successful? UNKNOWN

Measured as median time since initiating event Assume 24 hours
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 30 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 24 hours or NA

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	24 hours		.25 hours	0.5 hrs.	

Human Action Identifier: HDT1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   NA

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team] ALL

4a. At what point would the following be declared:
ALERT
SITE AREA LOCA
GENERAL

•A Should ~~additional~~ credit be given because of additional plant feedback? (yes, no) NA

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HDT1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for? NA No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HDT1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-7 ⇒ 1104-4. (example) ⇒ 1104-4
2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA
3. Which initiating events may lead to a need for this action? VL, ML, LL,
4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator __________.
5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-6 ⇒ 1104-4.
6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? - (yes, no) If yes, identify NA.
7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?
8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number __________.
10. If the incorrect procedure is entered, does it direct the operator to:

NA

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify __________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? NA

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Human Action Identifier: HDT1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control ~~room-team~~ as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? No - must have sufficient sump inventory.

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues: NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential ~~for selection~~ of a nonviable option high, medium, low, or very low?

Human Action Identifier: HDT 1

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action ≥ 24 hours
Best estimate of time to diagnose 0.25 hours

From G. Additional credit to rediagnosis due to plant feedback? N/A Arriving crew members? Full Support

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned manual action

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF1 Sheet 1 of 11 1E-4

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to replenish the 2-hour backup air supply after a loss of offsite power in which the instrument air compressors were not successfully loaded on to a diesel generator in time, or to send an auxiliary operator to open the EF-V30s.

2. List split fractions that include this human action.

EFN EF-1 (OP.Arm. DA/DB)
EFD EF-1 (OP.Arm)
EFE EF-1 (OP.Arm. GA/GB)
EFH EF-1 (OP, Arm. VA/VB)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of offsite power, two hours available to start compressors, the compressors are not started, the operator has to replenish air bottles.

Upon actuation of EFW an A.O. responds to the EF-V-30 valves (training)

Assume, depletion of air bottles acts as additional plant feedback

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TABLE 2-7 (continued)

Human Action Identifier: HEF1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 3
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HEF1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
1106-6 requires an operator to be sent to the EF-V-30 A/B valves whenever EFW is actuated.
1a. Are displays directly visible. (yes/no) Pump "ON" light EFW flow upscale

2. Alarms (name, location, audible, visual):
Control room audible, visual
EFW auto start actuated A
" " " " B

3. From where will action first be attempted? (control room, other - specify) Locally at EF-V-30's or diesel room.

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HEF1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
"LOOP"

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. only 1		
B.		
C.		
D.		

Human Action Identifier: HEF1

E. <u>Experience Level of Operating Team</u>
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HEF1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2hrs (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
A - < 5 minutes for valves
B - 2 hours + 5 minutes for air bottles.

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 2 1/2 hours
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. see below

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservative
A Valves	2 1/2		5 minutes	5 min	
B air bottles	2 1/2		2 hours + 5 min	15 min	

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Human Action Identifier: HEF1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
loss of control of EFW flow as evidenced by steam generator level deviating from established setpoint. Also, would note loss of 2 hour bottled air.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
after two hours when decay heat is low the steam generator level change should be noticed prior to significant over or under cooling.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT initially
SITE AREA
GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HEF1 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

~~no~~ Yes, Operator failed to reload air compressors on to diesels

2. How much influence do previous human errors have on this action? (significant, same, none) ~~SA~~

Very low because different operators would respond at a much different time

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

Prior to two hours a great deal of human action need to be done but by 2 hours after the event the plant should be in a cooldown.

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

Local control of seal injection flow.

Scenario Group	(Yes/No)	Comments
A.	Yes	low dependence on failure of HAm2
B.		
C.		
D.		

Human Action Identifier: HEF1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number Air – 1104-25; Valves – 1106-6

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
LOOP w/o diesels or with diesels
For Air - MSLB in the intermediate building.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ________.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) I' yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- ☐ Not do any related action?
- NA ☐ Perform an action that makes things worse? Identify ________
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? EF+, EF-

Human Action Identifier: HEF1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:
NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HEF1

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emerg.
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 2 1/2 hours - 5 min. = 2.4 hours
Best estimate of time to diagnose = .1 hr.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? SS + ER Team

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low dependence on failure of operators to reestablish air compressors on to vital buses, HAMR2
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Low

From J. Potential for selection of nonviable option? Very low

Recover Failed System

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF 2 Sheet 1 of 11 6C

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to properly control EFW flow locally after a loss of automatic control. System actuation was previously successful.

2. List split fractions that include this human action.

EFN EF-1 (OP.AM.DA/DB)
EFD EF-1 (OP.AM)
EFE EF-1 (OP.AM.GA/GB)
EFH EF-1 (OP.AM.VA/VB)
EFF EF-1 (GA.GB)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, LOOP - Loss of Auto EFW power

Human Action Identifier: HCF2

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 2
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2 YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HCF2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
On DIRECTION FROM CONTROL ROOM THAT EFW HAS ACTUATED
1a. Are displays directly visible. (yes/no)
Level less than setpoint, EFW flow not responding

2. Alarms (name, location, audible, visual):
Lo-Lo level alarm for OTSG level.

3. From where will action first be attempted? (control room, other - specify) Locally at valves

4. Is special coordination between operators required? (yes, no) - CRO has to tell A.O. the SG level

5. Is there corroboration among indications? (very good, some, none) RCS temp, press.

6. How specific is guidence given by procedure (very specific, not too specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HCF2

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Failure of pumps themselves or valves stick

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HEF2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2-3 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
AO → 10-15 minutes of initiating event
CRO → 5-10 minutes to tell A.O.

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ½ hour
   or as time since first indications 25 minutes
   0.5 hour - 3 min.

4. Estimate the median time to carry out the action, once decided to pursue. 15 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 22-23 minutes

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	½ hr.		3 min.	15 min	

0394G011386

Human Action Identifier: HEF2

Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

SPDS alarms loss of P-S heat removal
High RCS pressure alarm
PORV actuation alarm
High RCS temp alarm.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ______

yes
within 10-15 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT ≥ 620°F RCS temp.
SITE AREA
GENERAL

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

Human Action Identifier: HCF2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO; possibly the air compressors were successfully reloaded

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   Assume none.

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Recovery of LOOP.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1106-6.
   1210-4 directs operator to 1210-10
2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA
3. Which initiating events may lead to a need for this action?
   1) LOOP, Loss of Vital power to EFW 2) Loss of MFW, loss of Vital Power to EFW 3) Loss of RCPs, loss of Vital power
4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.
5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number See #1 above.
6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.
7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?
8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.
10. If the incorrect procedure is entered, does it direct the operator to:

N/A

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

0394G011386

Human Action Identifier: HEF2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) — He may go t HPI cooli while the A is trying to get water t w

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

The EF-V-30's are labeled well, each one has a plaque describing how to go to manual.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HCF82 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 0.5hr - 3 = 0.2 hrs
Best estimate of Time To Diagnose = .05 hours

From G. Additional credit to rediagnosis due to plant feedback?
Arriving crew members? Shift Sup

From H. Need to account for dependence with other actions for each scenario group?

Group A No.
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Backup auto. actuation

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF 3 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator restores instrument air by changing air bottles in the 2-hour backup air system (used in the steam line break tree for a break in the intermediate building).

2. List split fractions that include this human action.

   EFG EF-1 (SB.OP.AM)
   EFJ EF-1 (SB.OP.AM.DA/DB)
   EFK EF-1 (SB.OP.AM.GA/GB)
   ~~EFM~~

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Steamline break, air compressors fail, 2 hour bottles must be changed within 2 hours or repressurized from tank truck

0394G011385

Human Action Identifier: HEF3

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2yrs.

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HEF3 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
EF-V-30's go to ?? position, EFW flow will increase, MS-V-4's fail closed.
1a. Are displays directly visible. (yes, no) not obvious to operator to what has caused the problem.

2. Alarms (name, location, audible, visual):
~~High ??~~ none.

3. From where will action first be attempted? (control room, other - specify) the operator will try to operate valves from C.R. first.

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general) NONE

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [x] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HEF3 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Problems with truck pressure,

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF3 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: H EF3

F. Response Time Available

1. What is the timing of the first indications for the operator action? >2 hours (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
at >2 hours when valve control is lost.

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 2 hrs + 30 min.
or as time since first indications 30 minutes

4. Estimate the median time to carry out the action, once decided to pursue. ~~5-10 minutes~~
15 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~~30 min. prior to SG overfill~~
30 - 15 = 15 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVATIVE
Only 1	30 min		3 min.	15	

Human Action Identifier: HEF3 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

high steam generator level alarm

when MS-V-4's fail shut, OTSG pressure goes up, causing increasing RCS temperature.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

after loss of air, but before OTSG's are overfilled

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

Response team already pres.

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT – MSLB
SITE AREA
GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

Human Action Identifier: HCF3

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   NO

2. How much influence do previous human errors have on this action? (significant, same, none) __________
   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   Serially - controlling cooldown
   Parallel - operating makeup system and IC system air operated valves

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?
   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF3 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
Loss of instrument air

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 120P36. Loss of Instrument air.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ________
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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TABLE 2-7 (continued)

Human Action Identifier: HGF3 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) nothing tells CRO to change bottles during scenario

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) go to HPI cooling, try to recover EFW.

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues: NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:
Once the AO knows to change bottles the actual evolution is not hard.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

NA

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: H EF3   Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? ~~Skill~~ Knowledge

From C. Description of plant interface? Extremely Poor

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 15 min.
Best Estimate of Time required for diagnosis 3 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Yes, SS + ERT

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recover Failed System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF4

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Similar to HEF1 except for the case when all engineered safeguards electric power is lost. Operator fails to replenish the 2-hour backup air supply or to send an auxiliary operator to open the EF-V30s.

   (i.e. no power available to instrument air compressors)

2. List split fractions that include this human action.

   not used

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   LOOP, RT, Loss of Auto EFW power
   ALL ES power LOST. (GA and GB)

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HEF4 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 3
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2 YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HEF4

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
1106-6 requires an A.O. to go to the EF-V-30 valves whenever EFW is actuated.
1a. Are displays directly visible. (yes/no)
Pump 'on' lights
EFW flow upscale

2. Alarms (name, location, audible, visual):
EFW auto start actuated A
EFW auto start actuated B
Control room audible, visual

3. From where will action first be attempted? (control room, other - specify) Locally

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not too specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HCF4 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HCF4 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HEF4 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2hrs (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   A. < 5 minutes for valves - the A.O. responds when CFW starts
   B. 2hrs +5 minutes for air bottles

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 2.5 hours
   or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. Below

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ____________

SCENERIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
A Valves	2.5 hrs		5min	5min	*
B Air bottles	2.5 hrs		~~2hrs~~ +5min	15min	

* use these time limits, since local control w/o air is not difficult

Human Action Identifier: HEF4

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Loss of control of emergency feedwater flow as evidenced by steam generator level deviating from established setpoint.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   after 2 hours when decay heat is low the steam generator level change should be noticed prior to significant over or under cooling

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA ← CS actuation, GENERAL / BLACKOUT

A Should additional credit be given because of additional plant feedback? (yes, no)

B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HEF4 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

after two hours into the event personnel will be closely monitoring EFW and at the same time trying to regain the diesel generators and offsite power.

3a. Are there enough personnel available to carry out necessary actions? yes/no

Must a specific dependence with another human action be accounted for? N.

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF4

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number Air 1104-25. Valves 1106-6

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)
NA

3. Which initiating events may lead to a need for this action?
LOOP, Diesel generators fail to start
MSLB in intermediate building

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ______.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ______.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ______

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______

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TABLE 2-7 (continued)

Human Action Identifier: HEF4 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:
NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HEF4 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Grave
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform ~~correct action~~ diagnosis 2.5 hrs.

Best estimate of time to diagnose 5 min = .1 hrs.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supv. + ERT.

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned normal action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF5 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to manually actuate emergency feedwater given that automatic actuation fails. The allowed time for action is 30 minutes.

2. List split fractions that include this human action.

[illegible]

3. Situation (initiating events and plant conditions, support system status): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of MFW or RCP's all trip, 4# in RB or SG Lo. Lvl

Auto actuation system failed.

30 minutes until core damage.

0394G011386

Human Action Identifier: HEF5

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HEF5

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   Low FW flow
   Low FWP discharge pressure
   Low RCS Flow
   Hi RB pressure
   Low SG level

   1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
   RCP trip alarms
   MFW pump trip alarm
   4# in RB.
   SG low level alarms

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HEF5

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) EFW pumps fail to start or failure of valve control.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF5 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Trained. Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HCF5

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1-2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2-5 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 30 minutes
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 29 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	30 min		2 min.	1 min	

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Human Action Identifier: HEF5

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Loss of Pri to Sec heat transfer – RCS press + RCS temp increasing, SG temp increasing while SG pressure stays constant or decreases.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   as soon as the SG boils down (± 2 minutes)

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT >620°RCS temp.
   GENERAL
   SITE AREA >700°F on 2 inlore T/C.

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

TABLE 2-7 (continued)

Human Action Identifier: HEF5 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

no

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

n/a

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

no

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for? no

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

0394G011386

Human Action Identifier: HEF5

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-4.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
Loss of MFW LOCA LOOP
RCP trip SLB in RB

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ____________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ____________. NA

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ____________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________

0394G011386

Human Action Identifier: HCF5 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful?

   NO

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

   N/A

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: NO – pump controls well labelled, no other controls in area.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HCF25 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 30 - 1 - 2 minutes = 27 minutes
Best estimate of time to perform diagnosis 2 minutes

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Engineer

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very Low

From J. Potential for selection of nonviable option? Very Low

Backup to auto. actuation

5/5/86

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF8

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

~~SEE TMI QUANTIFICATION HUMAN ACTIONS TABLE 1-1 FOR DESCRIPTION~~

Operator fails to properly control EFW flow locally after one or more of the EF-V-30's fails open, either mechanically or fails to receive a signal to close closure. This action is used in the evaluation of top event EF+.

2. List split fractions that include this human action.

EFA EF+1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of feedwater initiating event
EF-V-30's fail open
Auxiliary operator has to take local manual control.

0394G011386

Human Action Identifier: HEF8

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2yrs

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

Human Action Identifier: HEF8

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Indication from CRO that EFW has actuated. AO responds to valves, high flow & inability to control. The CRO will tell the AO to throttle
1a. Are displays directly visible. (yes/no)
OTSG level higher than control point, excessive EFW flow.

2. Alarms (name, location, audible, visual):
OTSG high level

3. From where will action first be attempted? (control room, other - specify) locally at valves after the failure is noticed that control room control is g

4. Is specific coordination between operators required? (yes, no) CRO has to coordinate OTSG level control with Auxiliary Operator

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not too specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

0394G011386

Human Action Identifier: HEF8

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HEF8 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HEF8 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 5 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

10 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 20 minutes
or as time since first indications 15 min.

4. Estimate the median time to carry out the action, once decided to pursue. 10 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 5 minutes

20-10-5 = 5

Scenario Group Differences	Time Available		Best Estimate of Time to Diagnosis	Time to Perform	
	Best	Conserv.		Best	Conservat.
—	20 min		1 min.	10 min	

0394G011386

Human Action Identifier: HEF8 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   SPDS alarms
   Excessive cooling causing post trip RCS temperature and pressures to be lower than normal

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   5-10 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA
   GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HEF8 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) none

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Serially - shutting down unnecessary equipment
   Parallel - trying to recover FW.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HEF8 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1106-6, 1210-3

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? Loss of FW with loss of control power

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-3.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ______.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

- ☐ Not do any related action?
- NA ☐ Perform an action that makes things worse? Identify ______
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? EF+, TC

Human Action Identifier: HEF8

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

. The EF-V-30 valves are well labelled, each one has a plaque giving directions on how to place in manual.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HEF8

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 5 min.
Best estimate of time to diagnose 1 min

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Task type:
Power factor action

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF9 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

~~SEE TMI QUANTIFICATION HUMAN ACTIONS TABLE 1-1 FOR DESCRIPTION~~

Operator fails to properly control EFW flow ~~locally~~ remotely after one or more of the EF-V-30's fails open, either mechanically or fails to receive a signal to close closures. This action is used in the evaluation of top event EFH.

2. List split fractions that include this human action.

EFA EFH

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of feedwater initiating event
EF-V-30's fail open
~~Auxiliary~~ Control room operator has to take remote ~~local~~ manual control.

0394G011386

...man Action Identifier: HEF 9 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 3

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? 2yrs

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

Human Action Identifier: HEF 9

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Indication from CRO that EFW has actuated. AO responds to valves, high flow & inability to control. The CRO will tell the AO to then control.
1a. Are displays directly visible. (yes/no)
OTSG level higher than control point, excessive EFW flow.

2. Alarms (name, location, audible, visual):
OTSG high level

3. From where will action first be attempted? (control room, other - specify) locally at valves after the failure is noticed the control room control is
4. Is special coordination between operators required? (yes, no) CRO has to coordinate OTSG level control with Auxiliary Operator
5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not too specific, very general)
Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

0394G011386

Human Action Identifier: HEF 9

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF 9

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HEF 9

F. Response Time Available

1. What is the timing of the first indications for the operator action? 5 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
10 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 20 minutes
or as time since first indications 15 min.

4. Estimate the median time to carry out the action, once decided to pursue. 1 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 14 minutes

20-1-5 = 14 minutes

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
—	20 min		1 min.	1 min	

Human Action Identifier: HEF 9

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   SPDS alarms
   Excessive cooling causing post trip RCS te, sat... and pressures to be lower than normal

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   5-10 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA
   GENERAL

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HEF 9 Sheet 8 of 1[illegible]

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) none

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Serially - shutting down unnecessary equip.
   Parallel - trying to recover FW.

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HEF 9

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1106-6, 1210-
2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA
3. Which initiatir events may lead to a need for this action? Loss of FW with loss of control power
4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.
5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-3.
6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ______.
7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?
8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.
10. If the incorrect procedure is entered, does it direct the operator to:
    - ☐ Not do any related action?
    - NA ☐ Perform an action that makes things worse? Identify ______
    - ☐ Perform the correct action anyway?
11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? EF+, TC

Human Action Identifier: HEF 9 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

. The EF-V-30 valves are well labelled, each one has a plaque giving directions on how to place in manual.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HEF 9 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 14 min.
best estimate of time to diagnose 1 min

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A N/a
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Task type:
Recover failed system

0394G011386

To D.W.
9-3-86
Via phone, Fed. Ex. 9-4-86

OCT 0 3 RECD

TABLE 2-8. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HEF10

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

The operator is to close CO-V-13 or CO-V-14B if the "hotwell level high" alarm comes in and the problem ~~appears to be~~ is due to CO-V7 or 8 failing open. If the hotwell level gets excessive, the operator can break vacuum per ATP 1210-10 and use the hotwell inventory as a source of suction for the EFW pumps.

2. List split fractions that include this human action.

all EF- split fraction where OP is available and a condensor vacuum is also available.

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of Main Feedwater causes RT and EFW start

CO-V-7 or 8 fail open

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) Yes
   Rank on scale of 1 to 5, with 3 being average and 5 most familiar. 3

2. If yes, by what means? (procedures, training, frequent performance, or walk-throughs) Procedures
   Give procedure number if applicable ALARM PROCEDURES J-1-4, J-2-4

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) NO

4. Is this action included in simulator training? (yes, no) yes

5. How frequently are these actions reviewed by the operators? 2 yrs

Check descriptions that apply to this action:

Skill-Based

☐ Routine action, procedure not required.

☐ Routine action, procedure required, but personnel well trained in procedure.

☒ Action not routine but unambiguous and well understood by operators who are well trained.

☐ Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

☐ Routine action, but procedure required; operators not well trained, or procedure does not cover.

☐ Not routine, action unambiguous and well understood, but not well practiced.

☒ Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) J-1-4, J-2-4
PRF 1-15
M-2-5

Knowledge-Based

☐ Not routine, action ambiguous.

☐ Not routine, procedure does not cover.

☐ Not routine, procedure not well understood.

☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   Are displays directly visible? yes

2. Alarms (name, location, audible, visual):
   J-1-4 J-2-4 CST Low Level Alarm (11.5ft)
   (A) B

   Will there be many other alarms to distract the operator? (Describe.) yes - SG alarms, FW system alarms, primary system alarms on pressure, temp. cooldown.

3. From where will action first be attempted? (control room, other--specify) control Room

4. Is special coordination between operators required? (yes, no) NO

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)

6. How specific is the guidance for action? (component numbers, timing) very specific

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human-engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human-engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) ________

2. Why is this action needed? (_____ to an automatic action, planned ______ action, Recovery of failed system, ______ ESAS response) _______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) NO (Explain if yes.)

4. Are there any system failures that complicate this action? (none, one, multiple) VALVE FAILURE due to LOSS OF POWER, REQUIRING LOCAL ACTION

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) NO

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

A.			
B.			
C.			
D.			

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, well trained. Licensed with more than 5 years experience.
- [x] Average knowledge, training. Licensed with more than 6 months experience.
- [ ] Novice, minimum training. Licensed with less than 6 months experience.

F. Response Time Available

1. What is the timing of the first indications for the operator action? (in time since initiating event) 1 minute Hi cond Lev + CST alar

2. When may the operator first act? (in time from initiating event) 30 seconds of alarm

Time of LOF 0
Time of CST LLA. ___
Time of Loss of [illegible] ___

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event, 55 minutes
   or as time since first indications ________?

4. Estimate the median time to carry out the action, once decided to pursue. 30 seconds

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ________

Assess timing for each scenario group.

	Scenario Group	Allowed Best	Time Available Conservative	Time to Diagnose Best Estimate	Time to Perform Best Conservative
A.					
B.					
C.					
D.					

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   CST Lo-Lo Level Alarm 5 ft PRF 1-15

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ______
   yes ______

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?)
   (yes, no) ______

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., none, shift technical advisor (STA), remote emergency response team] STA, SS

   At what point would the following events be declared?

   - Alert (onsite response team called) ______
   - Site Area Emergency (offsite response team called ______
   - General Emergency (potential evacuation) ______

5. Should additional credit be given because of additional plant feedback? (yes, no) yes

6. Should additional credit be given because of newly arriving crew members? (yes, no) yes

H. Dependence with Otner Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
monitoring of EFW FLOW, SG LEVEL

2. How much influence do previous human errors have on this action? (significant, same, none) ______________
none

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
Serially performing post trip response items

4. Are there enough personnel available to carry out the necessary actions? yes

5. Must a specific dependence with another human action be accounted for?
no

	Scenario Group	Yes/No	Comments
A.			
B.			
C.			
D.			

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number J-1-4, M-2-5, J-2-4
2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA
3. Which initiating events may lead to a need for this action? Loss of Feed
4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) Yes If no, identify by initiator ________.
5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.
6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) No If yes, identify ________.
7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ________
8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

   Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low? ________
9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) ________ Identify by number ________.
10. If the incorrect procedure is entered, does it direct the operator to:

   ☐ Not do any related action?

   ☐ Perform an action that makes things worse? Identify ________.

   ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____EF-________

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________ Sort of

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ________ Identify:

4. Is more than one option pursued in parallel? (yes, no) ________

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) ________ Identify ________

If the correct action were taken prematurely, would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) ________
Identify cues:
Operator could shut wrong valves or not close the valves at all

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes, no) ________ Explain:

8. Is the potential for selection of a nonviable option high, medium, ~~low~~, or very low? ________

Human Action Identifier: HEF10

K. Summary Sheet

From B. What type of behavior is required? SKILL

From C. Description of plant interface? FAIR

From D. Expected stress level for each scenario group?

Group A High Workload
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average.

From F. Time available to perform correct action > 55 minutes.
Best estimate of time to diagnose 30 seconds.

From G. Additional credit for rediagnosis due to plant feedback? yes Arriving crew members? yes

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D

From I. Potential for incorrect diagnosis leading to failure? Low

From J. Potential for selection of nonviable option? Low

Type of human action

- [ ] Backup to an automatic action
- [ ] Detract from an ESAS response
- [x] Recovery of a failed system via realignment
- [ ] Planned manual action
- [ ] Action may lead to an extended outage; e.g., due to contamination.

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HFW4

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to manually control OTSG level after automatic control has failed. Level is sensed to be greater than normal causing main feedwater to be reduced too far.

2. List split fractions that include this human action.

MFG ; MF-1 BKIG

MF-2 e

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

AUTOMATIC CONTROL SYSTEM FAILURE

Power to ICS available

A - Both steam generators require manual level control

B - one steam generator requires manual level control after SCROS has isolated one or a stuck open safety valve requires isolation.

TABLE 2-7 (continued)

Human Action Identifier: HFW4 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6wks

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HFW4

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):

   Steam-generator level, feed water flow

   Hi/LO OTSG level alarms

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

   Steam generator. low level alarms

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HFW4 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Valves could fail to respond requiring other more complex actions

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

See Below

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. A	NORMAL	use high workload/ potential emergency [illegible]
B. B	High	
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HFW4

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HFW4

F. Response Time Available

1. What is the timing of the first indications for the operator action? 30 sec. (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
40 sec.

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ______
   or as time since first indications 90 sec.

4. Estimate the median time to carry out the action, once decided to pursue. 10 sec

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 80 sec.

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
A, B: same as above	90 sec.		20 sec.	10 sec.	

Human Action Identifier: HFW4

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   Loss of primary to secondary heat transfer

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NO

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA
   GENERAL
   N/A

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HFW4

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) NA.

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   REACTOR TRIP IMMEDIATE ACTIONS

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HFW4

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
Rx Trip, excessive Feedwater

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________ NA
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? MF-, [redacted]

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TABLE 2-7 (continued)

Human Action Identifier: HFW4

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful? Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

   NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

   He could manipulate the incorrect controls, the controls are close together for several valves. Could try to control flow with main FW valves rather than startup valves, but there would be no effect [illegible] FW-V-5's are closed

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HFW4 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 80 seconds = 1.33 minutes
Best estimate of time to diagnose 0.33 min

From G. Additional credit to rediagnosis due to plant feedback?
no Arriving crew members? none

From H. Need to account for dependence with other actions for each scenario group?

Group A no (assume no dependence even though operator may also have successfully prevented overcooling in event of a stuck open safety valve)
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? low
could manipulate the wrong valves which are nearby

Backup to an automatic action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HFW5 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to manually control main steam pressure after automatic control has failed.

causing the turbine bypass valves to close

2. List split fractions that include this human action.

MFG; MF-1

MF-2

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of automatic control of the turbine bypass valves following a plant trip (bypass valves fail closed)

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Human Action Identifier: HFW5

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 4
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6WKS

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HFWS   Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
Steam generator pressure, Bypass valve position indication

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
ICS/NNI power failure.

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HFWS   Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) if the loss is due to power failure, instrumentation would also be lost resulting in confusion.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HFW5

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HFW5

F. Response Time Available

1. What is the timing of the first indications for the operator action? IMMEDIATE (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 20 minutes
   or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 17 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
	20 min		2 min.	1 min	

Human Action Identifier: HFW5

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

higher than normal OTSG pressure and RCS temperature after a reactor trip

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes about 2 minutes when the MSSV's close

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

ALERT
SITE AREA NA
GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HFW5

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Reactor trip immediate actions

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

   no

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HFWS

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? Reactor trip, Loss of ICS power

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

NA ☐ Perform an action that makes things worse? Identify ______

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? MF- .

Human Action Identifier: HFW5 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

Indication of steam pressure and valve position are keyed on by the operator after a reactor trip.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HFW5

K. Summary Sheet

From B. What type of behavior is required? Skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 19 min
Best estimate of time to diagnose 2 min

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? very low

Backup to an automatic action

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D

TABLE 2-8. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HHA1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Pull divers out of the water in the river water pump house in order to run DHCCW + DR given a large LOCA event. Prior to the need for recirculation.

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Large LOCA with a diver in the RWPH desilting the floor.

HHA1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) 4
   Rank on scale of 1 to 5, with 3 being average and 5 most familiar. ____

2. If yes, by what means? (procedures, training, frequent performance, or walk-throughs) ____
   Give procedure number if applicable NA.

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) ____

4. Is this action included in simulator training? (yes, no) ____

5. How frequently are these actions reviewed by the operators? The action would be to go to the RWPH, direct the diver's helper to get the diver out of the water, then tell the control room that the pumps are operable (weekly)

Check descriptions that apply to this action:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) ____.

HHA2

Knowledge-Based

☐ Not routine, action ambiguous.

☐ Not routine, procedure does not cover.

☐ Not routine, procedure not well understood.

☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

HHA1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): ESAS status board

   Are displays directly visible? yes

2. Alarms (name, location, audible, visual):
   ES actuation alarms - audible, visual

   Will there be many other alarms to distract the operator? (Describe.) yes - multiple alarms due to the ES actuation and the Rx/Turbine Trips.

3. From where will action first be attempted? (control room, other--specify) The operator may first try to call on the phone, simultaneously send an auxiliary Operator to the River Water Pump House

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)
   multiple indication will show pumps off

6. How specific is the guidance for action? (component numbers, timing) General 1210-1 step 2.7 Verify ESAS components have actuate

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human-engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human-engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

HHA1

D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) ________

2. Why is this action needed? (X to an automatic action, planned ______ action, ________ of failed system, ______ ESAS response) ______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) _______ (Explain if yes.)

4. Are there any system failures that complicate this action? (none, one, multiple) ____________________

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

A.			
B.			
C.			
D.			

HHR2

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, well trained. Licensed with more than 5 years experience.
- [x] Average knowledge, training. Licensed with more than 6 months experience.
- [ ] Novice, minimum training. Licensed with less than 6 months experience.

HHA1

F. Response Time Available

1. What is the timing of the first indications for the operator action? (in time since initiating event) IMMEDIATE

2. When may the operator first act? (in time from initiating event) 2 minutes

3. When is the last time allowed for the operator to take action and be successful? 30 minutes

   Measured as median time since initiating event, ________
   or as time since first indications ________?

4. Estimate the median time to carry out the action, once decided to pursue. 10 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 20 minutes

Assess timing for each scenario group.

Scenario Group	Allowed Best	Time Available Conservative	Time to Diagnose Best Estimate	Time to Perform Best Conservative
A.				
B.				
C.				
D.				

HHA1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Procedure 1210-7 immediate action directs the operator to verify LPI pumps are operating this may cue him to look at the river water pumps also. Alarms on

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes   DHCCW high Temp at 100°, Should come i

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ________

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., none, shift technical advisor (STA), remote emergency response team] SS, STA

   At what point would the following events be declared?

   - Alert (onsite response team called) ~~R~~ > 50 gpm LEAK
   - Site Area Emergency (offsite response team called RB > 30 psig OR RCS LK
   - General Emergency (potential evacuation) RMG-8 > 9266, CAT-PAL not available RB > 30 psig or HL > 39%.

5. Should additional credit be given because of additional plant feedback? (yes, no)________

6. Should additional credit be given because of newly arriving crew members? (yes, no) ________

HHA2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   NORMAL POST TRIP + LOCA PROCEDURE STEPS

4. Are there enough personnel available to carry out the necessary actions? Yes

5. Must a specific dependence with another human action be accounted for?

   NO

	Scenario Group	Yes/No	Comments
A.			
B.			
C.			
D.			

HHA1 Sheet 10 of 13

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) _______ Identify by number 1210-1 step 2.7 directs the operator to verify ES equipment running.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) _______

3. Which initiating events may lead to a need for this action? LOCA with divers in RWPH desilting

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) NA If no, identify by initiator _______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NA.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) NA If yes, identify _______.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? _______

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) _______

   Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low? _______

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) _______ Identify by number _______.

10. If the incorrect procedure is entered, does it direct the operator to:

    NA

    ☐ Not do any related action?

    ☐ Perform an action that makes things worse? Identify _______.

    ☐ Perform the correct action anyway?

HHA1 Sheet 11 of 13

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? HA, HB, NS

HHA1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) NA Identify:

4. Is more than one option pursued in parallel? (yes, no) ________

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) ________ Identify ____

____

If the correct action were taken prematurely, would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) ________
Identify cues: High Temp in DHCCW, high temp in DHR pump bearing alarms

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes, no) ________ Explain:
The controls are human factor engineered and are well spaced for operator recognition of the problem.

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ________

Human Action Identifier: HHA1

K. Summary Sheet

From B. What type of behavior is required? SKILL

From C. Description of plant interface? FAIR

From D. Expected stress level for each scenario group?

Group A High Workload, Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team AVERAGE.

From F. Time available to perform correct ~~action~~ diagnosis 20 ~~30~~-MIN.
Best estimate of time to diagnose 2 min.

From G. Additional credit for rediagnosis due to plant feedback? yes Arriving crew members? yes

From H. Need to account for dependence with other actions for each scenario group?

Group A NO
Group B
Group C
Group D

From I. Potential for incorrect diagnosis leading to failure? LOW

From J. Potential for selection of nonviable option?

Type of human action

- [X] Backup to an automatic action
- [ ] Detract from an ESAS response
- [X] Recovery of a failed system via realignment
- [ ] Planned manual action
- [ ] Action may lead to an extended outage; e.g., due to contamination.

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HHL1A

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

~~SEE TMI QUANTIFICATION HUMAN ACTIONS TABLE 1-1 FOR DESCRIPTION~~

Operator fails to remotely open the DHR dropline valves to go on DHR following a normal plant cooldown (power to the valves is available)

2. List split fractions that include this human action.

HLA; HL-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Long response time

Normal cooldown - low stress

Cooldown and depressurization is successful

Remote actuation is possible, but the action ~~is instead conservatively~~ modeled as local manual action for HHL1B

HHL1A - 1C - operable (power available to operate valves)

~~HHL1B - 1C failed~~

TABLE 2-7 (continued)

Human Action Identifier: HHL1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar: 3
2. If yes, by what means? (~~procedures, training~~, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no) — for remote manual operation of the valve
5. How frequently are these actions revised in training? 2yrs

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HHL1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): Plant cooldown 1102-11 step 35 refer to DHR operating procedure 1104-4
RCS pressure, temperature

1a. Are displays directly visible: (yes/no)

2. Alarms (name location, audible, visual):
NONE

3. From where will action first be attempted? (control room, other - specify) ____________________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HHL1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) valves failing to operate

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HHL1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HHL1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 4 hours since start of cooldown (in time since initiating event)

2. When may the operator [illegible]? (in time from initiating event)

10 minutes - for CR opening of the valves but since manual local opening is modeled, it would take 2 hours to go inside the reactor building to complete the task.

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 12 hours
or as time since first indications 8 hours

4. Estimate the median time to carry out the action, once decided to pursue. 3 hours 10 min.

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~~B = 5 hours~~ c
A = 7.83 hours = 8 - 10/60

$12 - 3 - 4 = 5$ c
$12 - .17 - 4 = 7.83$ c

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT.
A	8 ~~12 hrs~~		~~4 hrs~~ 10 min.	10 min	
B	12 hrs		4 hrs	3 hrs	

Human Action Identifier: HHL1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Lower condensate storage tank alarms if the steam generated was dumped to atmosphere, but during a normal cooldown, this would be minimized so that the only new indications would be additional redundant instruments of RCS press and temperature. The decay heat may get too low and the condition would require the TBV to be full open

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   Prior to 12 hours

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

   ALERT NA GENERAL
   SITE AREA

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HHL1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   none

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   ~~B - Recovery of 1C-MCC~~

   A - none

   Previously, successfully achieved cooldown and depressurizat[illegible]

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

   ND

Scenario Group	(Yes/No)	Comments
A.	yes	low dependence on success of HCD1
B.		
C.		
D.		

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Human Action Identifier: HHL1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1104-4.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? ANY REACTOR TRIP THAT Requires a cooldown to make repairs.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NONE.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HHL1 A Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) B- He may ~~attempt electrical operation of the valve (try~~ to correct the electrical problem at the same time the operator is preparing to enter the Reactor Building

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful? Yes provided he didn't VIOLATE DH Valve opening interlocks.

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

The operators are trained as to the valve locations, no other valves in the area to cause confusion.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HHL1A

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 8 hours
best estimate of time to diagnose 0.2 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A yes, low dependence on success of HCD1
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned manual action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HHL1B   Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to locally open the DHR dropline valves to go on DHR following a normal plant cooldown. ~~(Used for HL-1 and assumed to apply even if 1C-ESV MCC is failed.~~ If 1C-ESV were available, remote actuation would be possible. However, the action to open these valves is conservatively modeled as if they can only locally be operated.

2. List split fractions that include this human action.

HLD; HL-1(TC) or (HL-3)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Long response time

Normal cooldown - low stress

Cooldown and depressurization is successful

~~Remote actuation is possible, but~~ the action is ~~instead conservatively~~ modeled as local manual action.

1C-ESV MCC is failed

TABLE 2-7 (continued)

Human Action Identifier: HHL1B   Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (~~procedures, training~~, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no) only for remote manual operation of the valve
5. How frequently are these actions reviewed in training? 2 yrs

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule. ~~Skill~~

Human Action Identifier: HHL1 B

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): Plant cooldown 1102-11 step 35 refer to DHR operating procedure 1104-4
RCS pressure, temperature

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
NONE

3. From where will action first be attempted? (control room, other - specify) ______________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HHL1B   Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no)   Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) valves failing to operate

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HHL18

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HHL1B

F. Response Time Available

1. What is the timing of the first indications for the operator action? 4 hours since start of cooldown (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   10 minutes - for CR opening of the valves but since manual local opening is modeled, it would take 2 hours to go inside the reactor building to complete the task.

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 12 hours
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 3 hours

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 5 hours

12-3-4 = 5

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	5 hrs.		10 min / 2 hours	3 hours	

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Human Action Identifier: HHL1B

Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error

Low condensate storage alarms if the steam generated was dumped to atmosphere, but during a normal cooldown, this would be minimized so that the only new indications would be additional redundant instruments of RCS press and temperature

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

Prior to 12 hours

The decay heat may get stable and the condition would require the TB to be full op

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

ALERT

SITE AREA

GENERAL

NA

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HHL1B

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
none

2. How much influence do previous human errors have on this action? (significant, same, none) ______________
NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
Recovery of 1C-MCC
Previously successfully achieved cooldown and depressurization

3a. Are there enough personnel available to carry out necessary actions? (yes/no)
yes

Must a specific dependence with another human action be accounted for?
~~no~~ Yes

Scenario Group	(Yes/No)	Comments
A.	Yes	low dependence on success of HCD1.2
B.		
C.		
D.		

Human Action Identifier: HHL1 B

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1104-4 .

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? ANY REACTOR TRIP THAT REQUIRES a cooldown to make repairs.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NONE .

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA .

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HHL1 B

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) He may attempt electrical operation of the valves (try to correct the electrical prob at the same time the operator is preparing to enter the Reactor Building)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful? Yes provided he didn't VIOLATE DH Valve opening interlocks.

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

The operators are trained as to the valve locations, no other valves in the area to cause confusion.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HHL1B Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 4.8 hours
Best estimate of time to diagnose 0.2 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low dependence on success of CD
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recovery of failed system

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE 5/20/86

Human Action Identifier: HHP1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

SEE TMI QUANTIFICATION HUMAN ACTIONS
TABLE 1-1 FOR DESCRIPTION

A) start MU-P-1B after LOOP, $\overline{GA}$, $\overline{HB}$ - operator has to select B pump on 1C SWGEAR, since not initially selected to ESAS

B) Start MU-P-1B after LOOP, $\overline{GB}$, $\overline{HA}$ - operator has to use Kirk Key interlock, Rack out 1E SWGR BKR FOR MUP1B, RACK IN 1D SWGR BKR, SELECT B Pump on 1D SWGR.

2. List split fractions that include this human action.

HPM HPA-1(OP.GA.HB)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

See 1 above

The 'B' scenario requires the operation of a Kirk Key interlock system and the repositioning of breakers for MU-P-1B and will require more time for completion.

Human Action Identifier: HHP1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
   during testing the makeup pumps are switched
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? yearly

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

Human Act . . . Identifier: H HP1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
1210-1 step 2.5 - Makeup pump status lights

1a. Are displays directly visible - (yes/no)

2. Alarms (name, location, audible, visual):
Pressurizer level low/~~[illegible]~~ - CR visual, audible
Seal injection flow low - CR, visual, audible
Makeup pump status lights

3. From where will action first be attempted? (control room, other - specify) Locally at the 1D, 1E switchgear rooms

4. Is specific coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not too specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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TABLE 2-7 (continued)

Human Action Identifier: HHP1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

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Human Action Identifier: HHP1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HHP1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 0.5 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
10 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 2-3 hours prior to RCP seal failure
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. ______

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______

   A) 120 − 5 − 0.5 = 114.5 min

   B) 120 − 10 − 0.5 = 109.5 min

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
A - LOOP, $\overline{GA}$ $\overline{HB}$	2-3 hours		10 min.	5 min	
B — LOOP, $\overline{GB}$, $\overline{HA}$	2-3 hours		10 min	10 min	

TABLE 2-7 (continued)

Human Action Identifier: HHP1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

High temperature alarm on #1 seals on the reactor coolant pumps.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes within ½ hour

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), SS Emergency Response Team]

4a. At what point would the following be declared:

ALERT >50gpm RCS leak GENERAL

SITE AREA 4# in RB or ESAS due to 1600# signal

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HHP1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this sc .ario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   The operators would be trying to recover the failed diesel and failed decay heat closed system

U3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

   no

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HHP1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ______.
not a specific emergency procedure

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
LOOP with equipment failures

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator NA.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NA.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? ~~yes~~, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

NA ☐ Perform an action that makes things worse? Identify ______

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______

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Human Action Identifier: HHP1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) not specific action in procedure.

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) the operators would be trying to regain the diesels and D.C. system.

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

yes

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

. The operator could initially turn the wrong switches at the switchgear but enough time is available to correct the problem.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HHP1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B mild
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis A 114 minutes B 109.
Best estimate of time to diagnose 10 min.

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Yes; shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B No
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Type of action:
Recover failed system

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HIC 1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to take manual control of the main feedwater valves, given auto-ICS control failure.

2. List split fractions that include this human action.

   FBCN

   MFF; MF+1

   MFN; MF+1 (DB)

   MFE; MFPT

   MFF; MFTBV/ADV

   MFG; MF-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   ICS failure of CTU limits and class limits or

   ICS loss of auto power - valves open too far - cause overcooling without operator intervention.

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Human Action Identifier: HIC1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6 MONTHS

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HIC 1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Main Feedwater flow - valve demand
Steam generator level

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

High steam generator level audible, visual in the control room.

3. From where will action first be attempted? (control room, other - specify) ____________________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HIC 1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) a total valve power failure will prevent control room operation of the valves

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HI^1

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HIC 1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1-2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 4 minutes
   or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. 30 seconds

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 2.5 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
	2.5 minutes		30 seconds	30 seconds	

Human Action Identifier: HIC1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   high steam generator pressure
   Low RCS pressure

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes 2 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA NA
   GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HIC 1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Reactor trip immediate actions

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HIC1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1, 1210-3

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
excessive cooling

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

NA ☐ Perform an action that makes things worse? Identify ________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________.

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Human Action Identifier: HIC1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

   NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

   The valve control position could be confused with other ICS controls.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

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TABLE 2-7 (continued)

Human Action Identifier: HIC 1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 2 minutes
Best estimate of time to diagnose 0.5 minute

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members: no

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? low
valve control positions may be confused with other ICS controls

Backup to automatic action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HIC2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to manually trip the main feedwater pumps, given failure of the main feedwater valves to control flow.

2. List split fractions that include this human action.
   FBK13

MFA; MF+1
MFB; MF+1 ($\overline{GA}/\overline{GB}$)
MFC; MF+1 ($\overline{A}$)
MFE; MFPT
MFF; MFTBY/ADV
MFG; MF-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   . mild stress
   . strongly dependent on HIC1 but HIC1 is always assumed failed.

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Human Action Identifier: HIC 2 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6 months intervals

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

Human Action Identifier: HIC 2   Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   MFW flow
   MFW valve demand

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
   Hi OTSG level audible & visual in CR.

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HIC2 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HIC2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HIC2 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1-2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2-4 minutes

3. When is the last time allowed for the operator to take action and be successful? 4 minutes

Measured as median time since initiating event 4 min.
or as time since first indications 2.5 min.

4. Estimate the median time to carry out the action, once decided to pursue. .5 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 2 minutes

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
only 1	4 min.		0.5 minute	2.5 min	

Human Action Identifier: HIC2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?.
   Hi OTSG level if not present during onset, failure
   Lo RCS pressure indication

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes - 2 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT NA (not in time GENERAL
   SITE AREA

● A Should additional credit be given because of additional plant feedback? (yes, no)

● B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HIC 2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
no, operator may have ~~has~~ failed to control feed with the valve but that action was very likely to not be possible because of a mechanical valve failure.

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A.	No	
B.		
C.		
D.		

Human Action Identifier: HIC2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ATP 1210-1, ATP 1210-3

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
~~ME +~~ any plant trip

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ____________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number steam line break.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ____________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ____________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________

Human Action Identifier: HIC2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) serially

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HIC2

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 1.5 min.
Best Estimate of time to diagnose 0.5 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? No

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Backup Auto. actuation

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HIC3

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to set the manual loader to zero, given that the manual loader was not initially set to zero.

2. List split fractions that include this human action.
FCK16

MFA ; MF+1
MFN ; MF+1 (OB)
MFE ; MFPT
MFF ; MFTBV/ADV
MFG ; MF-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   REACTOR TRIP, LOSS OF ATA

   open ADV causes steam pressure decrease because the manual loader (backup) was not set at zero.

TABLE 2-7 (continued)

Human Action Identifier: HIC3 Sheet 2 of 11

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar

2) If yes, by what means? (procedures, training, frequent performance)

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)

5) How frequently are these actions reviewed in training? 6 MONTHS

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HIC3 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):

   STEAM Pressure decreasing
   STATUS Lights FOR ICS/NNI power supply.

   1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

   —

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HIC3

C. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HIC3

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: [illegible]IC3

F. Response Time Available

1. What is the timing of the first indications for the operator action? immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   2 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 5 minutes
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 30 seconds

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 4.5 MINUTES

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	4.5 min.		1.0 min.	0.5 min.	

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TABLE 2-7 (continued)

Human Action Identifier: HIC3 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   decreasing RCS pressure and temperature
   decreasing steam generator pressure

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes in 2 minutes after the MSSV's initially close.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:

ALERT GENERAL
SITE AREA NA

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HIC3 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Reactor trip immediate and followup actions

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HIC3 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1202-40.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
Loss of ATA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
NONE.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

NA

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? MFT.

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Human Action Identifier: HIC3

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful?

   yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:

   lack of control of steam generator pressure

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

   The controls are checked frequently (every shift) for setpoint and operability (controlling at zero) check performed semiannually.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HIC3 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 4.5 minutes
Best estimate of time to diagnose 1.0 minute

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? none

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recovery of a failed system (ATA)

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HIC4

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to manually control the TBVs and ADVs using the hand/auto station, given failure of auto-power from bus ATA. Five minutes is assumed available for action.

2. List split fractions that include this human action.

   FSK18

   MFA; MF+1

   MFN; MF+1($\overline{DB}$)

   MFE; MFPT

   MFI; MFTBV/ADV

   MFG; MF-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   - Reactor Trip
   - Loss of ATA Auto power only
   - Operator has to close valves within 5 minutes to prevent overcooling
   - Operator selects backup controller which is not set a zero. If set at zero valves will close upon selection

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Human Action Identifier: HIC 4 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6 months

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Skill

Human Action Identifier: HIC4

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   status lights for ICS/NNI power supply
   MS-V-3 valve position indication

   1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
   ICS/NNI power failure - audible & visual

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HIC4

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) possible failure to auto transfer to backup controller. instrumentation lost due to pwr failure causes much confusion.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments. See J7

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.	Potential Emerg	Plant trip & instrumentation bus failure
B.		
C.		
D.		

Human Action Identifier: HIC4

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HIC4

F. Response Time Available

1. What is the timing of the first indications for the operator action? immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
<2 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 5 minutes
   or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. <1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ____________

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
	5 min		1 min	1 min	

Human Action Identifier: HIC4

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   decreasing RCS pressure
   decreasing OTSG pressure

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes ~2 minutes when MSSV's close

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA
   GENERAL
   NA

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HIC4

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for? no.

Scenario Group	(Yes/No)	Comments
A.	No	Backup Controller set at wrong position prior to initiator? [illegible] Independence on error of routine action is assumed because it occurred at much different time
B.		
C.		
D.		

Human Action Identifier: HIC 4 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ATP 1210-1 E. Loss of ICS/NNI power.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ____________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ~~None~~ NONE.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ____________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ____________

☒ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________

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Human Action Identifier: HIC4

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain: good indication of problem and switches to be operated are centrally located

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HIC 4

K. Summary Sheet

From B. What type of behavior is required? Skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 5 − 1 = 4 minutes
Best Estimate of time to diagnose 1

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? No

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Receiver Tank of System

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HID1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to identify a steam generator tube rupture as such; failure assumes that the operator takes it for a very small LOCA.

2. List split fractions that include this human action.

   ID

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Steam generator tube rupture, reactor trip

Human Action Identifier: HID 1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? yearly

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HI01 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable): 1210-1 step 2.11
RMA-5 higher than normal. - (condenser offgas radiation monitor)
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
RMA-5 alert, alarm

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HID1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) RM-A-5

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HID1

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HI01

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
15 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 5 hours
   or as time since first indications ________

4. Estimate the median time to carry out the action, once decided to pursue. 30 MINUTES

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 4.46 hours

$5^{hr} - \frac{1}{2}^{hr} - 2\,min = 4.46$ hours

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
	5 hours		15 min.	30 min.	

Human Action Identifier: HID1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   SG levels and flow rates not responding as they should after a reactor trip, condenser off gas line (in-line high range Radiation Monitor RM-G-25) alarms, RM-G-26 and 27 may show upscale also (scintillation detectors on steam lines between MS-V-2 and MS-V3's and MS-V4's

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   Variable depending on size of rupture, should be within 10 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared?

   ALERT RMA-5 alarm Hi. GENERAL

   SITE AREA RMA-5 alarm Hi-Hi

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HID1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   NO

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   NO

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HID1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? SGTR, LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-6 (Small LOCA)

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number 1210-6 Small Break LOCA Cooldown

10. If the incorrect procedure is entered, does it direct the operator to:

   - ☐ Not do any related action?
   - ☐ Perform an action that makes things worse? Identify ________
   - ☒ Perform the correct action anyway? 1210-6, (step 2.5) reevaluates, tube rupture indications, would direct back to 1210-5

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HI01 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

If the operator thought he had a LOCA instead of SGTR he could lose his BWST cooling water out through the break and not be able to recirculate the water via the R.B. sump.

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

No - He has two radiation monitors available to tell him that a SGTR has occurred.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HI01 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis/action 4.5 hours
estimate to perform diagnosis 0.25 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift supervisor, ERT

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Low ?

From J. Potential for selection of nonviable option? very low

~~Recover failed system~~
Planned manual action

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HID 2 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Similar to HID1 except that offsite power is lost. Failure of the operator to identify a steam generator tube leak. Flow to the main condenser is now not available.

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Same as HID1 but also includes a simultaneous LOOP.

Human Action Identifier: HID2

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 2
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2 YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HID2

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): (alarm response procedures)
RMA-26, 27 radiation monitors indicate upscale

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

alarms on RMA 26, 27 on the steam lines to the atmospheric dump valves.

3. From where will action first be attempted? (control room, other - specify) ________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HID2

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HID2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HID2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
20 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 5 hours
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 30 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 4.46 hours

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
	5 hours		20 minutes	3 min	

Human Action Identifier: HI.D2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

SG levels and flow rates not responding as they should after a reactor trip.

Also, note loss of BWST inventory

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared?
ALERT >50gpm P-S leak GENERAL
SITE AREA - saturation in the RCS

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HID2 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

NO

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

NO

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HI02 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number alarm response for RMA 26,27

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
SGTR, SGTR with LOOP, LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ________. 1210-6 (small LOCA)

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number 1210-6 (small LOCA).

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway? 1210-6 (Step 2.5) reevaluates tube rupture indications, would direct him back to 1210-5.

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________.

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Human Action Identifier: HID2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

The operator could respond as if the SGTR were actually a LOCA and not isolate the steam generator. This could cause him to lose the BWST inventory through the tube and out of the reactor building. He would not have that water available for long term core recirculation cooling.

4. Is more than one option pursued in parallel? (yes, no)
Regain LOOP, diesels condensor.

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

He could isolate the wrong steam generator if the radiation monitors do not indicate enough difference in their readings.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

He would likely later isolate the correct steam generator even if he initially isolated the wrong one

TABLE 2-7 (continued)

Human Action Identifier: HID2 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Descript n of plant interface? Fair

From D. Expected st s level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 5 hours
best estimate of time to diagnose 0.33 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Sup / ERT

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? medium (not isolate SG)

From J. Potential for selection of nonviable option? medium
isolate wrong SG.

~~Recover failed system~~

Planned Manual Action

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HINJ1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to open MU-V14A and start the standby makeup pump to provide seal injection flow when no ESAS signal is present (used in INJ-1).

2. List split fractions that include this human action.

   INA; INJ-1

   INE; INJ-1 (AM)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   RT, loss of MU-P-1B, no ESAS
   Air is available.

Human Action Identifier: HINJ 1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HINJ 1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Reactor trip indication, makeup tank level

1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
Reactor trip
Makeup tank low level alarm

3. From where will action first be attempted? (control room, other - specify) ______

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HINJ1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) pump failure or valve failure

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent. following plant trip
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

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Human Action Identifier: HINJ 1

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HINJ 1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 30 sec. (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   10 seconds

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event See below
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 10 seconds

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
A ICCW	24 h				
B No ICCW	2-3 h		3 minute		

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Human Action Identifier: HINJ1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Pressurizer at 20" level.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   at ≈ 90 seconds

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA N/A
GENERAL

•A Should additional credit be given because of additional plant feedback? (yes no)

•B Should additional credit be given because of newly arriving crew members? (yes no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

Human Action Identifier: HINJ 1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NO

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   NO

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HINJ1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? R.T.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HINJ 1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   N/A

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful?

   yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues: NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

   If the scenario occurred during an abnormal makeup system valve/pump lineup, (e.g. pump C may be [illegible] [illegible] [illegible] [illegible]. He might [illegible] start A [illegible] [illegible] without suction)

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

   N/A

TABLE 2-7 (continued)

Human Action Identifier: HINJ 1

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal conditions
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 2 hours
Best estimate of time to diagnose 3 min

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? medium
if system in nonnormal alignment

Planned Manual Action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HINJ2 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to open the makeup pump cross-connect valves (MU-V76A/B) and suction valve MU-V14B and to start makeup pump C after failure of Make-up Pumps A and B flowpaths(used in INJ-2).

Action should be completed prior to significant seal degradation.

2. List split fractions that include this human action.

HB; INJ-2

IHF; INJ-2 (AM)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, failure of A+B makeup pumps

Air is available.

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Human Action Identifier: HINJ2

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? yearly

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HINJ2

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
A + B makeup pump status
Low seal injection flow, low makeup flow.
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
Makeup pump trip alarms
Low seal injection flow alarm

3. From where will action first be attempted? (control room, other - specify) ______________ AO directed to makeup valve alley.

4. Is special coordination between operators required? (yes, no)
If the CRO starts the pump first, the AO may not be able to open the valve

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)
makeup system operating procedure

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HINJ2 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) if valves or pumps don't work

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

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Human Action Identifier: HINJ 2

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HINJ2

F. Response Time Available

1. What is the timing of the first indications for the operator action? immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   2-5 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 2-3 hours due to RCP seal failure
   or as time since first indications __________

4. Estimate the median time to carry out the action, once decided to pursue. 20-30 minutes (RWP area, dressing out required)

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 2 hr - ½ hr = 1.5 hours

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
Only 1	2 hrs		2 min.	30 min.	

Human Action Identifier: HINJ2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
20" in presourizer - CRO should initiate HPI
Previous to this he may be concentrating on restarting the A and/or B makeup pumps.
High Temp alarm on #1 seals on RCP's
2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
90 seconds

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT NA GENERAL
SITE AREA

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HINJ2 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO, If offsite power is available, the operator would first had to have recognized that the RCPs should be shutdown. (ICCW assumed failed) Conservatively assume offsite power lost.

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   The CRO could be trying to recover the other 2 makeup pumps

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HINJ2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1104-2.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) N/A

3. Which initiating events may lead to a need for this action?
RT, LOOP with GA failed.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number N/A.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify N/A.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

   - [ ] Not do any related action?
   - [ ] Perform an action that makes things worse? Identify ______ N/A
   - [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______

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Human Action Identifier: HJNJ2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

N/A

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

The wrong valves at the makeup valve alley could be selected.
The CRO could shock the RCP seals when the cross-ties were opened, causing seal failure.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HINS2

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 2hr-1/4hr = 1.5 hours
Best estimate of time to diagnose .033 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? medium

Recover Failed System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HINJ3

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to open the makeup pump cross-connect valves (MU-V76A/B) after failure of A and B Make-up Pump flowpaths and an ESAS signal is present (used in INJ-4).

2. List split fractions that include this human action.

IND; INJ-4

SNH; INJ-4 (AM)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, ESAS occurred

Loss of A+B makeup pumps

Human Action Identifier: HINJ3

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions re[illegible] in training? yearly

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HINJ3

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   A+B Makeup pump status
   Low seal inj. flow, low makeup flow

   1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
   Makeup pump trip alarms
   Low seal injection flow alarm

3. From where will action first be attempted? (control room, other - specify) AO directed to makeup valve alley

4. Is special coordination between operators required? (yes, no)
   If the CRO starts the pump first, the AO may not be able to open valve

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

0394G011386

Human Action Identifier: HINJ3 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)
Seal inj portion of HPI

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) if valve or pump doesn't work.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)
He may not want to cross tie because it would break the separation criteria for redundant system

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HINJ3

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. ..censed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HINJ3

F. Response Time Available

1. What is the timing of the first indications for the operator action? immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
10 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event B.2-3 hours prior RCP seal failure
or as time since first indications 2-7 :

4. Estimate the median time to carry out the action, once decided to pursue. 40 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 1.5 hours

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
	2 hr.		5 minutes	2 hr.	

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TABLE 2-7 (continued)

Human Action Identifier: HINJ3 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

High temp. alarms on #1 seals on RCP's. if ICCW is not on.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ~~Yes 3 minutes~~
No; hi-Temp alarms the same time as initial diagnosis

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT >50 gpm RCS leak GENERAL
SITE AREA 4# in R.B, ESAS due to 1600# RCS pressure

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HINJ3

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) N/A

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Serially the operator could be trying to repair the A + B pumps

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HINJ3 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1104-2 .

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) N/A

3. Which initiating events may lead to a need for this action?
ESAS; LOOP, GA failed

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ____________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NA.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify N/A.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?
0

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?
6

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ____________
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________

TABLE 2-7 (continued)

Human Action Identifier: HINJ3 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

NA

The operator may decide not to do this human action for fear that he may lose his last remaining HPI pump.

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

RCP seal alarms

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

incorrectly operate control valve

The auxiliary operator could open the wrong valves. The CRO could shock the RCP seals when the cross ties were opened, causing seal failure.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HINJ3 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 2-.7 = 1.3 hours
Best Estimate of time to diagnose 0.1 hr.

From G. Additional credit to rediagnosis due to plant feedback? no Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Low

Recover Failed System

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HINJ 4

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator failure to reopen MU-V20 after instrument air failure (Top Event AM failed)[used in INJ-1(AM), INJ-2(AM), INJ-3(AM), INJ-4(AM)].

2. List split fractions that include this human action.

INE ; INJ-1 (AM)
INF ; INJ-2 (AM)
ING ; INJ-3 (AM)
INH ; INJ-4 (AM)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, loss of air, presence of ESAS signal not important for this action.

TABLE 2-7 (continued)

Human Action Identifier: HINJY　　　　Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) The procedure cautions (1202-36) against holding open a CIV valve / written permission needed which presumably will be granted unless there are high pressure or radiation readings in the reactor building
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ~~Rule~~ Knowledge

Human Action Identifier: HINJ4

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Low AIR pressure ind. reading

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
Low air pressure alarms
Possible compressor alarms

3. From where will action first be attempted? (control room, other - specify) Locally at valve

4. Is special coordination between operators required? (yes, no) CRO has to notify AO.

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not too specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HINJ4

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Valve itself failing

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) Containment isolation cautions to leave closed.

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.

- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.

- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HINJ4 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HINJ4

F. Response Time Available

1. What is the timing of the first indications for the operator action? 5 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
immediately try to restart compressors, after this fails (10-15 minutes) he will try to recover MU-V20

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 2-3 hours
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 10-15 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVANT
	2.5 hrs.		15 min.	5 min	

Human Action Identifier: HINJ4

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
Low seal inj flow indicator and alarms
RCP trip

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
upon valves failing closed (IC + MU)

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA
GENERAL
NA

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HINJ4 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
Loss of IA could have been caused by human action.

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
other valves have to be manually operated.
ICCW

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?
no

Scenario Group	(Yes/No)	Comments
A.	Yes	Assume low dependence with loss of air. (HAMI)
B.		
C.		
D.		

Human Action Identifier: HINJ4

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1202-36.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? LOSS of Instrument air.

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

NA ☐ Perform an action that makes things worse? Identify ________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HINJ4 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

The AO may open the wrong valve.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HIN54 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? ~~Rule~~ Knowledge based

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emerg
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 2.5-.25 = 2.25 hrs.
Best Estimate to perform diagnosis 2.25 hrs

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low dep. with loss of instrument air [illegible]
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low
may open wrong valve but this would be recognized

Recover failed [illegible]

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HLT1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to take actions to provide makeup to the BWST or MUT during normal cooldown. (used in LT-1 split fraction).

   Top Event CD has failed, so a new source of borated inventory is eventually required.

2. List split fractions that include this human action.

   ~~all LT~~

HLT1A	HLT1B
LTA ; LT-1	LTA ; LT-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   - Plant is being cooled down following RT ~~or OTSG tube rupture~~
   - Since top event BW was not previously asked, this action really consists of two parts
     - HLT1 A) initial makeup to MU tank before it first goes dry or switchover to BWST before pumps suction lost
     - HLT1 B) long term makeup before BWST runs out
   - Assume a 100 gpm leak rate which is less than a very small LOCA and does not lead to a 1600# signal

TABLE 2-7 (continued)

Human Action Identifier: HLT 1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) (A) 5 (B) 2
1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? every 6 wks (A) not formally practiced (B)

Check those applicable descriptions of actions:

Skill-Based

A) [X] Routine action, procedure not required.

[ ] Routine action, procedure required, but personnel well trained in procedure.

[ ] Action not routine, but unambiguous and well understood by operators who are well trained.

[ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

[ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.

[ ] Not routine, action unambiguous and well understood, but not well practiced.

[ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

[ ] Not routine, action ambiguous.

B) [X] Not routine, procedure does not cover.

[ ] Not routine, procedure not well understood.

[ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? A) skill B) knowledge

Human Action Identifier: HLT 1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
(A) makeup tank level recorder
(B) BWST level instrument - 2 available

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
(A) low makeup tank level alarm - 2 ie low & very low - A&V
(B) low BWST level alarm - A&V

3. From where will action first be attempted? (A) control room, other - specify) (B) BWST requires in-plant operator action

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

A), B) ☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HLT 1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (A) (none, (B) one, multiple) for (B) CD has failed

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- (B) (A) [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HLT 1

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HLT I

F. Response Time Available

1. What is the timing of the first indications for the operator action? MUT level-6 minutes (in time since initiating event)
BWST level-7.6 hours (low level alarm), indications of level throughout

2. When may the operator first act? (in time from initiating event)

   MUT - 2 minutes

   BWST - 5 hours

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event A) MUT-25 min. BWST-~~8~~ 58 hrs
   or as time since first indications __________

4. Estimate the median time to carry out the action, once decided to pursue. BWST 30 min - MUT 1.5 min. 2

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. __________

	SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
A	MUT on Cooldown	21.6 min		5 minutes	1 min.	2 min.
B	BWST on OTSG T/R normal cooldown w/100gpm leak	7.6 hr 58. hrs ... SGTR	[redacted]	[redacted] 3 hours	[redacted] 20 min	1 hr.

*assume makeup on cooldown is 100 gal/min.
*assume 385 gal/min tube rupture

initially maintain MUT. w/other tanks (FC ... ~ 45,000 ...) - ... to BWST ↳ 300,000 gal - trucks ...

Human Action Identifier: HLT 1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   A) Lo-Lo level MUT
   B) Lo-Lo level BWST

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? A) yes - MUT gives 6 min to muf failure
   B) yes - BWST gives 26 min to muf failure

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team] - BWST

4a. At what point would the following be declared: ? if LOCA > 50 gpm
   ALERT GENERAL
   SITE AREA - BWST on OTSG T/R

●A Should additional credit be given because of additional plant feedback? (yes, no) both

●B Should additional credit be given because of newly arriving crew members? (yes, no) both A) shift support, B) Full Support

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HLT1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

A) No

B) Yes top event CD was unsuccessful

2. How much influence do previous human errors have on this action? (significant, same, none) A) ~~NA~~ none

B) same

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? A) No B) yes

Scenario Group	(Yes/No)	Comments
A. HLT1A	No	
B. HLT1B	Yes	Assume low dependence on failure of HCD1, New shift crews available, very large amounts of time.
C.		
D.		

Human Action Identifier: HLT1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (A) (yes, B) no) Identify by number 1210-1, 1210-5

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
SGTR, RT

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________________.

5. Which other procedures ~~have~~ entry conditions similar to the procedure encompassing this human action? Identify by number
A) SGTR ⇒ 1210-6 .
B) none

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, o. very low?
A, B

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) except anticipation of SGTR!

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________________

Human Action Identifier: HLT I

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)
   A) B)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful?
yes.

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:
   A) MUT yes
   B) BWST yes

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:
   A) • familiar with controls for MUT due to frequent use
   B) • seldom uses controls for BWST makeup but simple and well proceduralized.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HLT1A

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 25-1 = 24 min.
Best estimate of time to diagnose 5 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A N/o
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned manual Action

0394G011386

Human Action Identifier: HLT1B

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 58-1. = 57 hours
Best estimate to complete diagnosis 3 hrs.

From G. Additional credit to rediagnosis due to plant feedback? Yes
Arriving crew members? Yes, emergency response team

From H. Need to account for dependence with other actions for each scenario group?

Group A
Group B Yes, ~~medium~~ low with ~~...~~ ACD1 failure
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recover failed System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HLT1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to take actions to provide makeup to the BWST or MUT during normal cooldown . (used in LT-1 split fraction).

   Top Event CD has failed, so a new source of borated inventory is eventually required.

2. List split fractions that include this human action.

   ~~all LT~~

   HLT1A: LTA ; LT-1

   HLT1B: LTA ; LT-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   - Plant is being cooled down following RT ~~or OTSG tube rupture~~
   - Since top event BW was not previously asked, this [illegible] really consists of two parts
     - HLT1 A) [illegible] makeup to [illegible] tank before it [illegible] dry or switchover to BWST before pumps [illegible]
     - HLT1 B) [illegible] makeup before BWST [illegible].
   - Assume a 100 gpm leak rate which is less than a [illegible] [illegible] and does not lead to a [illegible] signal

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TABLE 2-7 (continued)

Human Action Identifier: HLT 1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) (A) 5 (B) 2
   1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? every 6 wks (A)
   not normally practiced (B)

Check those applicable descriptions of actions:

Skill-Based

A) [X] Routine action, procedure not required.

[ ] Routine action, procedure required, but personnel well trained in procedure.

[ ] Action not routine, but unambiguous and well understood by operators who are well trained.

[ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

[ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.

[ ] Not routine, action unambiguous and well understood, but not well practiced.

[ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

[ ] Not routine, action ambiguous.

B) [X] Not routine, procedure does not cover.

[ ] Not routine, procedure not well understood.

[ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? A) skill B) [illegible]

Human Action Identifier: HLT 1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
(A) makeup tank level recorder
(B) BWST level instrument - 2 available

1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
(A) low makeup tank level alarm - 2 ie low & very low - A&V
(B) low BWST level alarm - A&V

3. From where will action first be attempted? (A) (control room, other - specify) BWST requires in-plant operator action (B)

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

A), B) ☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HLT1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (A) (none, (B) one, multiple) for (B) CD has failed

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

(B) (A) ☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HLT 1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HLT1

F. Response Time Available

1. What is the timing of the first indications for the operator action? MUT level - 6 minutes (in time since initiating event)
BWST level - 7.6 hours (low level alarm), indications of level throughout

2. When may the operator first act? (in time from initiating event)

MUT - 2 minutes

BWST - 5 hours

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event A) MUT - 25 min. BWST - 8 hrs
or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. BWST 30 min - MUT 1.5 min.

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ____________

	Scenerio Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
A	MUT on Cooldown	21.6 min		5 minutes	1 min.	2 min.
B	BWST on OTSG T/R normal cooldown w/100 gpm T/R	7.6 hr	[redacted]	[redacted] 3 hours	[redacted] 20 min	1 hr.

* assume makeup on cooldown is 100 gal/min.
* assume 385 gal/min tube rupture

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Human Action Identifier: HLT 1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   A) Lo-Lo level MUT
   B) Lo-Lo level BWST

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? A) yes - MUT gives 6 min to MUP failure
   B) yes - BWST gives 26 min to MUP failure

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team] - BWST

4a. At what point would the following be declared:
   ALERT
   SITE AREA - BWST on OTSG T/R
   GENERAL

   [illegible] LOCA >500 gpm

- A Should additional credit be given because of additional plant feedback? (yes, no) both

- B Should additional credit be given because of newly arriving crew members? (yes, no) both A) shift supervisor, B) full support [illegible]

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HLT1 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   A) no

   B) Yes top event CD was unsuccessful

2. How much influence do previous human errors have on this action? (significant, same, none) A) ~~NA~~ none

   B) same

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes, no)

   Must a specific dependence with another human action be accounted for? A) no B) yes

Scenario Group	(Yes/No)	Comments
A. HLT1A	No	
B. HLT1B	Yes	Assume low dependence on failure of HCD1, 'cause shift crews are given a very large amount of time.
C.		
D.		

Human Action Identifier: HLT1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1, 1210-5
   A) B)

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
   SGTR, RT

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures ~~have entry~~ entry conditions similar to the procedure encompassing this human action? Identify by number
   A) SGTR ⇒ 1210-6.
   B) none

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress ~~level~~ at the time of selecting the proper procedure high, mild, optimal, or very low?
   A, B

8. Is the operator trained to ~~expect~~ expect the actual situation to be of extremely low frequency? (yes, no) except anticipation of SGTR!

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
   Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to: —

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HLT I

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)
   A) B)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes.

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:
   A) MUT yes
   B) BWST yes

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:
   A) • familiar with controls for MUT due to frequent use
   B) • seldom uses controls for BWST makeup but simple and well proceduralized.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HLT1A Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 25-1 = 24 min.
Best estimate of time to diagnose 5 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A 1/0
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Placement-oriented Actions

Human Action Identifier: HLTIB Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 58-1 = 57 hours
Best estimate to complete diagnosis

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Yes

From H. Need to account for dependence with other actions for each scenario group?

Group A
Group B Yes, ~~medium~~ low with PCS failure
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recover Failed System

0394G011386

Human Action Identifier: HLT2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Similar to HLT1§ except during a steam generator tube rupture after a failure to previously cool-down and depressurize to go on DHR. (used in LT-2)

2. List split fractions that include this human action.

   LT : LT-2

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   - Failure to cooldown following SGTR.
   - Top event BW already failed so it is assumed that the operators were successful in switching over from the BWST tank to the BWST before losing pump suction.
   - Tube rupture is assumed to yield a leak rate of 355 gpm
   - Top event CD failed

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HLT2 Sheet 2 of 11

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 5
1=unfamiliar 5=very familiar

2) If yes, by what means? (procedures training frequent performance)
4 8

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)

5) How frequently are these actions reviewed in training? ~~every 6 wks~~ seldom

Check those applicable descriptions of actions:

Skill-Based

☒ Routine action, procedure not required.

6

☐ Routine action, procedure required, but personnel well trained in procedure.

☐ Action not routine, but unambiguous and well understood by operators who are well trained.

☐ Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

☐ Routine action, but procedure required; operators not well trained, or procedure does not cover.

☐ Not routine, action unambiguous and well understood, but not well practiced.

☐ Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

☐ Not routine, action ambiguous.

☑ Not routine, procedure does not cover. (normal operating procedures do cover this action)

☐ Not routine, procedure not well understood.

☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ~~Skill~~ Knowledge

Human Action Identifier: HLT2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   BWST level instrument - 2 available

   1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
   Lo level BWST A+V

3. From where will action first be attempted? (control room, other - specify) in-plant operator assistance req'd

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HLTZ

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Failure to isolate the steam generator

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HLT2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HLT2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 7.6 hrs (in time since initiating event)
RWST level alarm; Operator would recognize need earlier 36"/low level say at 2 hours

2. When may the operator first act? (in time from initiating event)
~5 hrs.

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 8.2 hrs 9
or as time since first indications [illegible]

4. Estimate the median time to carry out the action, once decided to pursue. .5 hrs 1 hour

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 6 hours [illegible]

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
Only one	8.5 hrs		6 minutes	1.0 hours	

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Human Action Identifier: HLT2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   - Lo-Lo Level in BWST alarm, however this alarm may be too late to allow time to replenish inventory
   - At 21 feet, tube rupture procedure 1210-5 step 14 ~~17~~ tells operator to isolate affected steam generator (this feedback is in procedures but not alarmed ~~[illegible]~~ sufficiently to be called a new source of feedback.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ~~yes - 26 minutes~~ No [illegible] not enough time

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA - on discovery of SGTR
   GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HLT2   Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   failure to diagnose SGTR (assumed success fail.)
   failure to accomplish cooldown & depressurization

2. How much influence do previous human errors have on this action? (significant, same, none) ______

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

Scenario Group	(Yes/No)	Comments
A.	Yes	Assume ~~medium~~ low dependence with HCDY ~~[illegible]~~
B.		
C.		
D.		

Human Action Identifier: HLTZ

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no)   Identify by number 1210-5.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) in drills

3. Which initiating events may lead to a need for this action?
   SGTR

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no)   If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-2, 1210-6. N/A

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no)   If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
   Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

    ☐ Not do any related action?

    ☒ Perform an action that makes things worse? Identify failure to isolate OTSG at 21' in BWST causing loss of inventory

    ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

0394G011386

Human Action Identifier: HLT2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

believing he has LOCA and taking those prescribed action from 1210-6 (switchover to sump)

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain: see HLT1

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HLT2 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 6-1 = 5 hours
Best estimate of time to diagnose 1 hrs.

From G. Additional credit to rediagnosis due to plant feedback? no Arriving crew members? Emergency Response Team

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes (~~medium~~ low dep. w/CD / HCDF)
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Use switchover to ... instead of BWST emergency makeup.

Recover Failed System

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HMR1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to reestablish makeup pump recirculation after ESAS closure of MU-V-36 and 37 and after successful manual throttling of HPI flow. Failure to establish recirculation may result in failure of one or more makeup pumps.

2. List split fractions that include this human action.

MRA ; MR-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

After RT, Excessive cooldown, ESAS actuation HPI is successful, Throttling is successful. (High dependency on HTH 2)

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HMR1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, ~~training~~, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip. Procedure [illegible] very likely would not be reviewed even though it does describe proper action

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [x] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule Knowledge

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Human Action Identifier: HMR1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): 1210-10 Step 3.3.4

HPI flow < 400 gpm/pump

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
none

3. From where will action first be attempted? (control room, other - specify) ______

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HMR1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) MU-V-36, 37 do not open - Makeup tank level high.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HμR1 Sheet 5 of 11

E. <u>Experience Level of Operating Team</u>
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HMR 1

F. Response Time Available

1. What is the timing of the first indications for the operator action? almost immediate (in time since initiating event)
   varying dependence on LOCA size
2. When may the operator first act? (in time from initiating event)

   ~~See 1 above~~, after throttling to < 400 gpm/pump

3. When is the last time allowed for the operator to take action and be successful?

   at 80 gpm per pump

   Measured as median time since initiating event ________

   or as time since first indications 4 minutes

4. Estimate the median time to carry out the action, once decided to pursue. 1 min.

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 3 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
only 1	4 min.		1 min.	1 min.	

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TABLE 2-7 (continued)

Human Action Identifier: HMR1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

makeup pump trip alarms

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ______

possible, depending upon the ~~flow~~ flow through the injection lines after one pump trips off the others may be saved. Assume no.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, ~~Emergency Response Team~~]

4a. At what point would the following be declared:

ALERT — due to ESAS GENERAL

SITE AREA (Assume ERT would not arrive in time)

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)
SS

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HMR1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO, but Throttling was successful

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NO time, med. dependence

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Serially he could be trying to regain Pri to secondary heat transfer.

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for? ~~No~~ Yes Throttling of HPI flow

Scenario Group	(Yes/No)	Comments
A.	Yes	medium dependence w/ HTHZ success
B.		
C.		
D.		

Human Action Identifier: HMR1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-10.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
Excessive Cooling LOCA
Loss of Subcooling Margin

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HMR1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   He may decide not to throttle to less than 400 gpm/pump.

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   N/A

5a. If the action were taken prematurily would the action still be successful?

   yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

   NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: Valves are well labelled, mimiced.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

   NA

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Human Action Identifier: HMR1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? ~~Rule~~ Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A Optimal conditions
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 4-1=3 min
Best estimate of time to diagnose 1 min.

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, medium dependence with TH which is successful (HTH2)
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned manual action

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HNS1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to isolate a leaking, ruptured nuclear services heat exchanger. All support is assumed available. Thirty minutes is assumed available for action between the time a surge tank low level alarm is received until a loss of system cooling capability.

2. List split fractions that include this human action.

   NSA ; NS-1
   NSB ; NS-1 $(\overline{GB})$
   NSC ; NS-1 (GA/GB)
   NSD ; NS-1 $(\overline{EA}/\overline{EB})$
   NSE ; NS-1 $(\overline{EA,EB})$
   NSF ; LONS

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   RT, NS will be lost in 30 minutes

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Human Action Identifier: HNS1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 2
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? annually

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HNS1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
alarm PRF-1-1-7 high system leakage
PRF 1-2-7 low surge tank level
NSCC surge tank level indicators
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
alarm PRF 1-1-7 in control room, audible, visual
PRF 1-2-7 in control room, audible, visual
F-2-8 N.S. surge tank low pressure
Heat exchanger vault Sump high level alarm, Both sump pump running alarm

3. From where will action first be attempted? (control room, other - specify) the operator will try to fill the tank, then an A.O. will look for leaks

4. Is special coordination between operators required? (yes, no)
The AO has to look for leaks in the system.

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HNS1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) MU-P-1B has no cooling water if NS is lost

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) DW-P could fail the operator couldnot make up to the system

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

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Human Action Identifier: HNS1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HNS1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2 minutes to start DW makeup pump

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 30 minutes
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 15 minutes Assume will check heat exchanger fault first

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 14 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT.
	30 min.		3 min.	15 min.	

Human Action Identifier: HNS1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   none

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA
GENERAL
NA

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HNS1 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

no

2. How much influence do previous human errors have on this action? (significant, same, none) ______

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

Rx trip immediate actions

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HNS1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1203-20. ALARM Response sheets

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
   Seismic event
   Loss of NS (support system failure)

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

   ☐ Not do any related action?

   ☐ Perform an action that makes things worse? Identify ________

   NA

   ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HNS2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

he will try to refill simultaneously with isolation of the broken heat exchanger.

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

Manual valves at the heat exchanger are used to isolate the ruptured heat exchanger.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HNS2

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 15 min
Best estimate of time to diagnosis 3 min.

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? very low

Recovery of faulted system 0.5

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HNS2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to start an NSRW pump, given a loss of one train of AC power, and the remaining powered pump was not selected to engineered safeguards. Failure of power to 1C-ESV MCC would prevent the B NSRW pump discharge valve from opening. High temperature motor alarms would be expected in 2 to 3 minutes

2. List split fractions that include this human action.

NSC NS ($\overline{GA}$/$\overline{GB}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   * LOOP, one diesel fails
   * B-pump discharge valves on 1C which is selected to B side power
   * B-pump is on ES for A side - starts but discharge valve does not open due to loss of power to 1C ESV-MCC
   * B-pump trips giving alarm in aprox. 2 minutes
   * A-pump has to be started manually
   * Control bldg ventilation chiller is heating up due to lack of cooling to nuclear services closed cooling.
   * [illegible] our time to recovery
   * Control room confusion caused by LOOP, Loss of diesel, restart CBV, loss of river water systems, natural circ. cooling.

TABLE 2-7 (continued)

Human Action Identifier: HNS2 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) yes

2. If yes, by what means? (procedures, training, frequent performance) all three

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) no

4. Is this action included in simulator training? (yes, no) yes

4a. How often are these actions reviewed in training? very infrequently

Check those applicable descriptions of actions:

Skill-Based

- X Routine action, procedure not required.
- ___ Routine action, procedure required, but personnel well trained in procedure.
- ___ Action not routine, but unambiguous and well understood by operators who are well trained.
- ___ Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- ___ Routine action, but procedure required; operators not well trained, or procedure does not cover.
- X Not routine, action unambiguous and well understood, but not well practiced.
- ___ Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- ___ Not routine, action ambiguous.
- ___ Not routine, procedure does not cover.
- ___ Not routine, procedure not well understood.
- ___ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule
[Use logic tree (from HCR report, Figure B-3) if helpful.]

Human Action Identifier: HNS2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   NR discharge header pressure indication on console center
   valve status lights on console center, console right and P.C.R.
   amber motor overload light at NR-P-1B control switch

   Procedure EP 1202-2 step 11 tells operator to start NR pump

2. Alarms (name, location, audible, visual):
   480 volt motor trip - control room audible & visual
   data logger for computer prints alarm status for NRP's

3. From where will action first be attempted? (control room, other - specify) ________

4. Is special coordination between operators required? (yes, no) ________

5. Is there corroboration among indications? (very good, some, none) ________

6. How specific is guidence given in procedure. general ie start NRP.

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HNS2

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no) ________

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response) ______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) _______

4. Are there any system failures that complicate this action? (none, one, multiple) ____________________

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. Only		
B.		
C.		
D.		

Human Action Identifier: HNS2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Trained. Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HNS2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   5 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 23 hours
   or as time since first indications ________

   Best estimate of time to diagnose 10 min

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 12 hrs 59 minutes

Human Action Identifier: HNS2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   NSCC cooler outlet high temperature alarm
   Component high temperature alarm

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes 1 hour

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ________

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Remote Emergency Response Team]
   Shift Supervisor, STA, ~~Emergency Response Team~~

4a. NP Alert ~~or site area emergency~~ will be declared on LOOP

- Should additional credit be given because of additional plant feedback? (yes, no) ________
- Should additional credit be given because of newly arriving crew members? (yes, no) ________

TABLE 2-7 (continued)

Human Action Identifier: HNS 2 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

- recovery of offsite power
- control of emergency feedwater for natural circ. cooling
- recovery of control building ventilation
- recovery of failed diesel
- recovery of instrument air
- stopping DC motors which can be replaced by AC powered motors

Must a specific dependence with another human action be accounted for?

no

Scenario Group	(Yes/No)	Comments
A. [illegible]		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HiSS 2 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number EP 1202-2.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
loss of offsite power

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) ________ If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number EP 1202-2A. (i.e. loss of all AC)

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) ________ If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ________

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?
____

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) ________
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
____
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

TABLE 2-7 (continued)

Human Action Identifier: HNS2 Sheet 10 of 1[illegible]

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ________ Identify:

4. Is more than one option pursued in parallel? (yes, no) NA

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) NA
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

could possible operate wrong control switch for B Nuc. River pump.
but would easily see impact and try correct switch

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ________

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Human Action Identifier: HNS 2 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 2 hours
Best Estimate of time to diagnose 10 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Backup to Auto. Action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HNS6 — Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Failure to isolate a leaking heat exchanger supplied cooling by NSCCW. Thirty minutes is assumed available for action between the time a surge tank low level alarm is received until a loss of system cooling capability.

2. List split fractions that include this human action.

Same as HNS1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

- 30 minutes from time of receipt of surge tank low level alarm to loss of system function.
- long time to recover cooling capability once lost
- RCP's & CBV are lost

0394G011386

Human Action Identifier: HNS6

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 2
   1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? Annually

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ________

Human Action Identifier: HWS 6 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Alarm PRF 1-1-7 high system leakage, 26.1 gpm, alarm response procedure PRF 1-1-7
Alarm PRF 1-2-7 lo NSCC surge tank level, 1.6 " " " PRF 1-2-7
NSCC surge tank level A & B channel, console center
1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
PRF 1-1-7 located on PRF, A+V
PRF 1-2-7 " " " " "

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HN56

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) makeup pump, DW-P-1, failure

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HNS6

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HNS6

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1 minutes to calculate rate of change for ΔL alarm (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
1 1/2 minute

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 30 minutes
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 1 hour variable, time to find leaking heat exchanger depends on where it is, may be in the control building

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~11 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
	30 min.		3 min.	~~[illegible]~~ variable	C

Human Action Identifier: HNS6

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   none

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what ~~new~~ crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA
   GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HNS6

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HNS 6

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1203-20, PRF1-1-7, PRF1-2-7.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
seismic event

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NONE.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at ~~the~~ time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to: NA

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ______
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______

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Human Action Identifier: H NS 6 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:
NA

5a. If the action were taken prematurily would the action still be successful?
yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: Very low if any - manual valve operation at individual heat exchangers.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HUS 6 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis Variable
Best estimate of time to diagnose 3 min

From G. Additional credit to rediagnosis due to plant feedback? N/A Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A N/A
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low
Recover failed system

Time to perform action
... – .15, .5, .20, .25, .75
... – 5, ..., 25, 35

Time ...
...
... = 1.0

Recover a failed system

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HNS7

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Failure to locally isolate an idle NSCCW pump whose check valve suffers a gross reverse leakage.

2. List split fractions that include this human action.

   HNS7A

   NSC NS-1 ($\overline{OP}$)

   NSK NS-1 ($\overline{GA}/\overline{GB}$)

   HNS7B

   NSA ; NS-1

   NSD ; NS-1($\overline{EA}/\overline{EB}$)

   NSE ; NS-1($\overline{EA,EB}$)

   NSF ; LONS

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   LOOP, check valve stuck open ($\overline{GA}$ or $\overline{GB}$) on pump that is off, other pump on but the water recirculates through the stuck open check valve.

   A, e.g. $\overline{OP}$.$\overline{GA}/\overline{GB}$

   A. Power is not available to pump with failed valve (pump may not be started)

   B. Power is available to pump (pump may be started) with failed check valve - Assume 'B' pump is failed and its breaker is racked in on bus with power available from diesel.

   C. The running pump trips on overload and the operator starts the (B) pump which was windmilling (problem is then corrected)

TABLE 2-7 (continued)

Human Action Identifier: HNS7 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar ___1___

2. If yes, by what means? (procedures, training, frequent performance) NA

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? 2YRS - FUNDAMENTALS ARE DISCUSSED

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [x] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ______________

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Human Action Identifier: HNS 7

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   Increasing NSCCW component temperatures

1a. Are displays directly visible. (yes/no)

   yes

2. Alarms (name, location, audible, visual):

   High NSCC cooler outlet temperature alarm
   High component temp alarms.
   motor overload on running NSCC pump due to runout condition.

3. From where will action first be attempted? (control room, other - specify) A) Locally, (B) Control room C) Control room

4. Is special coordination between operators required? (yes, no) A) yes B) no C) No

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [x] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HNS7

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.	Potential Emergency	
B.	" "	
C.		
D.		

Human Action Identifier: HNS7

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Trained. Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HNS7 — Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? (A) 1 hr, (B) 1 hr, (C) 5-10 min. (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   (A) 1 hr
   (B) 1 hr
   (C) 5-10 min.

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 2 hours
   or as time since first indications (B) 1 hour

4. Estimate the median time to carry out the action, once decided to pursue. (A) 30 min, (B) ~~<1 min~~ 10, ~~(C) <1 minute~~

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ________

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVATIVE
A	1 hr		20 min.	10 min.	
B	1 hr		20 min.	10 min.	
~~C~~	~~2 hrs~~			~~1 min~~	

Human Action Identifier: HNS? Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

at significant new indications are there to tell the operator an earlier diagnosis was in error?
- NONE
- 'B' pump trip when started
- STARTING 'B' pump SOLVES The problem

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)
yes (A), yes (B), no (C)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team]

SS, STA for A, B
NONE FOR C

4a. At what point would the following be declared:
ALERT
SITE AREA
GENERAL
N/A

- A Should additional credit be given because of additional plant feedback? (yes, no) A yes, B yes, C No

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
A	yes	yes	
B	yes	yes	
C	No	No	

Human Action Identifier: HNS7

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   No

2. How much influence do previous human errors have on this action? (significant, same, none) NONE

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   Recover OFFSITE power
   Recover diesel
   Control SG Level AND pressure
   Control RCS Level, Temp, Pressure

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

Scenario Group	(Yes/No)	Comments
A.	NO	
B.	NO	
C.	NO	
D.		

Human Action Identifier: HNS7

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action? LOOP

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator No procedure.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? For A,B,C

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

N/A

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? CV, RP

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Human Action Identifier: HNS7

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team ~~as~~ to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful?
N/A

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:
NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:
No

8. Is the potential ~~for selec~~tion of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HNS7 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A Potential emergency
Group B "
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 1 hour
Best Estimate of Time to perform diagnosis 30 min

From G. Additional credit to rediagnosis due to plant feedback?
A) yes
B) Yes Arriving crew members? A) Shift supervisor
C) no B) shift supervisor
C) no

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B No
Group C ~~No~~
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? very low

Response Time Once Diagnosed

Scenario
A – 30 minute
B – 30 minute
~~C – ...~~

Recover Faulted System

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HNS8

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Failure to remotely isolate an idle NSRW pump whose check valve suffers a gross reverse leakage.

2. List split fractions that include this human action.

HNS8A		HNS8B	
NSB ;	NS-1 ($\overline{IP}$)	NSA ;	NS-1
NSC ;	NS-1 ($\overline{GA}/\overline{GB}$)	NSD ;	NS-1 (EA/EB)
		NSE ;	NS-1 (EA.EB)
		NSF ;	CONS

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

LOOP, check valve sticks open ($\overline{GA}$ OR $\overline{GB}$) on pump that's off, other pump ON but recirculates through the stuck open check valve.
(The strainer provides a flow restriction)

(A) Power is not available to pump with failed valve
(B) Power is available to pump with failed valve

A) OP. GA/GB failed, local closure required
B) Remote closure of pump discharge valve possible

0394G011386

Human Action Identifier: HNS8

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar ___1___
2. If yes, by what means? (procedures, training, frequent performance) NA
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? ___2YRS - FUNDAMENTALS ARE DISCUSSED___

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [x] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

Human Action Identifier: HNS8 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   P Low NSRW system pressure
   Plant effluent flow decreases

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
   High temperature alarms on components fed by NSRW.

3. From where will action first be attempted? (control room, other - specify) (A) Screen house (B) Control Room

4. Is special coordination between operators required? (yes, no) A - Yes B - No

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general, No guidance)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [x] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HNS8

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.	Potential Emergency	
B.		
C.		
D.		

Human Action Identifier: HNS8

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Trained. Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HNS8

F. Response Time Available

1. What is the timing of the first indications for the operator action? A - 1 hour B - 1 hour (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   A - 1 hour

   B - 1 hour

3. When is the last time allowed for the operator to take action and be successful? 2 hours

   Measured as median time since initiating event 2 hours

   or as time since first indications A) 60-30 = 30 min. B) 60-1 = 59 min.

4. Estimate the median time to carry out the action, once decided to pursue. A - 30 minute B - <1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ________

Scenerio Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
~~Scenario~~ A	1 hr		3 min.	30 min.	
B	1 hr.		3 min.	1 minute	

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Human Action Identifier: HNS8

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   A- no new indications
   B- B pump may trip when started

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

   A - yes
   B - yes

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team] — A SS, STA
   B SS, STA

4a. At what point would the following be declared:
   ALERT
   SITE AREA N/A
   GENERAL

● A Should additional credit be given because of additional plant feedback? (yes, no) A yes B yes

● B Should additional credit be given because of newly arriving crew members? (yes, no) A yes B yes

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HNS8 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   No

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   Recovery OF LOOP
   Recovery OF FAILED Diesel
   Control SG Level AND Pressure
   Control RCS Level, Temp, AND Pressure

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.	No	
B.	No	
C.		
D.		

Human Action Identifier: HNS8

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
Loss of OFFSITE power

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator N/A.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA
- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ________
- ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? CV, RP, GA, GB

0394G011386

Human Action Identifier: HNS 8

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) NA
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

He could try to start a different system's pump, the control switches are close together

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: H NS8 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A Potential emergency
Group B " "
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis ~~1 hour~~ A) 30 minutes B) 60 minutes

Best estimate of time to perform diagnosis 3 min.

From G. Additional credit to rediagnosis due to plant feedback? A) yes B) yes Arriving crew members? A) shift supervisor B) shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B No
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? Very low

Response Time once Diagnosed

Scenario
A - 30 min.
B - 1 min.
C - 1 min.

Recovery of failed system

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HPO1

A. Description of Human Action

1 Objective (task to be performed and failure criteria):

Operator fails to manually open the PORV for HPI cooling when the support systems needed for automatic control are not available. Makeup pumps have sufficient high pressure capacity if automatic pressure control is working.

2. List split fractions that include this human action.

POB

PO1 ($\overline{AA}$/$\overline{VA}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario grou s for evaluation. Emphasize factors affecting response time and stress level.

RT, Failure of secondary cooling, ATA failed

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TABLE 2-7 (continued)

Human Action Identifier: HP01 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 5
1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? 3 mos

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HP01 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):
Loss of primary to secondary heat transfer - (SG level and pressure control failure) & (RCS Tc not controlled by SG pressure).
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HPO1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.
HPI cooling causes the contamination of large area in the reactor building

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HP01

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HP01

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
5 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 30 minutes
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 30 seconds

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 27.5 minutes

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat
	28 min		3 min	0.5 min	

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Human Action Identifier: HPO1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   INCREASING PRIMARY SYSTEM pressure and temperature.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   <10 minutes after loss of heat transfer

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT — Th > 620°F
   SITE AREA — INCORE > 700°F
   GENERAL

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HP01

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Starting HPI pumps and opening BWST valves to HPI, trying to recover primary to secondary heat transfer.

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

Yes, HBW1 ?

Scenario Group	(Yes/No)	Comments
A.	Yes	success of HBW1, where operator deciding to initiate HPI cooling (medium dependence)
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HPO1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1, 1210-4

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
LOOP with AA failure and EF control problem

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ________.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, o. very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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Human Action Identifier: HP01

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful?
yes - provided HPI pumps were started

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

increasing RCS temperatures and pressure.

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HP01

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 27.5 min.
Best estimate of time to diagnose 3 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, success of HBW1, medium dependence
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option?

may lead to Extended Outage

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRC1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to close the PORV block valve (used in RC-4, 5, 6, 7, 8, and 9) if the PORV fails to reseat properly.

2. List split fractions that include this human action.

RCD; RC-4
RCE; RC-5
RCF; RC-6
RCG; RC-7
RCH; RC-8
RCI; RC-9

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT
Power is available to block valve
Secondary cooling (OTSG) is available

Human Action Identifier: HRC1

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar

2) If yes, by what means? (procedures, training, frequent performance)

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)

5) How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

TABLE 2-7 (continued)

Human Action Identifier: HRC 1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
RC DRAIN TANK Temperature/pressure above normal

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
C-1-7 RC-RV-2 opened (DIFFERENTIAL PRESSURE)
C-1-8 RC-RV-2 OPEN (ACOUSTIC MONITOR)

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HRC1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) RC-V-2 could fail to close electrically

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HRC1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HRC 1

F. Response Time Available

1. What is the timing of the first indications for the operator action? immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event) After he verifies that the valve should not be open by looking at RCS pressure
2 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 30 minutes
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 2 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 28 minutes

30 − 2 − 0 = 28

Scenerio Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservant
	30 min.		2 min.	2 min	

Human Action Identifier: HRC1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   RC Drain tank high level alarm
   RC Drain tank high pressure alarm not additional

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   2 minutes No

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
    ALERT – R.B. pressure > 4#
    RCS Leakage > 50 gpm

- A Should additional credit be given because of additional plant feedback? (yes, no) ✓
- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HRC1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Control EFW if needed otherwise monitor steam generator level, primary system pressure and temperature.

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HRC1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1202-29 .
   alarm C-1-7, C1-8
2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA
3. Which initiating events may lead to a need for this action?
   RT w/ failure of PORV
4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ____________.
5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ____________. none
6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ____________.
7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?
8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.
10. If the incorrect procedure is entered, does it direct the operator to:
    - [ ] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify ____________
    - [ ] Perform the correct action anyway?
11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________.

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TABLE 2-7 (continued)

Human Action Identifier: HRC1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

RB pressure going ~~up~~ telling the operator he has a possible LOCA, would be one indication but may not [illegible]

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

The control is well marked.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HRC1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 28 min.

Best estimate of time to diagnose 2 min.

From G. Additional credit to rediagnosis due to plant feedback? no Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recovery of failed system

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRC 2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to throttle HPI after the PORV or PSVs have passed water [used in RC-3, 6, 9, 6 (1C) and 9(1C)] to allow the PORV to reseat.

   Assume has 5 hours before depleting BWST

2. List split fractions that include this human action.

RCC; RC-3
RCF; RC-6
RCI; RC-9
RCL; RC-6(1C)
RCO; RC-9(1C)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Failing to throttle HPI caused PORV to lift.
   steam generator cooling assumed available

0394G011386

Human Action Identifier: HRC2 Sheet 2 of 11

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar
2) If yes, by what means? (procedures, training, frequent performance)

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)
5) How frequently are these actions reviewed in training? 6WKs for normal Throttle to prevent PORV opening

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are ell trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HRC2

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable): 2210-10 Step 1.3
HPI flow > 550gpm per pump, RCS pressure vs temperature approach brittle fracture curve limits
1a. Are displays directly visible. (yes, no) PORV indication that it is open

2. Alarms (name, location, audible, visual):

C-1-7 PORV open alarm or Safety open
C-1-8 PORV open alarm

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☒ Good. Displays carefully integrated with SPDS to help operator.

☐ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HRC2

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Loss of power to valves requires local operation

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HRC2

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HRC2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
5 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event ~~30 minutes~~ 5 hours
or as time since first indications 5 hours

4. Estimate the median time to carry out the action, once decided to pursue. 15 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available ~~24 minutes~~

~~30-5-1=24~~

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservant
	~~3 min~~ 5hrs.		~~3~~ 4 3/4 hr.	~~5 min~~ 1/4 hr.	

Human Action Identifier: HRC2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

RB sump level rising

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes Stet

PRIOR TO depletion OF BWST water and be within 30 minutes of PORV lift, ~~[illegible]~~

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT 4" in R.B.
SITE AREA 30" in RB
GENERAL

• A Should additional credit be given because of additional plant feedback? (yes no)

• B Should additional credit be given because of newly arriving crew members? (yes no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HRC2 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

yes
The operator should have throttled prior to water going out the PORV/PSV's

2. How much influence do previous human errors have on this action? (significant, same, none) ____________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

The operators are monitoring ES equipment operation, watching the secondary system pressure and SG level.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? ~~HMR1~~ c
HTH2 1

Scenario Group	(Yes/No)	Comments
A.	Yes	low ~~...~~ with HTH1, HTH2
B.		
C.		
D.		

Human Action Identifier: HRC2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-10.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
LOCA
Main steam line break, Excessive Cooling

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-3.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ______.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ______
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______ -

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Human Action Identifier: H________ Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

other alarms RB sump high

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

The operator is well trained on the location of these valve controls.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HRC2

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Good

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action diagnosis 4.75 hours

Best estimate of time to diagnose 3 minutes ≈ .05 hours

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low dependence with HTH1, HTH2 failing
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recover failed system

Human Action Identifier: HRE7[2]

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

~~SEE TMI QUANTIFICATION HUMAN ACTIONS TABLE 1-1 FOR DESCRIPTION~~

AFTER a loss of river water initiating event without near term recovery, the operators extend the time that seal injection is available by cycling among the three makeup pumps or hooking up fire service water

2. List split fractions that include this human action.

RE-2, (REB)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Loss of River water.
Assume electric power available to both vital buses

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Human Action Identifier: HRE72 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
   system training, not specific to this event.
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? NONE

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [x] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

Human Action Identifier: HRE72 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): no procedure
River water alarms showing screen problems
NSCCW temperatures rising

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

NSCCW component alarms

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no) when putting MU-P-1 on line

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general) None

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [x] Poor. Displays available, but not human engineered.
  Time to isolate based on component temperatures unknown
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HRE ?? Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) any cooling (DC, NS) system failure that reduces the heat absorption capacity.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HRE7[2]

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Trained. Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

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TABLE 2-7 (continued)

Human Action Identifier: HRE72

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1 hour after T.T. (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
3 hours after trip

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 6 hours after trip
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 6 minutes for transfer to 'A' pump from 'B' pump.

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______

   6 − 0.1 − 1 = 4.9 hours

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
			6 minutes		

Human Action Identifier: HRE72

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

none

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ____________

NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), SS Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA at the discretion of SS/SF
GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HRE72

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

~~NO~~ Yes

2. How much influence do previous human errors have on this action? (significant, same, none) ______

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

Yes, try to unclog screens, hook up cooling water from fire service system. (HRE6)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? Yes, HRE6

Scenario Group	(Yes/No)	Comments
A. —	Yes	low dependence on failure of HRE6
B.		
C.		
D.		

Human Action Identifier: HRE72

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number __________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
Loss of river water

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator NA.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number __________. None

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? NA

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number __________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify __________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? HPA, HPB,

Human Action Identifier: HRE7 2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) the operators will have to develop their own options.

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   cannot determine

4. Is more than one option pursued in parallel? (yes, no) unclog screens, Fire service to cool a heat exchanger

5. If no specific procedures apply, are there other possible plausible options that are nonviable? (yes, no) Identify:

   Unsuccessfully try to clean screens, they may cave in and clog the service water pump strainers.

5a. If the action were taken prematurely would the action still be successful?

   yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:

   continued rising equipment temperatures

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HRE72 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 49 hours
Best estimate of time to diagnose 0.1 hours

From G. Additional credit to rediagnosis due to plant feedback?
N/A Arriving crew members? Emerg. Response Team + Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low dependence on failure of HRE6
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? Very low

Type of action
Recovery from failed system

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRE4

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator failure to unplug the river water pump house screens before a loss of river water pump suction which eventually results in a turbine trip. Used in the loss of river water initiating event frequency. It is assumed that only 6 hours is allowed for unplugging.

2. List split fractions that include this human action.

   Used in the loss of river water initiating event.

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Six hours available for unplugging of the river water pump house intake screens before river water pumps suction lost.

Human Action Identifier: HRE4

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 2
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance) not very familiar
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? NA PROBABLY INITIAL SYSTEM OPERATION THEORY ONLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [x] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? KNOWLEDGE

Human Action Identifier: HREY   Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): no procedure for total screen plugging recovery.
River water system pressure decreasing
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
alarms indicating high differential pressure across the intake screens

3. From where will action first be attempted? (control room, other - specify) locally at the intake screens

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general) none

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [x] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HREY

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Screen failure could cause system plugging in heat exchangers.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HREY Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HREY

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
4 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 6. Hours
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 3 hours

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 3 hrs

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVATIVE
	6 hrs.	13 hrs.	20 min.	2 hrs.	6 hrs.

Human Action Identifier: HREY   Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

~~none~~

increase in differential pressure across the screens. No, ~~many~~ first indication is screen ΔP

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ~~yes~~ NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA   AT the SS discretion
GENERAL   Shift Sup

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HRC4 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   no

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

   Must a specific dependence with another human action be accounted for?

   no.

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HREY

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
Screens plugging

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator
no procedure for gross plugging of screens

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, o. very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? None

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Human Action Identifier: HRE4

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

The operator may only try to make the equipment run normally and not try to mechanically clean the screens with portable equipment.

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

See 3 above

5a. If the action were taken prematurily would the action still be successful?
yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

increasing differential pressure across the screens; this is hard to see because of the location of the screens

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HREY   Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 6 hours
best estimate of time to diagnose 15 minutes

From G. Additional credit to rediagnosis due to ~~plant feedback~~?
No Arriving crew members? Shift Supv.

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? very low

Time Allowed Distribution
hours ⇒ 1.3, 2.6, 4., 6., 8   prob → .01, .04, .25, .55, .15

Time To Perform Action
Times = 1, 2, 4, 6 hours
Prob = .25, .45, .25, .05

Recover Failed System

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRE2 C   Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to restore river water before RCP seal failure after the operators were not able to earlier restore river water before turbine trip occurrs. Success is achieved by the operators restoring river water. ~~or by successfully rotating service beween the three makeup pumps to provide seal injection without river water (used in RE-2).~~

2. List split fractions that include this human action.

REC; RE-3(EF)
REB; RE-2

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT due to the travelling screens plugging

Assume attempts to [illegible] screens continue to [illegible] needed to rotate the pumps.

6

6

Human Action Identifier: HRE26

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 2
2. If yes, by what means? (procedures, training, frequent performance) no
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [x] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

Human Action Identifier: HREL6 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable): no procedure

NSCCW temperatures going up.

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

NSCCW component alarms

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general) NONE

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [x] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HRC 26

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) any other component cooling system failure

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HRE26 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: ~~HRE2~~ HRE6

F. Response Time Available

1. What is the timing of the first indications for the operator action? ~~1 hour after Turbine Trip~~ initially on river water trouble alarm (2 minutes) (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

~~1.5 - 2hrs after turbine trip~~ 4 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event ~~8.1 hours~~ A) 12 Hours B) 7 Hours

or as time since first indications ~~___~~ same

4. Estimate the median time to carry out the action, once decided to pursue. ~~10 minutes~~ 3 Hours

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~~6.9 hours - 7 hours~~ ~~2-2 - 1.5 hours~~ A) 12 Hours B) 7 hours

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
A	~~[illegible]~~ 12 hrs	7.3 hours	~~5 min~~ 20 min.	~~[illegible]~~ 2 hrs	6 hrs.
B	7 hrs.	2.3 hours	2 min	2 hrs	6 hrs.

Human Action Identifier: HRE26

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

none

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ______

NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA
GENERAL
at the discression of the SF/SS.

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no) A - Emergency Response Team
B - Shift Supervisor only

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HRE#6 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

NO

~~Yes, failed to unplug screens~~

No

2. How much influence do previous human errors have on this action? (significant, same, none) ______

~~low dep~~

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

yes try to unclog screens, hook cooling water from other sources (ex fire system)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

~~no/yes~~ No

Scenario Group	(Yes/No)	Comments
A.	~~Yes~~ No	~~low dep. to some in failure to unplug screens, HRE4~~
B.	No	
C.		
D.		

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TABLE 2-7 (continued)

Human Action Identifier: H REZ6 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ______.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
Loss of River Water due to screen plugging

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______. NA

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ______. None

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? NA

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

- [x] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ______
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______.

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Human Action Identifier: HRe26 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) must think of their own options

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no) MAYbe

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify: dependent upon selected option

5a. If the action were taken prematurily would the action still be successful?
yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HRE16

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Poor

From D. Expected stress level for each scenario group?

Group A Potential Emerg.
Group B Potential Emerg.
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis A) 11 hours B) 7 hours

Best estimate of time to diagnose .05 hours

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? A) ERT - full B) Shift supervisor only

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B No
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? very low

Action Type - recover a failed system

Time to Perform Action
Times = 1, 2, 4, 6 hours scenarios A & B
Prob = .25, .45, .25, .05

Time Allowed Distribution
A) Times = 7.3, 8.6, 10, 12., 14. hours
B) Times = 2.3, 3.6, 5., 7., 9. hours
Both Prob = .01, .04, .25, .55, .15

Human Action Identifier: HRE9

A. Description of Human Action

1. Objective (task to be performed and failure criteria):
In the event of a very small LOCA with failure of both trains of DCCW or DCRW cooling to the DHR heat exchangers, failure of the operators to recover flow to the river water side of the Decay heat service coolers using a fire hose.

2. List split fractions that include this human action.
DHF DH-1 (HA,HB)

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.
General transient initiator but FXA fails, meaning a very small LOCA has occurred requiring recirculation from the sump eventually. All support systems except decay heat river water system trains A and B are available.

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) ________
   Rank on scale of 1 to 5, with 3 being average and 5 most familiar. _____

2. If yes, by what means? (procedures, training, frequent performance, or walk-throughs) ________________
   Give procedure number if applicable ______________.

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) ________

4. Is this action included in simulator training? (yes, no) ________

5. How frequently are these actions reviewed by the operators? _________

Check descriptions that apply to this action:

Skill-Based

☐ Routine action, procedure not required.

☐ Routine action, procedure required, but personnel well trained in procedure.

☐ Action not routine but unambiguous and well understood by operators who are well trained.

☐ Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

☐ Routine action, but procedure required; operators not well trained, or procedure does not cover.

☐ Not routine, action unambiguous and well understood, but not well practiced.

☐ Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) ________.

Knowledge-Based

☐ Not routine, action ambiguous.

☐ Not routine, procedure does not cover.

☐ Not routine, procedure not well understood.

☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ______________

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   Are displays directly visible?__________

2. Alarms (name, location, audible, visual):

   Will there be many other alarms to distract the operator? (Describe.)

3. From where will action first be attempted? (control room, other--specify) ______________________________

4. Is special coordination between operators required? (yes, no) ________

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)

   ____

6. How specific is the guidance for action? (component numbers, timing) ______________________________

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☐ Fair. Displays human-engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human-engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) ________

2. Why is this action needed? (______ to an automatic action, planned ______ action, ________ of failed system, ______ ESAS response) ______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) ______ (Explain if yes.)

4. Are there any system failures that complicate this action? (none, one, multiple) ____________________

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

A.			
B.			
C.			
D.			

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, well trained. Licensed with more than 5 years experience.
- [x] Average knowledge, training. Licensed with more than 6 months experience.
- [ ] Novice, minimum training. Licensed with less than 6 months experience.

F. Response Time Available

1. What is the timing of the first indications for the operat^^ action? (in time since initiating event) ____________

2. When may the operator first act? (in time from initiating event) ____________

   6 hours, may attempt to go to closed loop DHR

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event, ____________
   or as time since first indications ____________?

   @ 70 gpm should easily have 48 hrs to head for recirc.

4. Estimate the median time to carry out the action, once decided to pursue. ____________

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ____________

Assess timing for each scenario group.

Scenario Group	Allowed Best	Time Available Conservative	Time to Diagnose Best Estimate	Time to Perform Best Conservative
A.				
B.				
C.				
D.				

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ________________

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ______

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., none, shift technical advisor (STA), remote emergency response team] ______

   At what point would the following events be declared?

   - Alert (onsite response team called) ______________
   - Site Area Emergency (offsite response team called ______
   - General Emergency (potential evacuation) ______________

5. Should additional credit be given because of additional plant feedback? (yes, no)______

6. Should additional credit be given because of newly arriving crew members? (yes, no) ______

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

4. Are there enough personnel available to carry out the necessary actions? __________

5. Must a specific dependence with another human action be accounted for?

	Scenario Group	Yes/No	Comments
A.			
B.			
C.			
D.			

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number __________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) ________

3. Which initiating events may lead to a need for this action?

4. Do each of these initiating events result in the plant physical condition^r necessary to enter the procedure encompassing this human action? (yes, no) ________ If no, identify by initiator ____________________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number _______________.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) ________ If yes, identify ____________________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ________________

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

   Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low? ____________________

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) _________ Identify by number _______________.

10. If the incorrect procedure is entered, does it direct the operator to:

    ☐ Not do any related action?

    ☐ Perform an action that makes things worse? Identify ______________________.

    ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______________________

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ________ Identify:

4. Is more than one option pursued in parallel? (yes, no) ________

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) ________ Identify ________

   If the correct action were taken prematurely, would the action still be successful?________

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) ________
   Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes/no)______ Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ______________

Human Action Identifier: HRE9

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A potential emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team average.

From F. Time available to perform correct action ~~4 hours~~ 41 hours.
Best estimate of time to diagnose ~~4L hours~~ .05 hr.

From G. Additional credit for rediagnosis due to plant feedback?
Yes Arriving crew members? Yes, Full.

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? very low

Type of human action

- [ ] Backup to an automatic action
- [ ] Detract from an ESAS response
- [x] Recovery of a failed system via realignment
- [ ] Planned manual action
- [ ] Action may lead to an extended outage; e.g., due to contamination.

TABLE 2-8. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRE11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator decides to initiate DHR or DCCW pump repair within 3 hours following ESAS actuation.

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

ESAS ACTUATION, DHR or opposite DC pump needs repair.

HRE21

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) 3
   Rank on scale of 1 to 5, with 3 being average and 5 most familiar. ____

2. ~~If yes, by what means?~~ (procedures, training, frequent performance, or walk-throughs) ______________
   ~~Give procedure number if applicable~~ ____________.

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) ________

4. ~~Is~~ this action included in simulator training? (yes, no) ________

5. How frequently are these actions reviewed by the operators? SIMILAR ACTIONS CARRIED OUT WEEKLY OR MORE OFTEN

Check descriptions that apply to this action:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) ________.

HRE21

Knowledge-Based

☐ Not routine, action ambiguous.

☐ Not routine, procedure does not cover.

☐ Not routine, procedure not well understood.

☐ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

HRE11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   Are displays directly visible? yes
   PUMP TEMP, VIBRATION high.

2. Alarms (name, location, audible, visual):
   TRIP, COMPUTER ALARMS, DH REMOVAL FLOW LOW, 4KV E5 MOTOR

   Will there be many other alarms to distract the operator? (Describe.)
   no.

3. From where will action first be attempted? (control room, other--specify) The Emergency response organization will send a repair team to try to start the pump

4. Is special coordination between operators required? (yes, no) ________

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)

6. How specific is the guidance for action? (component numbers, timing) no procedural guidance

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [x] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human-engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human-engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

HRE11

D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) ________

2. Why is this action needed? (______ to an automatic action, planned ______ action, Recovery of failed system, ______ ESAS response) ______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) _______ (Explain if yes.)

4. Are there any system failures that complicate this action? (none, one, multiple) ____________________

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal-Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

A.			
B.			
C.			
D.			

HRE 11 Sheet 6 of 13

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, well trained. Licensed with more than 5 years experience.
- [x] Average knowledge, training. Licensed with more than 6 months experience.
- [ ] Novice, minimum training. Licensed with less than 6 months experience.

HRE11

F. Response Time Available

1. What is the timing of the first indications for the operator action? (in time since initiating event) immediate

2. When may the operator first act? (in time from initiating event) 15 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event, 3 hours
   or as time since first indications ?

4. Estimate the median time to carry out the action, once decided to pursue. ______

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______

Assess timing for each scenario group.

	Scenario Group	Allowed Best	Time Available Conservative	Time to Diagnose Best Estimate	Time to Perform Best Conservative
A.					
B.					
C.					
D.					

HRE 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   Possible DH cooler outlet temperature high alarm

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   Before the pump or cooler is damaged

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ________

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., ~~none, shift~~ technical advisor (STA), remote emergency response team] SS

   At what point would the following events be declared?

   - Alert (onsite response team called) >50 GPM Leak from RCS
   - Site Area Emergency (offsite response team called Auto ESAS Actuation
   - General Emergency (potential evacuation) ________

5. Should additional credit be given because of additional plant feedback? (yes, no) ________

6. Should additional credit be given because of newly arriving crew members? (yes, no) ________

TABLE 2-8 (continued)

HRE 11 Sheet 9 of 13

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   NO

4. Are there enough personnel available to carry out the necessary actions? yes

5. Must a specific dependence with another human action be accounted for?

   NO

Scenario Group	Yes/No	Comments
A.		
B.		
C.		
D.		

HRE21 Sheet 10 of 13

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number ALARMS ONLY

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) ________

3. Which initiating events may lead to a need for this action?
ESAS coincident with pump failure

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) ________ If no, identify by initiator ________________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) NA If yes, identify ________________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ________________

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

   Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?
   Low

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) ________ Identify by number ______________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________________. NA
- [ ] Perform the correct action anyway?

TABLE 2-8 (continued)

HRE 11 Sheet 11 of 13

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________________

HRE 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ______

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ______

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ______ Identify:

4. Is more than one option pursued in parallel? (yes, no) ______
Depending on the failure mode, recovery of both trains may be attempted simultaneously

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) ______ Identify ______
______ ______

If the correct action were taken prematurely, would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option?
(yes, no) ______
Identify cues:
unavailability of the DHR system

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes, no) ______ Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ______

Human Action Identifier: HRE11

K. Summary Sheet

From B. What type of behavior is required? SKILL

From C. Description of plant interface? GOOD

From D. Expected stress level for each scenario group?

Group A High Workload/Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average.

From F. Time available to perform correct action 3 hours.
Best estimate of time to diagnose 15 minutes.

From G. Additional credit for rediagnosis due to plant feedback? Yes Arriving crew members? Yes

From H. Need to account for dependence with other actions for each scenario group?

Group A NO
Group B
Group C
Group D

From I. Potential for incorrect diagnosis leading to failure? LOW

From J. Potential for selection of nonviable option? Low

Type of human action

- [ ] Backup to an automatic action
- [ ] Detract from an ESAS response
- [x] Recovery of a failed system via realignment
- [ ] Planned manual action
- [ ] Action may lead to an extended outage; e.g., due to contamination.

TABLE 2-8. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRE 12 A,B,C

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Locally start DHR, DC, DR pumps when DC power is lost, to establish DHR cooling.

A = 6 hours, Small Loca or PSV open
B = 12 hours, Very small LOCA or TR, or PORV stuck open, HPI cooling
C = 24 hours, Rx trip, small leak, have to cooldown to fix the leak.

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

A - 6 hours - small LOCA (or PSV)
B - 12 hours - VSL (PORV open)
C - 24 hours - Rx trip, with small leak, have to cooldown for repairs

HRE [12] A,B,C

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) ______
   Rank on scale of 1 to 5, with 3 being average and 5 most familiar. ______

2. If yes, by what means? (procedures, training, frequent performance, or walk-throughs) ______
   Give procedure number if applicable ______.

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) ______

4. Is this action included in simulator training? (yes, no) ______

5. How frequently are these actions reviewed by the operators? 2 YRS

Check descriptions that apply to this action:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) ______.

HRE 12 A,B,C Sheet 3 of 13

Knowledge-Based

- [ ] Not routine, action ambiguous.
- [x] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ~~Skill~~ Knowledge

HRE - 12 A,B,C

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   Are displays directly visible? yes control power lights out for the pumps in question

2. Alarms (name, location, audible, visual):
   D-2-5 BATTERY DISCHARGING (>100 amps) A-2-8 BATT 2B GROUND
   A-1-7 BATT 1A GROUND
   Will there be many other alarms to distract the operator? (Describe.) NO

3. From where will action first be attempted? (control room, other--specify) LOCALLY AT THE SWITCHGEAR

4. Is special coordination between operators required? (yes, no) ________

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)

6. How specific is the guidance for action? (component numbers, timing) NONE PROCEDURALIZED

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human-engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human-engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

HRE 12 A 3e

D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) ________

2. Why is this action needed? (______ to an automatic action, planned ______ action, Recovery of failed system, ______ ESAS response) ______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) _______ (Explain if yes.)

4. Are there any system failures that complicate this action? (none, one, multiple) ___________________

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

A. 6 hours, SL or PSV open — OPTIMAL

B. 12 hours, VSL or PORV open — OPTIMAL

C. 24 hours, Rx Trip, Small leak — OPTIMAL

D.

TABLE 2-8 (continued)

HRE 1C A, B, C Sheet 6 of 13

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, well trained. Licensed with more than 5 years experience.
- [x] Average knowledge, training. Licensed with more than 6 months experience.
- [ ] Novice, minimum training. Licensed with less than 6 months experience.

HRE12 A,B,C

F. Response Time Available

1. What is the timing of the first indications for the operator action? (in time since initiating event) IMMEDIATE

2. When may the operator first act? (in time from initiating event)

A, B, C within first hour

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event, ______ A 6 hrs B 12 hrs C 24 hrs
   or as time since first indications ______?

   Best estimate [illegible] 15 minutes

4. Estimate the median time to carry out the action, once decided to pursue. one hour

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. A = 5 hrs, B = 11 hrs, C = 23 hrs

Assess timing for each scenario group.

	Scenario Group	Allowed Best	Time Available Conservative	Time to Diagnose Best Estimate	Time to Perform Best Conservative Estimate
A.	A		6 hours	.25 ~~1~~ hour	1 hour
B.	B		12 hours	.25 ~~1~~ hour	1 hour
C.	C		24 hours	.25 ~~1~~ hour	1 hour
D.					

HRE 12 A, B, C

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   LACK OF CONTROL POWER to pumps & SWGR That the operator TRIES to CONTROL DURING the SCENARIO

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   During the scenario whenever the operator TRIES to operate BREAKERS that have a DC CONTROL POWER LOSS.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ________

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., none, shift technical advisor (STA), remote emergency response team] ST

   At what point would the following events be declared?

   - Alert (onsite response team called) >50 GPM leak from RCS
   - Site Area Emergency (offsite response team called AUTO ESAS ACTUATION
   - General Emergency (potential evacuation) ________

5. Should additional credit be given because of additional plant feedback? (yes, no) ________

6. Should additional credit be given because of newly arriving crew members? (yes, no) ________

TABLE 2-8 (continued)

HRE.12 A,B,C Sheet 9 of 13

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
NO

2. How much influence do previous human errors have on this action? (significant, same, none) ____________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
Possible recovery effots of DC control power

4. Are there enough personnel available to carry out the necessary actions? yes

5. Must a specific dependence with another human action be accounted for? Yes,
Success of cooldown and depressurization [illegible] HCD1

Scenario Group	Yes/No	Comments
A. 6 hours	~~NO~~ Yes, medium	
B. 12 hours	~~NO~~ Yes, medium	
C. 24 hours	NO Yes, medium	
D.		

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HRE 'Z ABC

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) ________

3. Which initiating events may lead to a need for this action?
   LOSS OF DC, LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) ________ If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
   None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator?
   (yes, no) ________ If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ________

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

   Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?
   ____

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) ________ Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- ☐ Not do any related action?
- ☐ Perform an action that makes things worse? Identify ________.
- ☐ Perform the correct action anyway?

TABLE 2-8 (continued)

HRE 12 ABC   Sheet 11 of 13

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? none

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ________ Identify:

4. Is more than one option pursued in parallel? (yes, no) ________
Possible recovery efforts on DC power

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) ________ Identify ________
____

If the correct action were taken prematurely, would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) NA
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes, no) ______ Explain:
The operators are not expertly familiar with this evolution, may hesitate in correctly performing it at first.

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ________

Human Action Identifier: HRE 12 A,B,C

K. Summary Sheet

From B. What type of behavior is required? ~~SKILL~~ Knowledge

From C. Description of plant interface? FAIR

From D. Expected stress level for each scenario group?

Group A 6 hours — OPTIMAL
Group B 12 hours — "
Group C 24 hours — "
Group D
Group E

From E. Experience level of operating team AVERAGE.

From F. Time available to perform correct action ______. A 5 hours B 11 hours C 23 hours
Best estimate of time to diagnose .25 hour.

From G. Additional credit for rediagnosis due to plant feedback? yes Arriving crew members? yes

From H. Need to account for dependence with other actions for each scenario group?

Group A 6 hours — NO
Group B 12 hours — NO
Group C 24 hours — NO
Group D

From I. Potential for incorrect diagnosis leading to failure? LOW

From J. Potential for selection of nonviable option? very Low

Type of human action

- [ ] Backup to an automatic action
- [ ] Detract from an ESAS response
- [x] Recovery of a failed system via realignment
- [ ] Planned manual action
- [ ] Action may lead to an extended outage; e.g., due to contamination.

* The loss of DC procedure prohibits this action but in an emergency it would probably be attempted if that would be the success path for core cooling.

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRT 7

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to manually trip the reactor by pushing the scram button within 30 seconds following a loss of main feedwater and failure of the automatic trip function.

2. List split fractions that include this human action.

RTA ; RT-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   ATWS and
   Loss of main feedwater

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Human Action Identifier: HRT7

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar 5
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6 wks

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

TABLE 2-7 (continued)

Human Action Identifier: HRT7 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): 1210-1 step 2.1
any condition requiring a reactor trip

1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
Reactor temp, flow, pressure, power, etc out of normal requiring a reactor trip.
CR, visual, audible

3. From where will action first be attempted? (control room, other - specify) ______

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [x] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HRT7

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HRT7 Sheet 5 of 11

E. Experience Level of Operating Team (specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

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Human Action Identifier: HRT7   Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 0.1 min (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
0.2 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ~~5 min Table 1-1~~ 0.5 min. DW note
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 0.1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 0.3 minutes based on D.W. notes
   ~~4.8 minutes based on Table 1-1~~

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	.5 min		.1 min	.1 min	

Human Action Identifier: HRT7

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
Reactor power >10% after the reactor should have tripped.
Rods not indicating on the bottom.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
within 0.1 minutes.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT — Failure of Rx Trip GENERAL
SITE AREA

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HRT7 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   other immediate actions for reactor trip.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? HRT8, asked later

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HRT7 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
any reactor trip

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1202-2, 1202-2A, 1202-9A
(LOOP) loss of all A.C, loss of DC Train A

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify 1202-9A.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

1202-9A ☒ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☐ Perform the correct action anyway? If operator first selects 1202-9A, and reactor fails to trip; believe operator would go back to 1210-1 procedure.

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? very low

Note, however, that 1202-9A does not specifically tell operator to assure reactor is tripped by pushing the button.

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Human Action Identifier: HRT7 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

No — one switch is all that's required to be located and pushed, it is centrally located

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HRT7 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Good

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 0.3 min.
Best estimate of Time to diagnose 0.1 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? No

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Backup to automatic actions

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRT8 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to interrupt power to the control rod drives from the control room within 30 seconds given failure of the automatic reactor trip function in order to prevent an ATWS condition.

2. List split fractions that include this human action.

RTA; RT-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   operator pushed the manual reactor trip button but the rods failed to insert.

TABLE 2-7 (continued)

Human Action Identifier: HRT8 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6 mos.

Check those applicable descriptions of actions:

Skill-Based

- [x] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HRT8

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
any condition requiring a reactor trip but power stays > 10%
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
Any condition of RCS power, temperature, flow or pressure that requires a reactor trip.

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [x] Good. Displays carefully integrated with SPDS to help operator.
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HRT8 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) one of the breakers could fail to open

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HRT8

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HRT8

F. Response Time Available

1. What is the timing of the first indications for the operator action? 0.1 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event) 0.2 minute

3. When is the last time allowed for the operator to take action and be successful? 0.5 min Table 1-1

   Measured as median time since initiating event 0.5 min D.W. NOTE
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 0.2 minute

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 0.2 minutes.

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	.4		0.1	.2	

Human Action Identifier: HRT8

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Reactor power >10% after the operator pushed the manual trip button. Rods not indicating on the bottom.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   within 0.1 minute

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
    ALERT – Failure of Rx Trip GENERAL
    SITE AREA

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HRT8

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
possible HRT7

2. How much influence do previous human errors have on this action? (significant, same, none) __________
If the operator failed to accomplish HRT7 he may also fail HRT8

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
other reactor trip immediate actions.

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?
HRT7

Scenario Group	(Yes/No)	Comments
A.	Yes	low dependence on HRT7 failed assumed. Only a small fraction of time that HRT8 is called upon would HRT7 have failed, usually due to failure breakers when pushbutton would also not work.
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HRT8 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
Any Reactor trip, ~~etc~~ failure of rods to insert

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1202-2, 1202-2A, 1202-9A

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify 1202-9A.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

1202-9A ☒ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? — very low

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(See corresponding discussion written HRT7)

Human Action Identifier: HRT8 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

The breakers controls the operator would open are located on panel PR with numerous other breakers contro of the same design.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HRT8

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Good

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 0.2 min
Best estimate of time to diagnose 0.1 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? No

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low dependence on HRT7 failed
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? medium

Confuse with other breaker controls.

Backup to automatic action

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HRV1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator terminates feedwater to one or more steam generators to mitigate the occurrence of a stuck open MSSV or ADV following plant trip.
(Action is performed as a backup to automatic isolation via SLRDS)

2. List split fractions that include this human action.

~~HR~~
RVB

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

HRV1A — 15 minutes available to terminate feedwater

~~HRV1B — 30 minutes available to terminate feedwater~~

Human Action Identifier: HCV1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) Yes
2. If yes, by what means? (procedures, training, frequent performance) procedures 1210-4 step 2.7 1210-3 step 1.4
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) No
4. Is this action included in simulator training? (yes, no) Yes

Check those applicable descriptions of actions:

Skill-Based

~~X~~ Routine action, procedure not required.

~~X~~ Routine action, procedure required, but personnel well trained in procedure.

~~X~~ Action not routine, but unambiguous and well understood by operators who are well trained.

X Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

___ Routine action, but procedure required; operators not well trained, or procedure does not cover.

X Not routine, action unambiguous and well understood, but not well practiced.

~~X~~ Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

___ Not routine, action ambiguous.

___ Not routine, procedure does not cover.

___ Not routine, procedure not well understood.

___ Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? ~~Skill~~ Rule

Human Action Identifier: HRV11 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   1210-1 Step 2.7 OTSG pressure < 600 psig
   1210-3 Step 1.4 OTSG pressure < 600 psig

2. Alarms (name, location, audible, visual):

   OTSG low pressure
   SLRDS actuated at < 600 psig (not effective itself)
   audible + visual

3. From where will action first be attempted? (control room, other - specify) control room

4. Is coordination between operators required? (yes, no) no

5. Is there corroboration among indications? (very good, some, none) some

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HPVI Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no) ________

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response) backup to auto action

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) no

4. Are there any system failures that complicate this action? (none, one, multiple) no

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ~~yes~~

not in procedure, but operators are told to open another valve to try and get pressure down so MSSV will spring shut by itself

What are the expected work conditions for the crew?

___ Vigilance Problem. Unexpected transient with no precursors.

___ Optimal Condition/Normal. Crew carrying out small load adjustments.

X High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

___ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. HPVI	mild	
B. ~~HPVI B~~	~~mild~~	
C.		
D.		

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TABLE 2-7 (continued)

Human Action Identifier: HRV1 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

___ Expert, Well Trained. Licensed with more than 5 years experience.

_X_ Average Knowledge, Training. Licensed with more than 6 months experience.

___ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HRV1 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2-5 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   3-6 minutes will throttle feed but will not terminate MFW unless <600 psig in OTSG. This is assumed to occur at 15 minutes.

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ~~HRV1A - 15 min~~ ~~HRV1B~~ - 30 min.
   or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. 1 minute

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 30-15-1 = 14 minutes

   ~~HRV1A → 15-5-1 = 9 minutes~~

   ~~HRV1B → 30-5-1 = 24 minutes~~

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Human Action Identifier: HRV1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

~~For scenario~~ ~~SLRDS isolation at setpoint~~
• Post trip conditions on primary outside of window
• Possibly an HPI actuation signal

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? No SLRDS should occur before PTS conditions develop but no credit taken

~~For scenario~~

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ________

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Remote Emergency Response Team] Shift supervisor, yes

• Should additional credit be given because of additional plant feedback? (yes, no) ~~Yes~~ No

• Should additional credit be given because of newly arriving crew members? (yes, no) Yes (SS)

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Human Action Identifier: HRV1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   No

3a. Are there enough personnel to carry out necessary actions? - Yes

   Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.	No	
B.	No	
C.		
D.		

Human Action Identifier: HRVI

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) —

3. Which initiating events may lead to a need for this action?

   any plant Trip

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) Yes If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number — .

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) ________ If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ________

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

   Is the potential for an incorrect diagnosis leading ~~to an~~ operator-induced failure high, medium, low, or very low?

   ____

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) ________ Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

    ___ Not do any related action?

    ___ Perform an action that makes things worse? Identify NA ________

    ___ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? NA ________

Human Action Identifier: HR1/1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ________ Identify:

4. Is more than one option pursued in parallel? (yes, no) ________

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) N/A Identify:

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) ________ Identify cues:
   falling OTSG pressure
   SLRDS isolation
   HPI actuation

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ________

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Human Action Identifier: HRV1

K. Summary Sheet

From B. What type of behavior is required? ~~Skill~~ Rule

From C. Description of plant interface? fair

From D. Expected stress level for each scenario group?

Group A mild
Group B ~~mild~~
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis [illegible] 14 min.
best estimate of time to diagnose ~~[illegible]~~ — 2 min

From G. Additional credit to rediagnosis due to plant feedback?
No ~~[illegible]~~ [illegible] Arriving crew members? Shift Supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A no
Group B ~~no~~
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? very low

From J. Potential for selection of nonviable option? very low

Type of Action
Backup to an automatic action.

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HSI1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to isolate the main steam lines for a downstream steam line break.

2. List split fractions that include this human action.

SIA; SI

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   Power to the MSIVs,
   (1C ESV's) is successful

Human Action Identifier: HSI 1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 3 mos

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HSI1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): 1210-3 step 1.4
Excessive primary to secondary heat transfer

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

Steam line rupture - CR - audible, visual

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HSI1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) 1C ESU MCC failure

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HS-7.2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HSI1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
3 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ______
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 3 minutes
(Valve stroke time = 2 minutes)

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______ A: 15 min
B 3 min

Scenario Group Differences	Q 3a Time Available Best	Conserv.	Q 2 Best Estimate of Time to Diagnosis	Q 4 Time to Perform Best	Conservat.
A SLRDS works	20 min		3 min	3 min	
B SLRDS fails	8 min		3 min	3 min	

* If SLRDS [illegible]

TABLE 2-7 (continued)

Human Action Identifier: HSI 1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Fire alarms in the area of the steam vapors, continuing cooldown

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   shortly after the break, continuous until the leak is isolated or the steam generator is dry.

3. Is the time available for the correct act[illegible] [illegible]fficient to allow newly arriving crew members to particip[illegible] the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

   A yes
   B no

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

   A – SS, STA
   B – none

4a. At what point would the following be declared:

   ALERT – Steam break + SLRDS
   SITE AREA
   GENERAL

see below

- A Should additional credit be given because of additional plant feedback? (yes, no)
- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
A	yes	yes	
B	NO	NO	If SLRDS doesn't isolate MFW,

conditions PTS will occur if the failure is due to the FW valves not shutting.

Human Action Identifier: HSI1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   no

2. How much influence do previous human errors have on this action? (significant, same, none) none

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   Reactor trip immediate actions

3a. Are there enough personnel available to carry out necessary actions? (yes / no)

Must a specific dependence with another human action be accounted for? no

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HSI1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-3.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)
NA

3. Which initiating events may lead to a need for this action?
MSLB in RB, IB, or TB

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number
none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

   - ☐ Not do any related action?
   - NA ☐ Perform an action that makes things worse? Identify ________
   - ☐ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? SI, TC, MC

Human Action Identifier: HSI1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   The operator could isolate the wrong steam generator

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:

   not if SLROS failed to isolate MFW to the ruptured steam side.

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

   The operator could shut the wrong main steam isolation valve

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HSI1

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 15 min.
Best estimate for time to diagnose 3 min.

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? low
may isolate wrong MSIVs.

Planned manual action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HSI 2

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to shut the MSIVs and stop EFW to the broken OTSG. for upstream breaks

2. List split fractions that include this human action.

SIB; SI-2

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

IC ES'I is successful

VA, VB are successful

HSI2A → Support systems for EF-V-30's AVAIL, oper. closes valv

HSI2B = 1.0 The support systems needed to close valves (EF-V-30's and MS-V-2's) are lost. Valves 30's fail open. closed Local control would not be possible to eliminate EFW

The operator would probably would not stop the EFW pumps.

Human Action Identifier: HSI2

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 3 mos.

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HSI 2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): 1210-3 step 1.5
OTSG level and pressure not stabilized

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
Steam line rupture - CR - Aud., Visual

3. From where will action first be attempted? (control room, other - specify) ______________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HSI2 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) power failure to valves or valve failure due to steam

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HSI2

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HSI2 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   3 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ____________
   or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. 3.5 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ____________ A_1 14.5 min
A_2 2.5 min

	Q3A		Q2	Q4	
SCENARIO GROUP DIFFERENCES	TIME AVAILABLE		BEST ESTIMATE	TIME TO PERFORM	
	BEST	CONSERV.	OF TIME TO DIAGNOSIS	BEST	CONSERVAT.
A_1 SCRDS WORKS	20 min		3	3.5	
A_2 SCRDS FAILS	8 min		3	3.5	

Human Action Identifier: HSI2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Fire alarms in the area of steam ruptured, continuing cooldown

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   shortly after break, continuous until the leak is isolated or the steam generator is dry.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

   A_1 = yes
   A_2 = no

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

   A_1 = SS, STA
   A_2 = none

4a. At what point would the following be declared:
   ALERT — STEAM BREAK + SLROS
   SITE AREA
   GENERAL

see below

- A Should additional credit be given because of additional plant feedback? (yes, no)
- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
A_1	yes	yes	
A_2	No	No	not enough time

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Human Action Identifier: HSI2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) none

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   Reactor trip - immediate action

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

   no

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HSI2 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-3.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action? MSLB in Int. Bldg., RB, or TB

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number none.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify NA.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

NA

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? SI, IC, MF

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Human Action Identifier: HSI2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   The operator could isolate the wrong steam generator

4. Is more th n one option pursued in parallel? (yes, no)

5. If no spec fic procedures apply, are there other plausible options th t are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful?

   Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

   The operator could isolate the wrong lines

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HSI2 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 14.5 min.
Best estimate of time to diagnose 3 min

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? low

Planned manual action

Could isolate the wrong steam generator

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HSR1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to switch over to sump recirculation following a large LOCA. Only a short response time is available. (about 36 minutes after event initiation but only about 1 minute after reaching the BWST low level alarm.

2. List split fractions that include this human action.

SAA; SA-1

SCB; SB-1($\overline{SA}$)

SBJ; SB-2($\overline{SA}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Large LOCA

One minute response time from receipt of lo-lo level alarm.

0394G011386

Human Action Identifier: HSR1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 12 week intervals

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

0394G011386

Human Action Identifier: HSR1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   BWST level ind. - 2 (slow level decreasing over [illegible] minute period)
   RCS pressure decrease rapidly, RHR pumps injecting

   1a. Are displays directly visible? (yes/no)

2. Alarms (name, location, audible, visual):
   Lo-Lo level BWST A&V

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

0394G011386

Human Action Identifier: HSR1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the ~~plant~~ or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☒ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HSR1

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years e: erience.
- [x] Average Knc·'edge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HSR 1

F. Response Time Available

1. What is the timing of the first indications for the operator action? 36 minutes (in time since initiating event)
alarm sounds
Time 0, level starts to reduce

2. When may the operator first act? (in time from initiating event)

34 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 37 minutes
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. <1 minute

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ______

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
	37		5 min.	1 min	

0394G011386

Human Action Identifier: HSR1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
none
Low BWST level alarm

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NA

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)
shift supervisor

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA - 2-4 minutes
GENERAL

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

TABLE 2-7 (continued)

Human Action Identifier: HSR 1 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (Yes/No)

Must a specific dependence with another human action be accounted for? No

Scenario Group	(Yes/No)	Comments
A.	No	
B.		
C.		
D,		

Human Action Identifier: HSR1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-6/7.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?

   Large LOCA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ______.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ______.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ______.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ______.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ______
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ______.

0394G011386

Human Action Identifier: H521

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful?
no.- must wait until level ≤ 36 feet or will not have enough inventory in RB. (est)

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

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Human Action Identifier: HSR1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? ~~Skill~~ Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Grave Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct action 27-1 36 min. (diagnosis)
But estimate of time to diagnose 5 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift Sup.

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? low
Switchover to ... RHR pumps?

Planned manual action

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HSR2 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to switch over to sump recirculation and align for high pressure recirculattion following a Small LOCA. A long response time is available. (about 10 minutes is available once the low BWST level is reached but this would not be for about 12 hours after the initiator)

2. List split fractions that include this human action.

SDC; SA-2
SBD; SB-2($\overline{SA}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

MEDIUM LOCA

10 minutes AVAILABLE AFTER LOW LEVEL ALARM

0394G011386

Human Action Identifier: HSR2

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule Skill

Human Action Identifier: HSR2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Level in the Borated Water Storage Tank

1a. Are displays directly visible. (yes/no) SBLOCA 1210-6 Step 2.20
LBLOCA 1210-7 Step 2.13

2. Alarms (name, location, audible, visual):
BWST Lo-Lo Level Alarm (36 inches)

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HSR2

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) if valves fail or alarms do not actuate, the injection pumps could be lost.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HSR2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HSR2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 12 hours (in time since initiating event)

10 minutes.

2. When may the operator first act? (in time from initiating event)

0.5 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event ______
or as time since first indications 10 MINUTES

4. Estimate the median time to carry out the action, once decided to pursue. 2 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 8 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	12 hrs.		8 min	2 min	

Human Action Identifier: HSR2

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   HPI pumps trip off due to loss of suction.
   Alarm at low-low level

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? NO Yes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT – 4 # in R.B. GENERAL
   SITE AREA – 30 # in R.B.

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

0394G011386

Human Action Identifier: HSR2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   NO

3a. Are there enough personnel available to carry out necessary actions? (Yes / no)

   Must a specific dependence with another human action be accounted for?

   No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HSR2 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-6, 1210-7 (Small LOCA, Large LOCA)

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
(Loss of Secondary HPI cooling Req.), LOCA, (SGTR if operator thinks he has water in the R. Sump)

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator SGTR.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-4. (loss of primary to secondary heat transfer)

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

0394G011386

Human Action Identifier: HSR2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:
NA

5a. if the action were taken prematurily would the action still be successful? Only if sufficient water was in the R.B. sump

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

The operator could manipulate the valves in the wrong order or close some that should not be closed, this may cause a loss of suction head to the HPI/LPI Pumps.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

0394G011386

Human Action Identifier: HSR2

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis ~12 hours

Best estimate of time to diagnose 8 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Low, may manipulate valves in wrong order & lose suction

Planned manual action

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HSR 3

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to switch over to sump recirculation and align for high pressure recirculattion following a medium LOCA. A long response time is available (about 2 minutes is available once the low BWST level is reached but this would not be for about 1 hour after the initiator)

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

MEDIUM LOCA

2 MINUTES AVAILABLE AFTER LOW LEVEL ALARM

0394G011386

Human Action Identifier: HSR 3

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar

2. If yes, by what means? (procedures, training, frequent performance)

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4. Is this action included in simulator training? (yes, no)

5. How frequently are these actions reviewed in training? YEARLY

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required, operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HSR 3 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Level in the Borated Water Storage TANK

1a. Are displays directly visible. (yes/no) SBLOCA 1210-6 Step 2.20
LBLOCA 1210-7 Step 2.13

2. Alarms (name, location, audible, visual):
BWST Lo-Lo Level Alarm (36 inches)

3. From where will action first be attempted? (control room, other - specify) ____________________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface.

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HSR 3

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) if valves fail or alarms do not actuate, the injection pumps could be lost.

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [x] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.	Grave	
B.		
C.		
D.		

Human Action Identifier: HSR3

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expe , Well Traine Licensed with more than 5 years expe, ce.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HSR 3

F. Response Time Available

1. What is the timing of the first indications for the operator action? ____________ (in time since initiating event)
~~minutes~~. At time 0, the alarm sounds, RWST level reduces
2. When may the operator first act? (in time from initiating event)
0.5 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 57 minutes
   or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. 2 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ____________
55 minutes

SCENARIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
	57 min		5 minutes	2 min	

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Human Action Identifier: HSR 3 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   HPI pumps trip off due to loss of suction.
   Alarm at low low-level

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? ~~NO~~ Yes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT – 4 # in R.B.
   SITE AREA – 30 # in R.B.
   GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

TABLE 2-7 (continued)

Human Action Identifier: HSR 3 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) ______________

   NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   NO

3a. Are there enough personnel available to carry out necessary actions? (yes / no)

Must a specific dependence with another human action be accounted for?

   No

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

0394G011386

Human Action Identifier: HSR 3 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-6, 1210-7 (Small LOCA, Large LOCA)

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
(Loss of Secondary HPI cooling Req.), LOCA, (SGTR if operator thinks he has water in the RB sump)

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator SGTR.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-4. (loss of primary to secondary heat transfer)

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HSR 3 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:
NA

5a. If the action were taken prematurily would the action still be successful?
Only if sufficient water was in the R.B. sum

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:
The operator could manipulate the valves in the wrong order or close some that should not be closed, this may cause a loss of suction hea to the HPI/LPI pumps.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HSR

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A ~~[illegible]~~ grave
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis ≈ 55 minutes
Best estimate of time to diagnose 5 minutes

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Low, may manipulate valves in wrong order & lose suction

Planned manual action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HSV1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator manually closes the reactor building sump drain valves to prevent loss of recirculation inventory after a failure of automatic isolation (used in SV-2).

2. List split fractions that include this human action.

SVE ; SV-2

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, LOCA

AUTOMATIC ISOLATION OF THE VALVES FAILED.

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TABLE 2-7 (continued)

Human Action Identifier: HSV2 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 4
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6WKS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [x] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HSV1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
Reactor Trip indication 1210-1 3.10
1210-6 1.2
RT isol. panel shows valve positions 1210-7 1.4
1a. Are displays directly visible. (yes, no)

2. Alarms (name, location, audible, visual):
Reactor Trip ⟶ Control Room Audible, Visual
ES ACTUATION ⟶ " " "

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HSV1

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Instrument air system contamination with Foreign Substance

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HSV1 | Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HSV1 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? immediate (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
2 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 10 minutes
or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 0.5 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 9.5 minutes

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	10 min.			.5 min	

Human Action Identifier: HSV1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   RB sump high level alarm
   Aux Bldg sump level high

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   depending on LOCA size - immediate to 10 min.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT 4 # in RB
   SITE AREA 30 # in RB
   GENERAL

●A Should additional credit be given because of additional plant feedback? (yes, no)

●B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HSV1 Sheet 8 of 11

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

NO

2. How much influence do previous human errors have on this action? (significant, same, none) ______

NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

RT immediate actions

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HSV1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-1,6,7.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?
LOCA - anything that would Require HPI cooling

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-3.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☒ Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? SR

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Human Action Identifier: HSV1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful?

   Yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:

   Radiation levels in Aux Bldg increasing

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

   The E.S. status board shows immediately the position of these valves and colored lights stand out if the valves are mispositioned.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HSV1

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 9.5 min.
Best estimate of time to diagnose 2 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Backup to automatic action

TABLE 2-8. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HTB1A,B

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Initiate turbine cooling following a tube rupture or a very small break.

A: Cooldown and depressurization successful
B: Cooldown and depressurization failed

2. List split fractions that include this human action.

3. Situation (initiating events and plant conditions, support system states, dependence on prior errors): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

A - VSL or TR and cooldown successful

B - VSL or TR and cooldown failed

HTB 1A/B Sheet 2 of 13

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (yes, no) -
Rank on scale of 1 to 5, with 3 being average and 5 most familiar. 2

2. If yes, by what means? (procedures, training, frequent performance, or walk-throughs) emergency drills, used in TMI-2 accident
Give procedure number if applicable ________.

3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) ________

4. Is this action included in simulator training? (yes, no) ________

5. How frequently are these actions reviewed by the operators? ________

Check descriptions that apply to this action:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip. (1210-1)

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip. (Identify by number) ________.

HTB1A/B

Knowledge-Based

- [ ] Not routine, action ambiguous.
- [x] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Knowledge

HT82A/B

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
RCS temp + pressure, OTSG pressure showing reduced or zero cooldown,
A) inability to START DHR system
B) NEED FOR INCREASED COOLDOWN RATE
Are displays directly visible? yes

2. Alarms (name, location, audible, visual): ——

Will there be many other alarms to distract the operator? (Describe.) ——

3. From where will action first be attempted? (control room, other--specify)

4. Is special coordination between operators required? yes, no)

5. Is there corroboration among indications? (i.e., Different parameters confirm the need for action.) (very good, some, none)

6. How specific is the guidance for action? (component numbers, timing) This guidance is not proceduralized

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human-engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human-engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

D. Stress Level

1. Is the control room team expected to have a high workload? (yes, no) ________ A NO / B yes

(see sheet 13) 2. Why is this action needed? (______ to an automatic action, planned ______ action, ________ of failed system, ______ ESAS response) ______________

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) _______ (Explain if yes.) on a T.R the secondary plant will become contaminated if the turbine is used for cooldown it will also become contaminated

4. Are there any system failures that complicate this action? (none, one, multiple) ____________________

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no) ________

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

A ☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

B ☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

A. CD (use on TR) NORMAL

B. CD (use on TR) High

C.

D.

HTB/A/B

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, well trained. Licensed with more than 5 years experience.
- [x] Average knowledge, training. Licensed with more than 6 months experience.
- [ ] Novice, minimum training. Licensed with less than 6 months experience.

HTB1A/B Sheet 7 of 13

F. Response Time Available

1. What is the timing of the first indications for the operator action? (in time since initiating event) A 5hrs B 1/2 hr

2. When may the operator first act? (in time from initiating event)
A 6 hours
B 1 1/2 hours

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event, A 12hr B 12hr
or as time since first indications ?

4. Estimate the median time to carry out the action, once decided to pursue. A 1 hr B 1 hr

Best estimate to diagnose

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. A 6 hr B 10.5 hr

Assess timing for each scenario group.

Scenario Group	Allowed Best	Time Available Conservative From I.E.	Time to Diagnose Best Estimate	Time to Perform Best Conservative
A. CD		12 hrs	1 hour	1 hour
B. $\overline{CD}$		12 hrs	1 hour	1 hour
C.				
D.				

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HTB1A/B

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

Inability to recover other systems to proceed with cooldown, RCS, Temp steady or rising.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

within ½ hour of loss of cooldown heat sink.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no) ______

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., none, shift technical advisor (STA), remote emergency response team] SS

At what point would the following events be declared?

- Alert (onsite response team called) TR > 50 gpm
- Site Area Emergency (offsite response team called Loss of SCM
- General Emergency (potential evacuation) ______

5. Should additional credit be given because of additional plant feedback? (yes, no) ______

6. Should additional credit be given because of newly arriving crew members? (yes, no) ______

HTB1A/B

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

~~no~~ possibly
B) cooldown and depressurization may have failed because the operator failed to initiate it

2. How much influence do previous human errors have on this action? (significant, same, none) Some

Some

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
Recovery of CD, or attempting to start the DHR system, or repair the DHR, DHCCW systems.

4. Are there enough personnel available to carry out the necessary actions? yes

emergency response teams available

5. Must a specific dependence with another human action be accounted for? ~~No~~ Yes

	Scenario Group	Yes/No	Comments
A.	CD success	Yes	medium
B.	CD failed	Yes	medium
C.			
D.			

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HTB/A/B

I. Potential for Confusion in Diagnosis Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) ________ Identify by number ________.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) This option has been pursued during emergency drills and at the TMI-2 accident.

3. Which initiating events may lead to a need for this action?
TR or VSL

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) ________ If no, identify by initiator ________. NA — no procedure

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ________.
1210-5 T.R.
1210-6 Small Break Cooldown

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) ________ If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low? ________ A optimal / B mild

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no) ________

Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?
____

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) ________
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

AT present there is no procedure for this action.

- [x] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________.
- [ ] Perform the correct action anyway?

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HTB 1A/B

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? none

HTB1A/B Sheet 12 of 13

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no) ________

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no) ________

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) ________ Identify:
He may try to recover the component or system that has failed, this could result in some lost time

4. Is more than one option pursued in parallel? (yes, no) see #3 above.

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) ________ Identify ________

If the correct action were taken prematurely, would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) ________
Identify cues:
continuing loss of cooldown rate, possible heatup

7. Is the plant/operator interface such that a potential exists for the operator to slip (i.e., manipulate the wrong controls) when implementing the correct action? (yes/no) ________ Explain:
To perform this action the operator would reset the turbine and roll it the same as during a startup. This evolution is familiar to the operators. The Turbine Trip [illegible]s may have to be bypassed.

8. Is the potential for selection of a nonviable option high, medium, low, or very low? ________

Human Action Identifier: HTBIA,B

K. Summary Sheet

From B. What type of behavior is required? Knowledge

From C. Description of plant interface? FAIR

From D. Expected stress level for each scenario group?

Group A OPTIMAL CONDITION/NORMAL
Group B High WORKLOAD/POTENTIAL EMERG
Group C ______
Group D ______
Group E ______

From E. Experience level of operating team Average.

From F. Time available to perform correct diagnosis ~~action~~ ______ {A 6 hrs B 10.5 hrs
Best estimate of time to diagnose 1 hour ______ {A 1 hour B 1 hour

From G. Additional credit for rediagnosis due to plant feedback?
Yes ______ Arriving crew members? Yes

From H. Need to account for dependence with other actions for each scenario group?

Group A ~~NO~~ Yes medium with HCD4 success
Group B ~~NO~~ Yes medium with HCD4 failed
Group C ______
Group D ______

From I. Potential for incorrect diagnosis leading to failure? ______
LOW

From J. Potential for selection of nonviable option? LOW

Type of human action

☐ Backup to an automatic action

☐ Detract from an ESAS response

☐ Recovery of a failed system via realignment

☐ Planned manual action

A, B ☒ Action may lead to an extended outage; e.g., due to contamination, due to turbine contamination if the event is a tube rupture.

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HTC 1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to locally close with a handwheel the turbine-driven EFW pump steam supply valves (MS-V-13) or to isolate the affected steam generator after a steam generator tube rupture [used in ~~TC-1(SG)~~, TC-2, ~~TC-2(AM)]~~ in time to prevent the need to provide makeup to the RCS.

2. List split fractions that include this human action.

TCB; TC-2
~~TC-1(SG)~~
~~TC-2(AM)~~

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

Main steam safety valves reclose as expected
Main feedwater does not cause overcooling.
Failure to perform this action causes excessive cooling due to steam flow through the EF-P-1 turbine.

TABLE 2-7 (continued)

Human Action Identifier: HTC1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 2 yrs (failure of valve and initial train of system)

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

TABLE 2-7 (continued)

Human Action Identifier: HTC 1 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable): SGTR 1210-5 step 3.15
Valve position
EF Pump discharge pressure
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
Loss of DC — VARIOUS ALARMS
Loss of air – Low air pressure

3. From where will action first be attempted? (control room, other - specify) Locally at the valve.

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not too specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HTC1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☐ Optimal Condition/Normal. Crew carrying out small load adjustments.

☒ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HTC1

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.

- [x] Average Knowledge, Training. Licensed with more than 6 months experience.

- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HTC1

F. Response Time Available

1. What is the timing of the first indications for the operator action? Almost Immediate, but used 6 [illegible] (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   10 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ~~1~~ 5 hr
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 10 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. ~~50 minutes~~ 5-.1-.2 = 4.7 hours

   ~~60-10 = 50~~

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	5 hr		5 min	10 min	

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Human Action Identifier: HTC1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
Continued decrease in OTSG pressure

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
probably noticed after first 15 minutes.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT
SITE AREA NA
GENERAL

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HTC1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   No , assume SGTR properly identified

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   control cooldown by shutting down on AOV's or TBU's

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

   Must a specific dependence with another human action be accounted for?
   No

Scenario Group	(Yes/No)	Comments
A. [illegible]	Yes	medium dependence on HSD1,2 success
B.		
C.		
D.		

Human Action Identifier: HTC1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-5.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)
NA

3. Which initiating events may lead to a need for this action?
SGTR with Loss of IA
SGTR with Loss of DC

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-3 (excessive cooling).

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number 1210-3.

10. If the incorrect procedure is entered, does it direct the operator to:

☐ Not do any related action?

☐ Perform an action that makes things worse? Identify ________

☒ Perform the correct action anyway? the 1210-3 procedure closes MS-V2A which is just as good

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

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TABLE 2-7 (continued)

Human Action Identifier: HTC 1 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

He could try to isolate the wrong OTSG.

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) Identify cues:

continued cooldown due to steam release

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

The wrong valve could be closed but if done by local handwheel this is very improbable since the operator is near the EF-P-1 and can tell when he has successfully stopped steam flow.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HTC1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team average

From F. Time available to perform correct diagnosis action 5-.1-.2 = 4.7 hours

Best estimate of time to diagnose 0.1 hours

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, medium dependence on HTD1 success (Alternate procedure 1210-3 says close valves anyway)
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? low

From J. Potential for selection of nonviable option? very low

Recovery of failure [illegible]

[illegible]

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HTC2 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to close the turbine-driven EFW pump steam supply valves or isolate the affected OTSG after a SGTR and failure of MF+. (used in TC-5)

2. List split fractions that include this human action.

TC4; TC-5

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

- MS-V-15's locally or MS-V-2's from control room must also be shut to terminate steam release
- MSSV's close as expected.
- Same as HTC1 except for ~~scena~~ scenario group which include MF+0.

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Human Action Identifier: HTCZ

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 4
1=unfamiliar 5=very familiar

2) ~~If yes,~~ by what means? (procedures, training, frequent performance)

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)

5) How frequently are these actions reviewed in training? 6 weeks – also

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [x] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HTC2 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
   low OTSG press
   low RCS pressure

1a. Are displays directly visible (yes/no)

2. Alarms (name, location, audible, visual):
   steam relief alarm - A&V

3. From where will action first be attempted? (control room, other - specify) local if must close MS-V-15A/B

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidance given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

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Human Action Identifier: HTCZ

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is ~~this action~~ needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) MFF SGTR identified

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

☐ Vigilance Problem. Unexpected transient with no precursors.

☒ Optimal Condition/Normal. Crew carrying out small load adjustments.

☐ High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

☐ Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HTC2 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HTCZ

F. Response Time Available

1. What is the timing of the first indications for the operator action? <2 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)

   10 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event ~~30 minutes~~ 5 Hours
   or as time since first indications ____________

4. Estimate the median time to carry out the action, once decided to pursue. 2-10 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 5-.1-.2 = 4.7 hours

SCENERIO GROUP DIFFERENCES	TIME AVAILABLE BEST	TIME AVAILABLE CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	TIME TO PERFORM CONSERVAT
[illegible]	5 hours		5 min.	10 min.	

Human Action Identifier: HTC 2 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?
   ms-v-3 bypass valve position closed position
   continued decrease in OTSG pressure
   lack of radiation alarms in RB or Aux/FH bldg

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes – 2-10 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA NA
   GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HTC2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for?

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HTC2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-3.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)

3. Which initiating events may lead to a need for this action?
   ATA

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ____________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number ____________.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ____________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ____________.

10. If the incorrect procedure is entered, does it direct the operator to:

    - [ ] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify ____________
    - [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ____________

Human Action Identifier: HTC2

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team ~~as~~ to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HTC2

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Potential Emergency
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 4.7 hours
Best estimate of time to diagnose .1 hour

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No, assume HTF due to stuck open ADV
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Recovery of failed system (ADV stuck open)

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HTH1

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

   Operator fails to throttle HPI by using MU-V217. (Operator earlier opened MU-V217 and started a second MUP on RT/TT). No ESAS signal was generated (used in TH-1). Thirty minutes are assumed available.

2. List split fractions that include this human action.

   THA ; TH-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

   No ESAS

   RT occurred, no overcooling, the operator opened MU-V-217 earlier and started the second makeup pumps

   Throttling criteria in 1210-10

   1) MU pumps runout @ 550gpm or greater
   2) P-T curve for brittle fracture
   3) LPI > 1000 gpm in each line for 20 minutes or longer
   4) 25° subcooling exists and pressurizer level >0"

Human Action Identifier: HTH1

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 1=unfamiliar 5=very familiar **5**
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no) Specific guidance given to operators when they may throttle
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? every 6 weeks

Check those applicable descriptions of actions:

Skill-Based

- [X] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? SKILL

Human Action Identifier: HTH1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and stop if applicable):

Pressurizer level high, RCS pressure going up
alarm response procedure tell the operator to shut MU-V217 if it's open

1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

control room audible, visual
Pressurizer level high alarm at 260"

3. From where will action first be attempted? (control room, other - specify) ______

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☐ Good. Displays carefully integrated with SPDS to help operator.

☒ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HTH2 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenaric group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HTH1

E. Experience Level of Operating Team
(specific team member who would perform the action)

- [ ] Expert, Well Traine Licensed with more than 5 years experience.
- [x] Average Knowledge, Training. Licensed with more than 6 months experience.
- [ ] Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HTH1 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? 10 minutes (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   11 ~~X~~ minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 30 min.
   or as time since first indications ____

4. Estimate the median time to carry out the action, once decided to pursue. 3 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 17 minutes

30 - 3 - 10 = 17

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	30 min.		3 min.	3 min.	

Human Action Identifier: HTH1 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Pressurizer level high-high alarm 315"

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   2.5 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT
   SITE AREA
   GENERAL
   NA

- A Should additional credit be given because of additional plant feedback? (yes, no)
- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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TABLE 2-7 (continued)

Human Action Identifier: HTH1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   no

2. How much influence do previous human errors have on this action? (significant, same, none) NA

   However operator assumed to previously successfully open MU-V217

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   no

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

   Must a specific dependence with another human action be accounted for?

   Opening of MU-V-217 and starting of the second makeup pump

Scenario Group	(Yes/No)	Comments
A.	Yes	success of above action
B.		
C.		
D.		

Human Action Identifier: HTH1

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number ALARM RESPON G-1-5 AND G-2-5

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) NA

3. Which initiating events may lead to a need for this action?

   RT, Excessive Cooling

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number NONE.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

    - [ ] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify ________
    - [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? ________

Human Action Identifier: HTH1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

NA

5a. If the action were taken prematurily would the action still be successful?

yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
Identify cues:

NA

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

This part of the control room panel is continuously monitored and used, increasing the operators familiarity with the controls

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HTH1 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? skill

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A optimal
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 17 min.
Best estimate of time to diagnose 3 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A Yes, low, succeeding action to open MU-V717.
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned manual action

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TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HTH2 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to throttle HPI by using MU-V16A, MU-V16B, MU-V16C, and MU-V16D after ES actuation. (used in TH-2).

2. List split fractions that include this human action.

THB; TH-2
THC; TH2 ($\overline{GA}/\overline{GB}$)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, ESAS, overcooling have occurred. Assume EFW is successful.

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Human Action Identifier: HTH2

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no)
5. How frequently are these actions reviewed in training? 6 WKS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HTH2

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable): 1210-10 step 1.3
HPI Flow > 550 GPM per pump, RCS Pressure vs. Temperature approach brittle fracture curve limits
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
—

3. From where will action first be attempted? (control room, other - specify) ____________

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

☐ Excellent. Same as below, but with advanced operator aids to help in accident situations.

☒ Good. Displays carefully integrated with SPDS to help operator.

☐ Fair. Displays human engineered, but require operator to integrate information.

☐ Poor. Displays available, but not human engineered.

☐ Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HTH 2 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple) Loss of power to the valves requires local operation

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.

- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.

- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.

- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HTH2

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HTH2

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
5 minutes

3. When is the last time allowed for the operator to take action and be successful?

Measured as median time since initiating event 20 minutes
or as time since first indications ____

4. Estimate the median time to carry out the action, once decided to pursue. 5 minutes

Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 14 minutes

20-5-1 = 14

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	10 min.		3 min.	5 min.	

TABLE 2-7 (continued)

Human Action Identifier: HTH2 Sheet 7 of 11

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

Pressurizer level hi alarm
Pressurizer level hi-hi alarm

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

Prior to lifting of PORV/safeties due to solid pressurizer

Hi → 260" – 10 min.
Hi-Hi → 315" – 12.5 min.

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
ALERT – 4# in RB.
SITE AREA – 30# in RB.
GENERAL

•A Should additional credit be given because of additional plant feedback? (yes, no)

•B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

Human Action Identifier: HTH2

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?
   NO

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)
   OPERATORS CONTROLLING EFW OR MFW FLOW, monitoring STATUS OF ES EQUIPMENT.

3a. Are there enough personnel available to carry out necessary actions? (yes/no)

Must a specific dependence with another human action be accounted for? HMR1, but HTH2 asked first

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HTH2

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-10.
   (Abnormal Transient rates)
2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)
   NA
3. Which initiating events may lead to a need for this action?
   LOCA
   Excessive Cooling, Main Steam Line Break
4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.
5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-3 (excessive cooling)
6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.
7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?
8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.
10. If the incorrect procedure is entered, does it direct the operator to:

    - [ ] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify ________
    - [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? PO, PV, RC

Human Action Identifier: HTH2 Sheet 10 of 11

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken prematurily would the action still be successful?

   yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:

   Other alarms, pressurizer hi and hi-hi level,

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain:

   The operator is well trained on the location of these valve controls.

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HTH2 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Good

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct ~~action~~ diagnosis 14 min.
Best estimate of time to diagnose 3 min.

From G. Additional credit to rediagnosis due to plant feedback? Yes Arriving crew members? shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Planned manual action

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HTH3

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to throttle HPI after ESAS actuation followed by the loss of the A train of engineered safeguards electric power. The A side injection valves remain open and must be locally closed because the B makeup pump must continue running for seal injection.

2. List split fractions that include this human action.

HTC; TH-2 (GA/GB)

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

RT, ESAS followed by loss of GA, the operator cannot throttle MU-V-16 A or B from the control room.
MU-P-1B stays running.

TABLE 2-7 (continued)

Human Action Identifier: HTH3 Sheet 2 of 11

B. Cognitive Processing Type:

1) Is the operator familiar with the action? (1 to 5) 3
1=unfamiliar 5=very familiar

2) If yes, by what means? (procedures, training, frequent performance)

3) Does this action contradict operator training, rules of thumb, or intuition? (yes, no)

4) Is this action included in simulator training? (yes, no)

5) How frequently are these actions reviewed in training? YEARLY for A.O.

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [ ] Not routine, action unambiguous and well understood, but not well practiced.
- [x] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HTH3 Sheet 3 of 11

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):
HPI Flow → 550gpm per pump, RCS pressure VS Temperature approach brittle fracture curve limits.
1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):
—

3. From where will action first be attempted? (control room, other - specify) FOR 16A,B LOCALLY AT THE VALVES

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general)

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [x] Good. Displays carefully integrated with SPDS to help operator. STA monitoring periodically
- [ ] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

TABLE 2-7 (continued)

Human Action Identifier: HTH3

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [ ] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [x] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A.		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HTH3 Sheet 5 of 11

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

Human Action Identifier: HTH3

F. Response Time Available

1. What is the timing of the first indications for the operator action? 1 minute (in time since initiating event)

2. When may the operator first act? (in time from initiating event)
   AO – 10 minutes

3. When is the last time allowed for the operator to take action and be successful?

   Measured as median time since initiating event 20 minutes
   or as time since first indications ______

4. Estimate the median time to carry out the action, once decided to pursue. 10 minutes

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. 9 minutes

   20-10-1 = 9

Scenario Group Differences	Time Available Best	Time Available Conserv.	Best Estimate of Time to Diagnosis	Time to Perform Best	Time to Perform Conservat.
	19 min		3 min.	13 min.	

Human Action Identifier: HTH3

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   Pressurizer level high alarm
   Pressurizer level high-high alarm

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes
   No

   Hi - 10 minutes
   HiHi - 12.5 minutes

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), S/S, Emergency Response Team]

4a. At what point would the following be declared:
   ALERT - 4# in RB
   SITE AREA - 30# in RB
   GENERAL

• A Should additional credit be given because of additional plant feedback? (yes, no)

• B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN

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Human Action Identifier: HTH3

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occurred in this scenario?

   No

2. How much influence do previous human errors have on this action? (significant, same, none) NA

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   parallel - recovery of the 'A' diesel generator
   - control steam generator level, EFW flow

3a. Are there enough personnel available to carry out necessary actions? (Yes/no)

Must a specific dependence with another human action be accounted for?

HMR1 but HTH3 asked first

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

Human Action Identifier: HTH3 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? (yes, no) Identify by number 1210-10.
Abnormal transient rules

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no)
NA

3. Which initiating events may lead to a need for this action?
LOCA, Excessive Cooling, Main Steam Line Break

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator ________.

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number 1210-3 (excessive cooling)

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, or very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely)
Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

- [ ] Not do any related action?
- [ ] Perform an action that makes things worse? Identify ________
- [x] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? PO, PV, RC

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Human Action Identifier: HTH3

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) Identify:

   NA

4. Is more than one option pursued in parallel? (yes, no)

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) Identify:

   NA

5a. If the action were taken premoturily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no)
   Identify cues:

   pressurizer high and hi-hi-level alarms

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes, no) Explain:

   The location of these valves is stressed during training

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

TABLE 2-7 (continued)

Human Action Identifier: HTH3 Sheet 11 of 11

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Good

From D. Expected stress level for each scenario group?

Group A mild
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action 8 min.

Best estimate of time to diagnose 3 min.

From G. Additional credit to rediagnosis due to plant feedback? No Arriving crew members? Shift Sup.

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? very low

Recovering of failed system

0394G011386

TABLE 2-7. DYNAMIC HUMAN ACTIONS QUESTIONNAIRE

Human Action Identifier: HVB1 Sheet 1 of 11

A. Description of Human Action

1. Objective (task to be performed and failure criteria):

Operator fails to transfer to inverter 1E in the event that the inverter supplying power to vital instrument bus VBB or VBD fails

2. List split fractions that include this human action.

VC2 , VA-1

3. Situation (initiating events and plant conditions, support system states): collect into separate scenario groups for evaluation. Emphasize factors affecting response time and stress level.

B or D inverter failed, caused 2nd or 3rd floor dampers to close. Operator must recognize B or D inverter failure and damper closure, re-energize the inverter vital bus from the E inverter. Able to recognize the fact that dampers are tripped caused confusion

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Human Action Identifier: HVβ1 Sheet 2 of 11

B. Cognitive Processing Type:

1. Is the operator familiar with the action? (1 to 5) 3
   1=unfamiliar 5=very familiar
2. If yes, by what means? (procedures, training, frequent performance)
3. Does this action contradict operator training, rules of thumb, or intuition? (yes, no)
4. Is this action included in simulator training? (yes, no) FOR RECOVE. OF INVERTER IN CONTROL RM
5. How frequently are these actions reviewed in training? 2YRS

Check those applicable descriptions of actions:

Skill-Based

- [ ] Routine action, procedure not required.
- [ ] Routine action, procedure required, but personnel well trained in procedure.
- [ ] Action not routine, but unambiguous and well understood by operators who are well trained.
- [ ] Action is listed in procedures for turbine trip or reactor trip.

Rule-Based (procedures)

- [ ] Routine action, but procedure required; operators not well trained, or procedure does not cover.
- [x] Not routine, action unambiguous and well understood, but not well practiced.
- [ ] Action described in emergency procedures, but not for turbine trip or plant trip.

Knowledged-Based

- [ ] Not routine, action ambiguous.
- [ ] Not routine, procedure does not cover.
- [ ] Not routine, procedure not well understood.
- [ ] Decision to act based on a rule-of-thumb, but not in emergency procedures.

Decide on one. What type of behavior is required? Rule

Human Action Identifier: HYB1

C. Operator/Plant Interface (items on which operators will key to base judgment)

1. Instruments and readings that trigger action (identify procedure number and step if applicable):

   Loss of selected instruments

   1a. Are displays directly visible. (yes/no)

2. Alarms (name, location, audible, visual):

   RPS cabinet trip
   Inverter trouble alarm

   Many other alarms both visual and audible in the control room

3. From where will action first be attempted? (control room, other - specify) Locally at inverters

4. Is special coordination between operators required? (yes, no)

5. Is there corroboration among indications? (very good, some, none)

6. How specific is guidence given by procedure (very specific, not to specific, very general

Check most applicable description of plant interface:

- [ ] Excellent. Same as below, but with advanced operator aids to help in accident situations.
- [ ] Good. Displays carefully integrated with SPDS to help operator.
- [x] Fair. Displays human engineered, but require operator to integrate information.
- [ ] Poor. Displays available, but not human engineered.
- [ ] Extremely Poor. Displays needed to alert operator are not directly visible to operators.

Human Action Identifier: HYB1 Sheet 4 of 11

D. Stress Level

1. Is the control room team expected to have a high work load? (yes, no)

2. Why is this action needed? (backup to an automatic action, required manual action, recovery of failed system, defeat ESAS response)

3. Will this action contaminate a portion of the plant or otherwise result in an extended plant shutdown? (yes, no) Explain if yes.

4. Are there any system failures that complicate this action? (none, one, multiple)

5. Is this action the opposite to the response required in another procedure or to general training? (yes, no)

What are the expected work conditions for the crew?

- [ ] Vigilance Problem. Unexpected transient with no precursors.
- [x] Optimal Condition/Normal. Crew carrying out small load adjustments.
- [ ] High Workload/Potential Emergency. Mild stress, partway through accident with high work load or equivalent.
- [ ] Grave Emergency. High stress, emergency with operator feeling threatened.

Assess stress level for each scenario group.

Scenario Group	Stress Level	Comments
A. Only		
B.		
C.		
D.		

TABLE 2-7 (continued)

Human Action Identifier: HVB1

E. Experience Level of Operating Team
(specific team member who would perform the action)

☐ Expert, Well Traine Licensed with more than 5 years experience.

☒ Average Knowledge, Training. Licensed with more than 6 months experience.

☐ Novice, Minimum Training. Licensed with less than 6 months experience.

TABLE 2-7 (continued)

Human Action Identifier: HYB1 Sheet 6 of 11

F. Response Time Available

1. What is the timing of the first indications for the operator action? IMMEDIATE (in time since initiating event)

2. When may the operator first act? (in time from initiating event) 10 MINUTES

3. When is the last time allowed for the operator to take action and be successful? TBD FROM CBU STUDY

   Measured as median time since initiating event 5-24 hours
   or as time since first indications "

4. Estimate the median time to carry out the action, once decided to pursue. ONE HOUR

   Estimate the median time available for the operator to decide to perform the correct action. Measure the time available from when he would first turn his attention to the indications until the last time available. (5-1-1) = 3.9 hours

SCENERIO GROUP DIFFERENCES	TIME AVAILABLE BEST	CONSERV.	BEST ESTIMATE OF TIME TO DIAGNOSIS	TIME TO PERFORM BEST	CONSERVAT
	5	24	5 minutes	1 hour	

Human Action Identifier: HVB1

G. Recovery from Earlier Misdiagnosis

1. What significant new indications are there to tell the operator that an earlier diagnosis was in error?

   High Temp ALARMS in Rooms isolated due to damper FAILURE. Personnel in rooms trying to replace the inverter(s) should notice the loss of ventilation and so inform the control room.

2. Does the additional plant feedback occur prior to the allowed time for successful action? When? yes

   ?

3. Is the time available for the correct action sufficient to allow newly arriving crew members to participate in the decision? (i.e., Is the error rate essentially time independent?) (yes, no)

4. During the time available for diagnosis, what new crew members will be able to address the problem? [e.g., None, Shift Technical Advisor (STA), Emergency Response Team] → SS, STA

4a. At what point would the following be declared:

   ALERT
   SITE AREA
   GENERAL

   N/A

- A Should additional credit be given because of additional plant feedback? (yes, no)

- B Should additional credit be given because of newly arriving crew members? (yes, no)

SCENARIO GROUP	BULLET A	BULLET B	EXPLAIN
[illegible]			

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Human Action Identifier: HYB 1

H. Dependence with Other Human Actions in Same Scenario

1. Have other errors of human actions occ red in this scenario?

   NO

2. How much influence do previous human errors have on this action? (significant, same, none) ____________

3. Are other actions being performed serially or in parallel? (Attach operator time line if necessary to describe.)

   NO

3a. Are there enough personnel available to carry out necessary actions? (yes / no)

Must a specific dependence with another human action be accounted for? NO

Scenario Group	(Yes/No)	Comments
A.		
B.		
C.		
D.		

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TABLE 2-7 (continued)

Human Action Identifier: HVB1 Sheet 9 of 11

I. Potential for Confusion in Diagnosis, Leading to Unsuccessful Response

1. Are there procedures available to instruct operator to perform the action? yes no Identify by number 1107-2.

2. If no procedures apply, is the operator trained to perform the specific action? (yes, no) N/A

3. Which initiating events may lead to a need for this action?

   Loss of inverter, loss of offsite power

4. Do each of these initiating events result in the plant physical conditions necessary to enter the procedure encompassing this human action? (yes, no) If no, identify by initiator Loss of offsite power

5. Which other procedures have entry conditions similar to the procedure encompassing this human action? Identify by number None.

6. Do the indications describing the entry conditions for other procedures differ from the correct procedures only by parameters not normally keyed on by the operator? (yes, no) If yes, identify ________.

7. Is the stress level at the time of selecting the proper procedure high, mild, optimal, o. very low?

8. Is the operator trained to expect the actual situation to be of extremely low frequency? (yes, no)

8a. Is the potential for an incorrect diagnosis leading to an operator-induced failure high, medium, low, or very low?

9. What is the likelihood of the operator initially entering the wrong procedure? (likely, somewhat likely, unlikely) Identify by number ________.

10. If the incorrect procedure is entered, does it direct the operator to:

    - [ ] Not do any related action?
    - [ ] Perform an action that makes things worse? Identify ________
    - [ ] Perform the correct action anyway?

11. What top events are likely impacted in some way that makes recovery more complicated prior to the successful rediagnosis? CV.

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TABLE 2-7 (continued)

Human Action Identifier: HVB1

J. Potential for Selection of Nonviable Action (assuming a correct diagnosis)

1. Are procedures available to instruct the operator to perform the action? (yes, no)

2. Is discretion given to the control room team as to the proper option among several to be selected? (yes, no)

3. Are any of the options nonviable for any one of the scenario groups identified? (yes, no) N/A Identify:

4. Is more than one option pursued in parallel? (yes, no) → Try to regai inverter the same ti as transf of vital bu

5. If no specific procedures apply, are there other plausible options that are nonviable? (yes, no) NA Identify:

5a. If the action were taken prematurily would the action still be successful? yes

6. If a nonviable solution is selected, are sufficient cues and time available to later pursue a viable option? (yes, no) NA
Identify cues:

7. Is the plant/operator interface such that a potential exists for the operator to slip when implementing the correct action? (yes/no) Explain: NO

8. Is the potential for selection of a nonviable option high, medium, low, or very low?

Human Action Identifier: HVB1

K. Summary Sheet

From B. What type of behavior is required? Rule

From C. Description of plant interface? Fair

From D. Expected stress level for each scenario group?

Group A Optimal conditions
Group B
Group C
Group D
Group E

From E. Experience level of operating team Average

From F. Time available to perform correct diagnosis action ~1—7 hours
Best estimate of time to diagnose 5 minutes

From G. Additional credit to rediagnosis due to plant feedback?
Yes Arriving crew members? Shift supervisor

From H. Need to account for dependence with other actions for each scenario group?

Group A No
Group B
Group C
Group D
Group E

From I. Potential for incorrect diagnosis leading to failure? Very low

From J. Potential for selection of nonviable option? Very low

Time to respond = 1 hour, probability 1.0 once diagnosed

Time assessed distribution

Time = 5, 6, 11, 24.

Probability = .1, .4, .3, .2

Recovery Feedwater System

0394G011386

APPENDIX C

SIMSCRIPT PROGRAM LISTING

The following computer printout is a listing of the SIMSCRIPT program used for recovery of electric power at TMI-1.

CACI SIMSCRIPT II.5 for PRIME Systems, Release 2.0

```

'' PROGRAM TMI1.EP - PROGRAM TO SIMULATE THE RECOVERY OF ELECTRIC
''                   POWER AT TMI-1

PREAMBLE

   PROCESSES
      INCLUDE INITIALIZE, OFFSITE_POWER, 1ST_DIESEL, 2ND_DIESEL,
         1ST_DC_BUS, 2ND_DC_BUS, AND DECISION

   DEFINE DG.FAILURE.TIME AS A REAL FUNCTION

   DEFINE .RECOVERED TO MEAN 4
   DEFINE .ACTIVATED TO MEAN 3
   DEFINE .AVAILABLE TO MEAN 2
   DEFINE .UNDER_REPAIR TO MEAN 1
   DEFINE .UNAVAILABLE TO MEAN 0
   DEFINE .SUSPENDED TO MEAN -1
   DEFINE .NOT_RECOVERABLE TO MEAN -2
   DEFINE .OFFSITE TO MEAN 1
   DEFINE .1ST_DIESEL TO MEAN 2
   DEFINE .2ND_DIESEL TO MEAN 3
   DEFINE .YES TO MEAN 1
   DEFINE .NO TO MEAN 0

   DEFINE
      AC_RECOVERY_TIME,
      AC_RECOVERY_INTERVAL,
      AC_LOSS_TIME,
      MEAN_OP_RECOVERY_TIME,
      DG_REPAIR_TIME_BOUND,
      INVERSE_EARLY_DG_FAILURE_RATE,
      INVERSE_LATE_DG_FAILURE_RATE,
      FAILURE_CHANGE_TIME,
      MEAN_DG_ARRIVAL_TIME AND
      MEAN_DG_REPAIR_TIME AS REAL VARIABLES

   DEFINE NUMBER_OF_RUNS,
      OP_STATE,
      DGA_STATE,
      DGB_STATE,
      DGA_INITIAL_STATE,
      DGB_INITIAL_STATE,
      NO_DGS_EVENTUALLY_AVAILABLE,
      DG_CCF_RUNNING,
      DCA_STATE,
      DCB_STATE,
      DCA_INITIAL_STATE,
      DCB_INITIAL_STATE AND
      RD_STATE AS INTEGER VARIABLES

   DEFINE OFP, DG_A, DG_B, DC_A AND DC_B AS INTEGER VARIABLES

END '' PREAMBLE
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES
.1ST_DIESEL	DEFINE TO MEAN				21
.2ND_DIESEL	DEFINE TO MEAN				22
.ACTIVATED	DEFINE TO MEAN				14
.AVAILABLE	DEFINE TO MEAN				15
.NO	DEFINE TO MEAN				24
.NOT_RECOVERABLE	DEFINE TO MEAN				19
.OFFSITE	DEFINE TO MEAN				20
.RECOVERED	DEFINE TO MEAN				13
.SUSPENDED	DEFINE TO MEAN				18
.UNAVAILABLE	DEFINE TO MEAN				17
.UNDER_REPAIR	DEFINE TO MEAN				16
.YES	DEFINE TO MEAN				23
1ST_DC_BUS	PROCESS NOTICE	ARR	7		9
1ST_DIESEL	PROCESS NOTICE	ARR	35		8
2ND_DC_BUS	PROCESS NOTICE	ARR	24		9
2ND_DIESEL	PROCESS NOTICE	ARR	47		8
AC_LOSS_TIME	GLOBAL VARIABLE	ARR	36	DOUBLE	29
AC_RECOVERY_INTERVAL	GLOBAL VARIABLE	ARR	32	DOUBLE	28
AC_RECOVERY_TIME	GLOBAL VARIABLE	ARR	40	DOUBLE	27
DCA_INITIAL_STATE	GLOBAL VARIABLE	ARR	49	INTEGER	48
DCA_STATE	GLOBAL VARIABLE	ARR	27	INTEGER	46
DCB_INITIAL_STATE	GLOBAL VARIABLE	ARR	52	INTEGER	49
DCB_STATE	GLOBAL VARIABLE	ARR	48	INTEGER	47
DC_A	GLOBAL VARIABLE	ARR	2	INTEGER	52
DC_B	GLOBAL VARIABLE	ARR	3	INTEGER	52
DECISION	PROCESS NOTICE	ARR	9		9
DG_FAILURE_TIME	ROUTINE			DOUBLE	11
DGA_INITIAL_STATE	GLOBAL VARIABLE	ARR	4	INTEGER	42
DGA_STATE	GLOBAL VARIABLE	ARR	23	INTEGER	40
DGB_INITIAL_STATE	GLOBAL VARIABLE	ARR	1	INTEGER	43
DGB_STATE	GLOBAL VARIABLE	ARR	39	INTEGER	41
DG_A	GLOBAL VARIABLE	ARR	10	INTEGER	52
DG_B	GLOBAL VARIABLE	ARR	11	INTEGER	52
DG_CCF_RUNNING	GLOBAL VARIABLE	ARR	8	INTEGER	45
DG_REPAIR_TIME_BOUND	GLOBAL VARIABLE	ARR	53	DOUBLE	31
FAILURE_CHANGE_TIME	GLOBAL VARIABLE	ARR	25	DOUBLE	34
INITIALIZE	PROCESS NOTICE	ARR	51		8
INVERSE_EARLY_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	5	DOUBLE	32
INVERSE_LATE_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	13	DOUBLE	33
MEAN_DG_ARRIVAL_TIME	GLOBAL VARIABLE	ARR	21	DOUBLE	35
MEAN_DG_REPAIR_TIME	GLOBAL VARIABLE	ARR	18	DOUBLE	36
MEAN_OP_RECOVERY_TIME	GLOBAL VARIABLE	ARR	30	DOUBLE	30
NO_DGS_EVENTUALLY_AVAILABLE	GLOBAL VARIABLE	ARR	50	INTEGER	44
NUMBER_OF_RUNS	GLOBAL VARIABLE	ARR	16	INTEGER	38
OFFSITE_POWER	PROCESS NOTICE	ARR	29		8
OFP	GLOBAL VARIABLE	ARR	17	INTEGER	52
OP_STATE	GLOBAL VARIABLE	ARR	46	INTEGER	39
RD_STATE	GLOBAL VARIABLE	ARR	28	INTEGER	50

```
 1
 2
 3  MAIN
 4  ''
 5  ''  ROUTINE MAIN READS THE INPUT DATA (USING READ_DATA) AND PERFORMS
 6  ''  SIMULATION INITIALIZATIONS (USING INITIALIZE)
 7  ''
 8     USE 2 FOR INPUT
 9     CALL READ_DATA
10     ACTIVATE AN INITIALIZE NOW
11     START SIMULATION
12  END  '' MAIN
```

C R O S S - R E F E R E N C E

NAME	TYPE				MODE	LINE NUMBERS OF REFERENCES
EVENTS.V	PERMANENT ATTRIBUTE	SYS	11		INTEGER	3*
F.EV.S	PERMANENT ATTRIBUTE	SYS	13	(1-D)	INTEGER	3*
INITIALIZE	PROCESS NOTICE	ARR	51			10
	+ GLOBAL VARIABLE	ARR	51		INTEGER	10*
L.EV.S	PERMANENT ATTRIBUTE	SYS	14	(1-D)	INTEGER	3*
READ_DATA	ROUTINE				INTEGER	9

```
PROCESS INITIALIZE
    FOR I=1 TO NUMBER_OF_RUNS,
    DO
        LET TIME.V = 0
        LET AC_LOSS_TIME = -1
        ''
        ''  OFFSITE POWER BECOMES UNAVAILABLE AT TIME=0
        ''
        ACTIVATE AN OFFSITE_POWER CALLED OFP NOW
        LET OP_STATE = .UNAVAILABLE
        ''
        ''    DIESEL MAY BE AVAILABLE AT TIME=0, DEPENDING UPON INPUT DATA
        ''

        LET DCA_STATE = DCA_INITIAL_STATE
        LET DCB_STATE = DCB_INITIAL_STATE
        LET NO_DGS_EVENTUALLY_AVAILABLE = 0

        IF DCA_STATE = .AVAILABLE,
           ACTIVATE A 1ST_DIESEL CALLED DG_A NOW
           LET DGA_STATE = DGA_INITIAL_STATE
           ADD 1 TO NO_DGS_EVENTUALLY_AVAILABLE
        ALWAYS

        IF DCB_STATE = .AVAILABLE,
           ACTIVATE A 2ND_DIESEL CALLED DG_B NOW
           LET DGB_STATE = DGB_INITIAL_STATE
           ADD 1 TO NO_DGS_EVENTUALLY_AVAILABLE
        ALWAYS

        LET RD_STATE = .SUSPENDED

        IF (DCA_INITIAL_STATE = .UNAVAILABLE) AND
           (DCB_INITIAL_STATE = .UNAVAILABLE)
          LET AC_LOSS_TIME = 24*TIME.V
        ALWAYS

        SUSPEND
    LOOP
'' PRINT 6 LINES WITH MEAN_REC_TIME, STDDV_REC_TIME, MEAN_REC_INTVL,
'' AND STDDV_REC_INTVL THUS
''
'' AC RECOVERY TIME MEAN                     =  ***.**** HOURS
'' AC RECOVERY TIME STANDARD DEVIATION       =  ***.**** HOURS
'' AC RECOVERY INTERVAL MEAN                 =  ***.**** HOURS
'' AC RECOVERY INTERVAL STANDARD DEVIATION   =  ***.**** HOURS

END  '' INITIALIZE
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES		
.AVAILABLE	DEFINE TO MEAN				21	27	
.SUSPENDED	DEFINE TO MEAN				33		
.UNAVAILABLE	DEFINE TO MEAN				12	35	36
1ST_DIESEL	PROCESS NOTICE	ARR	35		22		
2ND_DIESEL	PROCESS NOTICE	ARR	47		28		
AC_LOSS_TIME	GLOBAL VARIABLE	ARR	36	DOUBLE	7	37	
DCA_INITIAL_STATE	GLOBAL VARIABLE	ARR	49	INTEGER	17	35	
DCA_STATE	GLOBAL VARIABLE	ARR	27	INTEGER	17	21	
DCB_INITIAL_STATE	GLOBAL VARIABLE	ARR	52	INTEGER	18	36	
DCB_STATE	GLOBAL VARIABLE	ARR	48	INTEGER	18	27	
DGA_INITIAL_STATE	GLOBAL VARIABLE	ARR	4	INTEGER	23		
DGA_STATE	GLOBAL VARIABLE	ARR	23	INTEGER	23		
DGB_INITIAL_STATE	GLOBAL VARIABLE	ARR	1	INTEGER	29		
DGB_STATE	GLOBAL VARIABLE	ARR	39	INTEGER	29		
DG_A	GLOBAL VARIABLE	ARR	10	INTEGER	22*		
DG_B	GLOBAL VARIABLE	ARR	11	INTEGER	28*		
I	RECURSIVE VARIABLE	WORD	1	DOUBLE	4*		
INITIALIZE	PROCESS NOTICE	ARR	51		3	50	
	+ GLOBAL VARIABLE	ARR	51	INTEGER	3*		
NO_DGS_EVENTUALLY_AVAILABLE	GLOBAL VARIABLE	ARR	50	INTEGER	19	24*	30*
NUMBER_OF_RUNS	GLOBAL VARIABLE	ARR	16	INTEGER	4		
OFFSITE_POWER	PROCESS NOTICE	ARR	29		11		
OFP	GLOBAL VARIABLE	ARR	17	INTEGER	11*		
OP_STATE	GLOBAL VARIABLE	ARR	46	INTEGER	12		
PROCESS.V	PERMANENT ATTRIBUTE	SYS	47	INTEGER	50*		
RD_STATE	GLOBAL VARIABLE	ARR	28	INTEGER	33		
TIME.V	PERMANENT ATTRIBUTE	SYS	17	DOUBLE	6	37	

```
  1
  2
  3  PROCESS OFFSITE_POWER
  4  ''
  5  ''  MODELS RECOVERY PROCESS FOR OFFSITE POWER
  6  ''
  7     DEFINE OP_RECOVERY_TIME AS A REAL VARIABLE
  8     LET OP_RECOVERY_TIME = EXPONENTIAL.F(MEAN_OP_RECOVERY_TIME,2)
  9     LET OP_STATE = .UNDER_REPAIR
 10  ''**********************************************************************
 11  PRINT 3 LINES WITH 24*TIME.V, OP_STATE, AND
 12  OP_RECOVERY_TIME THUS
TIME = ***.***    OFFSITE POWER LOST,                      OFFSITE POWER STATION 1
                  OP_STATE = *
                  OP_RECOVERY_TIME = ***.***
 13  ''**********************************************************************
 14     ''
 15     ''  HOLD OFFSITE POWER PROCESS UNTIL RECOVERY
 16     ''
 17     WAIT OP_RECOVERY_TIME HOURS
 18     LET OP_STATE = .RECOVERED
 19  ''**********************************************************************
 20  PRINT 2 LINES WITH 24*TIME.V AND OP_STATE THUS
TIME = ***.***    OFFSITE POWER RECOVERED,                 OFFSITE POWER STATION 2
                  C?_STATE = *
 21  ''**********************************************************************
 22     LET AC_RECOVERY_TIME = 24*TIME.V
 23     LET AC_RECOVERY_INTERVAL = AC_RECOVERY_TIME - AC_LOSS_TIME
 24     CALL END_RUN GIVING .OFFSITE
 25  END  '' OFFSITE_POWER
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES			
.OFFSITE	DEFINE TO MEAN				24			
.RECOVERED	DEFINE TO MEAN				18			
.UNDER_REPAIR	DEFINE TO MEAN				9			
AC_LOSS_TIME	GLOBAL VARIABLE	ARR	36	DOUBLE	23			
AC_RECOVERY_INTERVAL	GLOBAL VARIABLE	ARR	32	DOUBLE	23			
AC_RECOVERY_TIME	GLOBAL VARIABLE	ARR	40	DOUBLE	22	23		
END_RUN	ROUTINE			INTEGER	24			
EXPONENTIAL.F	ROUTINE			DOUBLE	8			
MEAN_OP_RECOVERY_TIME	GLOBAL VARIABLE	ARR	30	DOUBLE	8			
OFFSITE_POWER	PROCESS NOTICE	ARR	29		3	25		
	+ GLOBAL VARIABLE	ARR	29	INTEGER	3*			
OP_RECOVERY_TIME	RECURSIVE VARIABLE	WORD	1	DOUBLE	7	8	11	17
OP_STATE	GLOBAL VARIABLE	ARR	46	INTEGER	9	11	18	20
PROCESS.V	PERMANENT ATTRIBUTE	SYS	47	INTEGER	25*			
TIME.V	PERMANENT ATTRIBUTE	SYS	17	DOUBLE	11	20	22	

```
PROCESS 1ST_DIESEL
''
''  MODELS FAILURE AND RECOVERY PROCESSES FOR DIESEL GENERATOR A
''
   DEFINE DGA_FAILURE_TIME, DGA_ARRIVAL_TIME, AND
      DGA_REPAIR_TIME AS REAL VARIABLES
   WAIT 0.1 MINUTES
   ''
   ''  HOLD DIESEL UNTIL FAILURE
   ''
   IF DGA_STATE = .ACTIVATED,
      LET DGA_FAILURE_TIME = DG.FAILURE.TIME(INVERSE_EARLY_DG_FAILURE_RATE,
         INVERSE_LATE_DG_FAILURE_RATE,FAILURE_CHANGE_TIME,3)
      WAIT DGA_FAILURE_TIME HOURS
   ALWAYS
   LET DGA_STATE = .UNAVAILABLE
''*****************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND DGA_STATE THUS
TIME = ***.***:  DG_A LOST,                                      DGA STATION 1
          DGA_STATE = *
''*****************************************************************************
   ''
   ''  START BATTERY A WHEN DIESEL A FAILS
   ''
      IF DCA_STATE = .AVAILABLE,
         ACTIVATE A 1ST_DC_BUS CALLED DC_A NOW
    ALWAYS
   ''
   ''  TIME DELAYS FOR DIESEL A IF IT IS THE ONLY DIESEL AVAILABLE FOR
   ''  RECOVERY (I.E., NO_DGS_EVENTUALLY_AVAILABLE = 1)
   ''
   IF NO_DGS_EVENTUALLY_AVAILABLE = 1,
      LET AC_LOSS_TIME = 24*TIME.V
      LET DGA_ARRIVAL_TIME = EXPONENTIAL.F(MEAN_DG_ARRIVAL_TIME,4)
      WAIT DGA_ARRIVAL_TIME HOURS
      LET DGA_STATE = .UNDER_REPAIR
''*****************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND DGA_STATE THUS
TIME = ***.***:  OPERATORS ARRIVE AT DG_A, 1 DG AVAILABLE,        DGA STATION 2
          DGA_STATE = *
''*****************************************************************************
      LET DGA_REPAIR_TIME = EXPONENTIAL.F(MEAN_DG_REPAIR_TIME,5)
      WAIT DGA_REPAIR_TIME HOURS
      LET DGA_STATE = .RECOVERED
''*****************************************************************************
PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***:  DG_A RECOVERED, 1 DG AVAILABLE                   DGA STATION 3
''*****************************************************************************
```

```
    ELSE
    ''
    ''  TIME DELAYS FOR DIESEL A IF IT IS ONE OF TWO DIESELS AVAILABLE
    ''  FOR RECOVERY (NO_DGS_EVENTUALLY_AVAILABLE = 2)
    ''
       ''
       ''  DIESEL B IS RUNNING WHEN DIESEL A FAILS
       ''
       IF DGB_STATE = .ACTIVATED,
          ''
          ''  COMMON-CAUSE FAILURE OF DIESELS WHEN RUNNING
          ''
          IF DG_CCF_RUNNING = .YES,
             INTERRUPT 2ND_DIESEL CALLED DG_B
             LET DGB_STATE = .SUSPENDED
          ALWAYS
          ''
          ''  DELAY UNTIL OPERATORS ARRIVE AT DIESELS
          ''
          LET DGA_ARRIVAL_TIME = EXPONENTIAL.F(MEAN_DG_ARRIVAL_TIME,4)
          WAIT DGA_ARRIVAL_TIME HOURS
          LET DGA_STATE = .UNDER_REPAIR
''**************************************************************************
PRINT 3 LINES WITH 24*TIME.V, DGA_STATE AND DGB_STATE THUS
TIME = ***.***:  OPERATORS ARRIVE AT DG_A,                        DGA STATION 4
                 DGA_STATE = *
                 DGB_STATE = *
''**************************************************************************
          IF DGB_STATE = .SUSPENDED,
             ACTIVATE A DECISION IN DG_REPAIR_TIME_BOUND HOURS
''**************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND 24*TIME.V+DG_REPAIR_TIME_BOUND
   THUS
TIME = ***.***:  REPAIR DECISION SCHEDULED FOR DG_B,              DGA STATION 5
                 SCHEDULED AT ***.***
''**************************************************************************
          ALWAYS
       ELSE
       ''
       ''  DIESEL B IS FAILED AND IS EITHER UNDER REPAIR OR AWAITING
       ''  THE ARRIVAL OF THE REPAIR CREW WHEN DIESEL A FAILS
       ''
         LET AC_LOSS_TIME = 24*TIME.V
         IF DGB_STATE = .UNDER_REPAIR,
            ACTIVATE A DECISION IN DG_REPAIR_TIME_BOUND HOURS
''**************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND 24*TIME.V+DG_REPAIR_TIME_BOUND
   THUS
TIME = ***.***:  REPAIR DECISION SCHEDULED FOR DG_A,              DGA STATION 6
                 SCHEDULED AT ***.***
''**************************************************************************
```

```
 90           ALWAYS
 91           LET DGA_STATE = .SUSPENDED
 92  ''*******************************************************************************
 93  PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***:   DG_A SUSPENDED                                          DGA STATION 7
 94  ''*******************************************************************************
 95           SUSPEND
 96  ''*******************************************************************************
 97  PRINT 2 LINES WITH 24*TIME.V AND DGA_STATE THUS
TIME = ***.***:   DG_A REAWAKENED.                                        DGA STATION 8
                  DGA_STATE = *
 98  ''*******************************************************************************
 99        ALWAYS
100     ''
101     ''  DELAY UNTIL REPAIRS ARE COMPLETED
102     ''
103     LET DGA_REPAIR_TIME = EXPONENTIAL.F(MEAN_DG_REPAIR_TIME,5)
104     WAIT DGA_REPAIR_TIME HOURS
105     LET DGA_STATE = .RECOVERED
106  ''*******************************************************************************
107  PRINT 3 LINES WITH 24*TIME.V, DGA_STATE AND DGB_STATE THUS
TIME = ***.***:   DG_A RECOVERED.                                         DGA STATION 9
                  DGA_STATE = *
                  DGB_STATE = *
108  ''*******************************************************************************
109     ALWAYS
110     ''
111     ''  COMPUTATION OF IMPORTANT TIMES
112     ''
113     LET AC_RECOVERY_TIME = 24*TIME.V
114     LET AC_RECOVERY_INTERVAL = AC_RECOVERY_TIME - AC_LOSS_TIME
115     CALL END_RUN GIVING .1ST_DIESEL
116  END  '' 1ST_DIESEL
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES		
.1ST_DIESEL	DEFINE TO MEAN				115		
.ACTIVATED	DEFINE TO MEAN				13	54	
.AVAILABLE	DEFINE TO MEAN				25		
.RECOVERED	DEFINE TO MEAN				42	105	
.SUSPENDED	DEFINE TO MEAN				60	71	91
.UNAVAILABLE	DEFINE TO MEAN				18		
.UNDER_REPAIR	DEFINE TO MEAN				36	67	84
.YES	DEFINE TO MEAN				58		
1ST_DC_BUS	PROCESS NOTICE	ARR	7		26		
1ST_DIESEL	PROCESS NOTI[illegible]	ARR	35		3	116	
	+ GLOBAL VARIA[illegible]E	ARR	35	INTEGER	3*		

2ND_DIESEL	PROCESS NOTICE	ARR	47		59						
AC_LOSS_TIME	GLOBAL VARIABLE	ARR	36	DOUBLE	33	83	114				
AC_RECOVERY_INTERVAL	GLOBAL VARIABLE	ARR	32	DOUBLE	114						
AC_RECOVERY_TIME	GLOBAL VARIABLE	ARR	40	DOUBLE	113	114					
DCA_STATE	GLOBAL VARIABLE	ARR	27	INTEGER	25						
DC_A	GLOBAL VARIABLE	ARR	2	INTEGER	26*						
DECISION	PROCESS NOTICE	ARR	9		72	85					
	+ GLOBAL VARIABLE	ARR	9	INTEGER	72*	85*					
DG_FAILURE_TIME	ROUTINE			DOUBLE	14						
DGA_ARRIVAL_TIME	RECURSIVE VARIABLE	WORD	3	DOUBLE	7	34	35	65	66		
DGA_FAILURE_TIME	RECURSIVE VARIABLE	WORD	1	DOUBLE	7	14	16				
DGA_REPAIR_TIME	RECURSIVE VARIABLE	WORD	5	DOUBLE	8	40	41	103	104		
DGA_STATE	GLOBAL VARIABLE	ARR	23	INTEGER	13	18	20	36	38	42	67
					69	91	97	105	107		
DGB_STATE	GLOBAL VARIABLE	ARR	39	INTEGER	54	60	69	71	84	107	
DG_B	GLOBAL VARIABLE	ARR	11	INTEGER	59*						
DG_CCF_RUNNING	GLOBAL VARIABLE	ARR	8	INTEGER	58						
DG_REPAIR_TIME_BOUND	GLOBAL VARIABLE	ARR	53	DOUBLE	72	74	85	87			
END_RUN	ROUTINE			INTEGER	115						
EXPONENTIAL.F	ROUTINE			DOUBLE	34	40	65	103			
FAILURE_CHANGE_TIME	GLOBAL VARIABLE	ARR	25	DOUBLE	15						
INVERSE_EARLY_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	5	DOUBLE	14						
INVERSE_LATE_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	13	DOUBLE	15						
MEAN_DG_ARRIVAL_TIME	GLOBAL VARIABLE	ARR	21	DOUBLE	34	65					
MEAN_DG_REPAIR_TIME	GLOBAL VARIABLE	ARR	18	DOUBLE	40	103					
NO_DGS_EVENTUALLY_AVAILABLE	GLOBAL VARIABLE	ARR	50	INTEGER	32						
PROCESS.V	PERMANENT ATTRIBUTE	SYS	47	INTEGER	116*						
TIME.V	PERMANENT ATTRIBUTE	SYS	17	DOUBLE	20	33	38	44	69	74*	83
					87*	93	97	107	1 3		

```
PROCESS 2ND_DIESEL
''
''  MODELS FAILURE AND RECOVERY PROCESSES FOR DIESEL GENERATOR B
''
   DEFINE DGB_FAILURE_TIME, DGB_ARRIVAL_TIME, AND
      DGB_REPAIR_TIME AS REAL VARIABLES
   WAIT 0.1 MINUTES
   ''
   ''  HOLD DIESEL UNTIL FAILURE
   ''
   IF DGB_STATE = .ACTIVATED,
      LET DGB_FAILURE_TIME = DG.FAILURE.TIME(INVERSE_EARLY_DG_FAILURE_RATE,
         INVERSE_LATE_DG_FAILURE_RATE,FAILURE_CHANGE_TIME,3)
      WAIT DGB_FAILURE_TIME HOURS
   ALWAYS
   LET DGB_STATE = .UNAVAILABLE
''***********************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND DGB_STATE THUS
TIME = ***.***:  DG_B LOST,                                        DGB STATION 1
                 DGB_STATE = *
''***********************************************************************************
   ''
   ''  START BATTERY B WHEN DIESEL B FAILS
   ''
      IF DCB_STATE = .AVAILABLE,
         ACTIVATE A 2ND_DC_BUS CALLED DC_B NOW
      ALWAYS
   ''
   ''  TIME DELAYS FOR DIESEL B IF IT IS THE ONLY DIESEL AVAILABLE FOR
   ''  RECOVERY (I.E., NO_DGS_EVENTUALLY_AVAILABLE = 1)
   ''
   IF NO_DGS_EVENTUALLY_AVAILABLE = 1,
      LET AC_LOSS_TIME = 24*TIME.V
      LET DGB_ARRIVAL_TIME = EXPONENTIAL.F(MEAN_DG_ARRIVAL_TIME,4)
      WAIT DGB_ARRIVAL_TIME HOURS
      LET DGB_STATE = .UNDER_REPAIR
''***********************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND DGB_STATE THUS
TIME = ***.***:  OPERATORS ARRIVE AT DG_B, 1 DG AVAILABLE,         DGB STATION 2
                 DGB_STATE = *
''***********************************************************************************
      LET DGB_REPAIR_TIME = EXPONENTIAL.F(MEAN_DG_REPAIR_TIME,5)
      WAIT DGB_REPAIR_TIME HOURS
      LET DGB_STATE = .RECOVERED
''***********************************************************************************
PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***:  DG_B RECOVERED, 1 DG AVAILABLE                    DGB STATION 3
''***********************************************************************************
```

```
    ELSE
    ''
    ''  TIME DELAYS FOR DIESEL B IF IT IS ONE OF TWO DIESELS AVAILABLE
    ''  FOR RECOVERY (NO_DGS_EVENTUALLY_AVAILABLE = 2)
    ''
        ''
        ''  DIESEL A IS RUNNING WHEN DIESEL B FAILS
        ''
        IF DGA_STATE = .ACTIVATED,
            ''
            ''  COMMON-CAUSE FAILURE OF DIESELS WHEN RUNNING
            ''
            IF DG_CCF_RUNNING = .YES,
                INTERRUPT 1ST_DIESEL CALLED DG_A
                LET DGA_STATE = .SUSPENDED
            ALWAYS
            ''
            ''  DELAY UNTIL OPERATORS ARRIVE AT DIESELS
            ''
            LET DGB_ARRIVAL_TIME = EXPONENTIAL.F(MEAN_DG_ARRIVAL_TIME,4)
            WAIT DGB_ARRIVAL_TIME HOURS
            LET DGB_STATE = .UNDER_REPAIR
''*************************************************************************************
PRINT 3 LINES WITH 24*TIME.V, DGB_STATE AND DGA_STATE THUS
TIME = ***.***:  OPERATORS ARRIVE AT DG_B,                          DGB STATION 4
                 DGB_STATE = *
                 DGA_STATE = *
''*************************************************************************************
            IF DGA_STATE = .SUSPENDED,
               ACTIVATE A DECISION IN DG_REPAIR_TIME_BOUND HOURS
''*************************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND 24*TIME.V+DG_REPAIR_TIME_BOUND
    THUS
TIME = ***.***:  REPAIR DECISION SCHEDULED FOR DG_A,                DGB STATION 5
                 SCHEDULED AT ***.***
''*************************************************************************************
            ALWAYS
        ELSE
        ''
        ''  DIESEL A IS FAILED AND IS EITHER UNDER REPAIR OR AWAITING
        ''  THE ARRIVAL OF THE REPAIR CREW WHEN DIESEL B FAILS
        ''
           LET AC_LOSS_TIME = 24*TIME.V
           IF DGA_STATE = .UNDER_REPAIR,
              ACTIVATE A DECISION IN DG_REPAIR_TIME_BOUND HOURS
''*************************************************************************************
PRINT 2 LINES WITH 24*TIME.V AND 24*TIME.V+DG_REPAIR_TIME_BOUND
    THUS
TIME = ***.***:  REPAIR DECISION SCHEDULED FOR DG_B,                DGB STATION 6
                 SCHEDULED AT ***.***
''*************************************************************************************
```

```
 90          ALWAYS
 91          LET DGB_STATE = .SUSPENDED
 92   ''****************************************************************************
 93   PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***:   DG_B SUSPENDED                                       DGB STATION 7
 94   ''****************************************************************************
 95          SUSPEND
 96   ''****************************************************************************
 97   PRINT 2 LINES WITH 24*TIME.V AND DGB_STATE THUS
TIME = ***.***:   DG_B REAWAKENED.                                     DGB STATION 8
                  DGB_STATE = *
 98   ''****************************************************************************
 99        ALWAYS
100      ''
101      ''  DELAY UNTIL REPAIRS ARE COMPLETED
102      ''
103     LET DGB_REPAIR_TIME = EXPONENTIAL.F(MEAN_DG_REPAIR_TIME,5)
104     WAIT DGB_REPAIR_TIME HOURS
105     LET DGB_STATE = .RECOVERED
106   ''****************************************************************************
107   PRINT 3 LINES WITH 24*TIME.V, DGB_STATE AND DGA_STATE THUS
TIME = ***.***:   DG_B RECOVERED.                                      DGB STATION 9
                  DGB_STATE = *
                  DGA_STATE = *
108   ''****************************************************************************
109     ALWAYS
110      ''
111      ''  COMPUTATION OF IMPORTANT TIMES
112      ''
113     LET AC_RECOVERY_TIME = 24*TIME.V
114     LET AC_RECOVERY_INTERVAL = AC_RECOVERY_TIME - AC_LOSS_TIME
115     CALL END_RUN GIVING .2ND_DIESEL
116   END  '' 2ND_DIESEL
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES		
.2ND_DIESEL	DEFINE TO MEAN				115		
.ACTIVATED	DEFINE TO MEAN				13	54	
.AVAILABLE	DEFINE TO MEAN				25		
.RECOVERED	DEFINE TO MEAN				42	105	
.SUSPENDED	DEFINE TO MEAN				60	71	91
.UNAVAILABLE	DEFINE TO MEAN				18		
.UNDER_REPAIR	DEFINE TO MEAN				36	67	84
.YES	DEFINE TO MEAN				58		
1ST_DIESEL	PROCESS NOTICE	ARR	35		59		
2ND_DC_BUS	PROCESS NOTICE	ARR	24		26		
2ND_DIESEL	PROCESS NOTICE	ARR	47		3	116	
	+ GLOBAL VARIABLE	ARR	47	INTEGER	3*		

AC_LOSS_TIME	GLOBAL VARIABLE	ARR	36	DOUBLE	33	83	114				
AC_RECOVERY_INTERVAL	GLOBAL VARIABLE	ARR	32	DOUBLE	114						
AC_RECOVERY_TIME	GLOBAL VARIABLE	ARR	40	DOUBLE	113	114					
DCB_STATE	GLOBAL VARIABLE	ARR	48	INTEGER	25						
DC_B	GLOBAL VARIABLE	ARR	3	INTEGER	26*						
DECISION	PROCESS NOTICE	ARR	9		72	85					
	+ GLOBAL VARIABLE	ARR	9	INTEGER	72*	85*					
DG.FAILURE.TIME	ROUTINE			DOUBLE	14						
DGA_STATE	GLOBAL VARIABLE	ARR	23	INTEGER	54	60	69	71	84	107	
DGB_ARRIVAL_TIME	RECURSIVE VARIABLE	WORD	3	DOUBLE	7	34	35	65	66		
DGB_FAILURE_TIME	RECURSIVE VARIABLE	WORD	1	DOUBLE	7	14	16				
DGB_REPAIR_TIME	RECURSIVE VARIABLE	WORD	5	DOUBLE	8	40	41	103	104		
DGB_STATE	GLOBAL VARIABLE	ARR	39	INTEGER	13	18	20	36	38	42	67
					69	91	97	105	107		
DG_A	GLOBAL VARIABLE	ARR	10	INTEGER	59*						
DG_CCF_RUNNING	GLOBAL VARIABLE	ARR	8	INTEGER	58						
DG_REPAIR_TIME_BOUND	GLOBAL VARIABLE	ARR	53	DOUBLE	72	74	85	87			
END_RUN	ROUTINE			INTEGER	115						
EXPONENTIAL.F	ROUTINE			DOUBLE	34	40	65	103			
FAILURE_CHANGE_TIME	GLOBAL VARIABLE	ARR	25	DOUBLE	15						
INVERSE_EARLY_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	5	DOUBLE	14						
INVERSE_LATE_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	13	DOUBLE	15						
MEAN_DG_ARRIVAL_TIME	GLOBAL VARIABLE	ARR	21	DOUBLE	34	65					
MEAN_DG_REPAIR_TIME	GLOBAL VARIABLE	ARR	18	DOUBLE	40	103					
NO_DGS_EVENTUALLY_AVAILABLE	GLOBAL VARIABLE	ARR	50	INTEGER	32						
PROCESS.V	PERMANENT ATTRIBUTE	SYS	47	INTEGER	116*						
TIME.V	PERMANENT ATTRIBUTE	SYS	17	DOUBLE	20	33	38	44	69	74*	83
					87*	93	97	107	113		

```
 1
 2
 3 PROCESS 1ST_DC_BUS
 4 ''
 5 ''  MODELS THE RESTRICTIVE EFFECT OF TRAIN A BATTERIES ON DG_A RECOVERY
 6 ''
 7    DEFINE DCA_FAILURE_TIME AS A REAL VARIABLE
 8    LET DCA_STATE = .ACTIVATED
 9 ''***************************************************************************
10 PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***:   1ST_DC_BUS ACTIVATED,                         DCA STATION 1
11 ''***************************************************************************
12    LET DCA_FAILURE_TIME = 2.
13    WAIT DCA_FAILURE_TIME HOURS
14    LET DCA_STATE = .UNAVAILABLE
15 ''***************************************************************************
16 PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***:   1ST_DC_BUS LOST,                              DCA STATION 2
17 ''***************************************************************************
18    ''
19    ''  IF BATTERIES ARE DRAINED, DIESEL CANNOT BE RECOVERED
20    ''  (STOP DIESEL REPAIR EFFORTS)
21    ''
22    IF DGA_STATE NE .SUSPENDED,
23       INTERRUPT 1ST_DIESEL CALLED DG_A
24    ALWAYS
25    LET DGA_STATE = .NOT_RECOVERABLE
26    SUSPEND
27 END  '' 1ST_DC_BUS
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES		
.ACTIVATED	DEFINE TO MEAN				8		
.NOT_RECOVERABLE	DEFINE TO MEAN				25		
.SUSPENDED	DEFINE TO MEAN				22		
.UNAVAILABLE	DEFINE TO MEAN				14		
1ST_DC_BUS	PROCESS NOTICE	ARR	7		3	27	
	+ GLOBAL VARIABLE	ARR	7	INTEGER	3*		
1ST_DIESEL	PROCESS NOTICE	ARR	35		23		
DCA_FAILURE_TIME	RECURSIVE VARIABLE	WORD	1	DOUBLE	7	12	13
DCA_STATE	GLOBAL VARIABLE	ARR	27	INTEGER	8	14	
DGA_STATE	GLOBAL VARIABLE	ARR	23	INTEGER	22	25	
DG_A	GLOBAL VARIABLE	ARR	10	INTEGER	23*		
PROCESS.V	PERMANENT ATTRIBUTE	SYS	47	INTEGER	27*		
TIME.V	PERMANENT ATTRIBUTE	SYS	17	DOUBLE	10	16	

```
    1
    2
    3  PROCESS 2ND_DC_BUS
    4  ''
    5  ''  MODELS THE RESTRICTIVE EFFECT OF TRAIN B BATTERIES ON DG_B RECOVERY
    6  ''
    7     DEFINE DCB_FAILURE_TIME AS A REAL VARIABLE
    8     LET DCB_STATE = .ACTIVATED
    9  ''*************************************************************************
   10  PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***   2ND_DC_BUS ACTIVATED,                                DCB STATION 1
   11  ''*************************************************************************
   12     LET DCB_FAILURE_TIME = 2.
   13     WAIT DCB_FAILURE_TIME HOURS
   14     LET DCB_STATE = .UNAVAILABLE
   15  ''*************************************************************************
   16  PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***   2ND_DC_BUS LOST,                                     DCB STATION 2
   17  ''*************************************************************************
   18     ''
   19     ''  IF BATTERIES ARE DRAINED, DIESEL CANNOT BE RECOVERED
   20     ''  (STOP DIESEL REPAIR EFFORTS)
   21     ''
   22     IF DGB_STATE NE .SUSPENDED,
   23        INTERRUPT 2ND_DIESEL CALLED DG_B
   24     ALWAYS
   25     LET DGB_STATE = .NOT_RECOVERABLE
   26     SUSPEND
   27  END  '' 2ND_DC_BUS
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES		
.ACTIVATED	DEFINE TO MEAN				8		
.NOT_RECOVERABLE	DEFINE TO MEAN				25		
.SUSPENDED	DEFINE TO MEAN				22		
.UNAVAILABLE	DEFINE TO MEAN				14		
2ND_DC_BUS	PROCESS NOTICE	ARR	24		3	27	
	+ GLOBAL VARIABLE	ARR	24	INTEGER	3*		
2ND_DIESEL	PROCESS NOTICE	ARR	47		23		
DCB_FAILURE_TIME	RECURSIVE VARIABLE	WORD	1	DOUBLE	7	12	13
DCB_STATE	GLOBAL VARIABLE	ARR	48	INTEGER	8	14	
DGB_STATE	GLOBAL VARIABLE	ARR	39	INTEGER	22	25	
DG_B	GLOBAL VARIABLE	ARR	11	INTEGER	23*		
PROCESS.V	PERMANENT ATTRIBUTE	SYS	47	INTEGER	27*		
TIME.V	PERMANENT ATTRIBUTE	SYS	17	DOUBLE	10	16	

```
  1
  2
  3 PROCESS DECISION
  4 ''
  5 ''  ROUTINE TO START REPAIR EFFORTS ON OTHER DIESEL IF REPAIRS ON
  6 ''  FIRST DIESEL ARE TAKING TOO LONG
  7 ''
  8    LET RD_STATE = .ACTIVATED
  9 ''**********************************************************************
 10 PRINT 1 LINE WITH 24*TIME.V THUS
TIME = ***.***:   REPAIR DECISION MADE                 REPAIR DECISION STATION 1
 11 ''**********************************************************************
 12    IF DGA_STATE = .SUSPENDED,
 13       REACTIVATE THE 1ST_DIESEL CALLED DG_A NOW
 14       LET DGA_STATE = .UNDER_REPAIR
 15 ''**********************************************************************
 16 PRINT 2 LINES WITH 24*TIME.V AND DGA-STATE THUS
TIME = ***.***:   DG_A RESUMED.                        REPAIR DECISION STATION 2
                  DGA_STATE = *
 17 ''**********************************************************************
 18    ALWAYS
 19    IF DGB_STATE = .SUSPENDED,
 20       REACTIVATE THE 2ND_DIESEL CALLED DG_B NOW
 21       LET DGB_STATE = .UNDER_REPAIR
 22 ''**********************************************************************
 23 PRINT 2 LINES WITH 24*TIME.V AND DGB_STATE THUS
TIME = ***.***:   DGB RESUMED.                         REPAIR DECISION S  TION 3
                  DGB_STATE = *
 24 ''**********************************************************************
 25    ALWAYS
 26    LET RD_STATE = .SUSPENDED
 27    SUSPEND
 28 END  '' DECISION
```

C R O S S - R E F E R E N C E

NAME		TYPE			MODE	LINE NUMBERS OF REFERENCES		
.ACTIVATED		DEFINE TO MEAN				8		
.SUSPENDED		DEFINE TO MEAN				12	19	26
.UNDER_REPAIR		DEFINE TO MEAN				14	21	
1ST_DIESEL		PROCESS NOTICE	ARR	35		13		
2ND_DIESEL		PROCESS NOTICE	ARR	47		20		
DECISION		PROCESS NOTICE	ARR	9		3	28	
	+	GLOBAL VARIABLE	ARR	9	INTEGER	3*		
DGA		RECURSIVE VARIABLE	WORD	12	DOUBLE	16		
DGA_STATE		GLOBAL VARIABLE	ARR	23	INTEGER	12	14	
DGB_STATE		GLOBAL VARIABLE	ARR	39	INTEGER	19	21	23
DG_A		GLOBAL VARIABLE	ARR	10	INTEGER	13*		
DG_B		GLOBAL VARIABLE	ARR	11	INTEGER	20*		
PROCESS.V		PERMANENT ATTRIBUTE	SYS	47	INTEGER	28*		
RD_STATE		GLOBAL VARIABLE	ARR	28	INTEGER	8	26	
STATE		RECURSIVE VARIABLE	WORD	14	DOUBLE	16		
TIME.V		PERMANENT ATTRIBUTE	SYS	17	DOUBLE	10	16	23

```
ROUTINE END_RUN GIVEN RECOVERY
   DEFINE RECOVERY AS AN INTEGER VARIABLE
   ''
   ''  PROBLEM OUTPUT
   ''
   IF RECOVERY = .OFFSITE,
      PRINT 7 LINES WITH AC_LOSS_TIME, AC_RECOVERY_INTERVAL, AND
         AC_RECOVERY_TIME THUS

RECOVERY MODE                                          =  OFFSITE
TIME AT LOSS OF ALL AC POWER                           =  ***.*** HOURS
TIME INTERVAL TO RECOVER AC POWER                      =  ***.*** HOURS
TIME AT FIRST RECOVERY OF OFFSITE POWER OR A DG        =  ***.*** HOURS

   ELSE
      IF RECOVERY = .1ST_DIESEL,
         PRINT 7 LINES WITH AC_LOSS_TIME, AC_RECOVERY_INTERVAL, AND
            AC_RECOVERY_TIME THUS

RECOVERY MODE                                          =  DIESEL A
TIME AT LOSS OF ALL AC POWER                           =  ***.*** HOURS
TIME INTERVAL TO RECOVER AC POWER                      =  ***.*** HOURS
TIME AT FIRST RECOVERY OF OFFSITE POWER OR A DG        =  ***.*** HOURS

      ELSE
         PRINT 7 LINES WITH AC_LOSS_TIME, AC_RECOVERY_INTERVAL, AND
            AC_RECOVERY_TIME THUS

RECOVERY MODE                                          =  DIESEL B
TIME AT LOSS OF ALL AC POWER                           =  ***.*** HOURS
TIME INTERVAL TO RECOVER AC POWER                      =  ***.*** HOURS
TIME AT FIRST RECOVERY OF OFFSITE POWER OR A DG        =  ***.*** HOURS

      ALWAYS
   ALWAYS
   ''
   ''  PREPARE FOR NEXT RUN
   ''
   IF OP_STATE NE .RECOVERED,
      INTERRUPT OFFSITE_POWER CALLED OFP
      DESTROY THE OFFSITE_POWER CALLED OFP
   ALWAYS

   IF DCA_STATE NE .AVAILABLE,
      IF DCA_STATE = .ACTIVATED,
         INTERRUPT 1ST_DC_BUS CALLED DC_A
      ALWAYS
      DESTROY THE 1ST_DC_BUS CALLED DC_A
   ALWAYS
```

```
34
35     IF DCB_STATE NE .AVAILABLE,
36        IF DCB_STATE = .ACTIVATED,
37           INTERRUPT 2ND_DC_BUS CALLED DC_B
38        ALWAYS
39        DESTROY THE 2ND_DC_BUS CALLED DC_B
40     ALWAYS
41
42     IF DGA_STATE NE .RECOVERED,
43        IF DGA_STATE = .UNAVAILABLE OR
44           DGA_STATE = .UNDER_REPAIR OR
45           DGA_STATE = .ACTIVATED,
46              INTERRUPT 1ST_DIESEL CALLED DG_A
47        ALWAYS
48        DESTROY THE 1ST_DIESEL CALLED DG_A
49     ALWAYS
50
51     IF DGB_STATE NE .RECOVERED,
52        IF DGB_STATE = .UNAVAILABLE OR
53           DGB_STATE = .UNDER_REPAIR OR
54           DGB_STATE = .ACTIVATED,
55              INTERRUPT 2ND_DIESEL CALLED DG_B
56        ALWAYS
57        DESTROY THE 2ND_DIESEL CALLED DG_B
58     ALWAYS
59
60     IF RD_STATE NE .SUSPENDED,
61        IF RD_STATE = .ACTIVATED,
62           INTERRUPT DECISION
63        ALWAYS
64        DESTROY THE DECISION
65     ALWAYS
66
67     RESUME INITIALIZE
68
69  RETURN
70  END  '' END_RUN
```

C R O S S - R E F E R E N C E

NAME	TYPE		MODE	LINE NUMBERS OF REFERENCES				
.1ST_DIESEL	DEFINE TO MEAN			12				
.ACTIVATED	DEFINE TO MEAN			29	36	45	54	61
.AVAILABLE	DEFINE TO MEAN			28	35			
.OFFSITE	DEFINE TO MEAN			8				
.RECOVERED	DEFINE TO MEAN			23	42	51		
.SUSPENDED	DEFINE TO MEAN			60				
.UNAVAILABLE	DEFINE TO MEAN			43	52			
.UNDER_REPAIR	DEFINE TO MEAN			44	53			
1ST_DC_BUS	PROCESS NOTICE	ARR 7		30	32			

1ST_DIESEL		PROCESS NOTICE	ARR	35		46	48		
2ND_DC_BUS		PROCESS NOTICE	ARR	24		37	39		
2ND_DIESEL		PROCESS NOTICE	ARR	47		55	57		
AC_LOSS_TIME		GLOBAL VARIABLE	ARR	36	DOUBLE	9	13	16	
AC_RECOVERY_INTERVAL		GLOBAL VARIA3LE	ARR	32	DOUBLE	9	13	16	
AC_RECOVERY_TIME		GLOBAL VARIABLE	ARR	40	DOUBLE	9	13	16	
DCA_STATE		GLOBAL VARIABLE	ARR	27	INTEGER	28	29		
DCB_STATE		GLOBAL VARIABLE	ARR	48	INTEGER	35	36		
DC_A		GLOBAL VARIABLE	ARR	2	INTEGER	30*	32*		
DC_B		GLOBAL VARIABLE	ARR	3	INTEGER	37*	39*		
DECISION		PROCESS NOTICE	ARR	9		62	64		
	+	GLOBAL VARIABLE	ARR	9	INTEGER	62*	64*		
DGA_STATE		GLOBAL VARIABLE	ARR	23	INTEGER	42	43	44	45
DGB_STATE		GLOBAL VARIABLE	ARR	39	INTEGER	51	52	53	54
DG_A		GLOBAL VARIABLE	ARR	10	INTEGER	46*	48*		
DG_B		GLOBAL VARIABLE	ARR	11	INTEGER	55*	57*		
END_RUN		ROUTINE			INTEGER	3			
INITIALIZE		PROCESS NOTICE	ARR	51		67			
	+	GLOBAL VARIABLE	ARR	51	INTEGER	67*			
OFFSITE_POWER		PROCESS NOTICE	ARR	29		24	25		
OFP		GLOBAL VARIABLE	ARR	17	INTEGER	24*	25*		
OP_STATE		GLOBAL VARIABLE	ARR	46	INTEGER	23			
RD_STATE		GLOBAL VARIABLE	ARR	28	INTEGER	60	61		
RECOVERY		ARGUMENT	NO.	1	INTEGER	3	4	8	12
TIME.A		TEMPORARY ATTRIBUTE	WORD	4	DOUBLE	67			
TIME.V		PERMANENT ATTRIBUTE	SYS	17	DOUBLE	67			

```
 1
 2
 3  ROUTINE DG.FAILURE.TIME(TIME1,TIME2,TIME3,STREAM)
 4     DEFINE BOUND, ETERM, F, TIME1, TIME2 AND TIME3 AS REAL VARIABLES
 5     DEFINE STREAM AS AN INTEGER VARIABLE
 6     LET ETERM = EXP.F(-TIME3/TIME1)
 7     LET BOUND = 1 - ETERM
 8     LET F = RANDOM.F(STREAM)
 9     IF F < BOUND,
10        RETURN WITH -TIME1*LOG.E.F(1.0 - F)
11     ELSE
12        RETURN WITH
13           TIME1 - TIME2*LOG.E.F(1.0 - (F - BOUND)/ETERM)
14     END  '' DG.FAILURE.F
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES				
BOUND	RECURSIVE VARIABLE	WORD	1	DOUBLE	4	7	9	13	
DG.FAILURE.TIME	ROUTINE			DOUBLE	3				
ETERM	RECURSIVE VARIABLE	WORD	3	DOUBLE	4	6	7	13	
EXP.F	ROUTINE			DOUBLE	6				
F	RECURSIVE VARIABLE	WORD	5	DOUBLE	4	8	9	10	13
LOG.E.F	ROUTINE			DOUBLE	10	13			
RANDOM.F	ROUTINE			DOUBLE	8				
STREAM	ARGUMENT	NO.	4	INTEGER	3	5	8		
TIME1	ARGUMENT	NO.	1	DOUBLE	3	4	6	10	13
TIME2	ARGUMENT	NO.	2	DOUBLE	3	4	13		
TIME3	ARGUMENT	NO.	3	DOUBLE	3	4	6		

```
ROUTINE READ_DATA
    DEFINE ERROR_CHECK AS AN INTEGER VARIABLE
    READ NUMBER_OF_RUNS,
          DGA_INITIAL_STATE,
          DGB_INITIAL_STATE,
          DG_CCF_RUNNING,
          DCA_INITIAL_STATE,
          DCB_INITIAL_STATE,
          MEAN_OP_RECOVERY_TIME,
          INVERSE_EARLY_DG_FAILURE_RATE,
          INVERSE_LATE_DG_FAILURE_RATE,
          FAILURE_CHANGE_TIME,
          DG_REPAIR_TIME_BOUND,
          MEAN_DG_ARRIVAL_TIME, AND
          MEAN_DG_REPAIR_TIME

    ''
    ''  INPUT ECHO
    ''
    PRINT 25 LINES WITH NUMBER_OF_RUNS,
          DGA_INITIAL_STATE,
          DGB_INITIAL_STATE,
          DG_CCF_RUNNING,
          DCA_INITIAL_STATE,
          DCB_INITIAL_STATE,
          MEAN_OP_RECOVERY_TIME,
          INVERSE_EARLY_DG_FAILURE_RATE,
          INVERSE_LATE_DG_FAILURE_RATE,
          FAILURE_CHANGE_TIME,
          DG_REPAIR_TIME_BOUND,
          MEAN_DG_ARRIVAL_TIME, AND
          MEAN_DG_REPAIR_TIME THUS
SIMULATION OF ELECTRIC POWER RECOVERY FOR TMI-1

   PROBLEM INPUT:

   NUMBER OF RUNS                                                     =  ***

   DIESEL GENERATOR A INITIAL STATE (3=ACTIVATED, 0=UNAVAILABLE)     =    *
   DIESEL GENERATOR B INITIAL STATE (3=ACTIVATED, 0=UNAVAILABLE)     =    *
   COMMON CAUSE FAILURE OF DGS WHEN RUNNING? (1=YES, 0=NO)            =    *

   DC BUS A INITIAL STATE (2=AVAILABLE, 0=UNAVAILABLE)                =    *
   DC BUS B INITIAL STATE (2=AVAILABLE, 0=UNAVAILABLE)                =    *
     (DGS DOWN FOR MAINTENANCE ARE REPRESENTED BY THE
     UNAVAILABILITY OF THE CORRESPONDING DC BUSES)
```

```
MEAN TIME TO RECOVER OFFSITE POWER                                        = **.**
1/EARLY DIESEL GENERATOR FAILURE RATE                                     = **.**
1/LATE DIESEL GENERATOR FAILURE RATE                                      = **.**
TIME AT WHICH DG FAILURE RATE CHANGES                                     = **.**
UPPER BOUND ON REPAIR TIME FOR FIRST DG                                   = **.**
   (BEFORE REPAIR ON THE SECOND BEGINS)
MEAN TIME TO OPERATOR ARRIVAL AT FAILED DG'S                              = **.**
MEAN TIME TO DIESEL GENERATOR REPAIR                                      = **.**

       START NEW PAGE
       PRINT 5 LINES THUS

SIMULATION OF ELECTRIC POWER RECOVERY FOR TMI-1



       ''
       ''  INPUT CHECK
       ''
       LET ERROR_CHECK = 0
       IF (DGA_INITIAL_STATE NE 0) AND (DGA_INITIAL_STATE NE 3),
          PRINT 1 LINE THUS
    INPUT ERROR:  DGA_INITIAL_STATE MUST BE 0 OR 3
          ADD 1 TO ERROR_CHECK
       ALWAYS
       IF (DGB_INITIAL_STATE NE 0) AND (DGB_INITIAL_STATE NE 3),
          PRINT 1 LINE THUS
    INPUT ERROR:  DGB_INITIAL_STATE MUST BE 0 OR 3
          ADD 1 TO ERROR_CHECK
       ALWAYS
       IF (DG_CCF_RUNNING NE 0) AND (DG_CCF_RUNNING NE 1),
          PRINT 1 LINE THUS
    INPUT ERROR:  DG_CCF_RUNNING MUST BE 0 OR 1
          ADD 1 TO ERROR_CHECK
       ALWAYS
       IF (DCA_INITIAL_STATE NE 0) AND (DCA_INITIAL_STATE NE 2),
          PRINT 1 LINE THUS
    INPUT ERROR:  DCA_INITIAL_STATE MUST BE 0 OR 2
          ADD 1 TO ERROR_CHECK
       ALWAYS
       IF (DCB_INITIAL_STATE NE 0) AND (DCB_INITIAL_STATE NE 2),
          PRINT 1 LINE THUS
    INPUT ERROR:  DCB_INITIAL_STATE MUST BE 0 OR 2
          ADD 1 TO ERROR_CHECK
       ALWAYS
       IF MEAN_OP_RECOVERY_TIME <= 0,
          PRINT 1 LINE THUS
    INPUT ERROR:  MEAN_OP_RECOVERY_TIME MUST BE GREATER THAN 0
          ADD 1 TO ERROR_CHECK
       ALWAYS
```

```
   IF INVERSE_EARLY_DG_FAILURE_RATE <= 0.
      PRINT 1 LINE THUS
---- INPUT ERROR:  INVERSE_EARLY_DG_FAILURE_RATE MUST BE GREATER THAN 0
      ADD 1 TO ERROR_CHECK
   ALWAYS
   IF INVERSE_LATE_DG_FAILURE_RATE <= 0.
      PRINT 1 LINE THUS
---- INPUT ERROR:  INVERSE_LATE_DG_FAILURE_RATE MUST BE GREATER THAN 0
      ADD 1 TO ERROR_CHECK
   ALWAYS
   IF FAILURE_CHANGE_TIME < 0.
      PRINT 1 LINE THUS
---- INPUT ERROR:  FAILURE_CHANGE_TIME MUST BE GREATER THAN OR EQUAL TO 0
      ADD 1 TO ERROR_CHECK
   ALWAYS
   IF DG_REPAIR_TIME_BOUND < 0.
      PRINT 1 LINE THUS
---- INPUT ERROR:  DG_REPAIR_TIME_BOUND MUST BE GREATER THAN OR EQUAL TO 0
      ADD 1 TO ERROR_CHECK
   ALWAYS
   IF MEAN_DG_ARRIVAL_TIME <= 0.
      PRINT 1 LINE THUS
---- INPUT ERROR:  MEAN_DG_ARRIVAL_TIME MUST BE GREATER THAN 0
      ADD 1 TO ERROR_CHECK
   ALWAYS
   IF MEAN_DG_REPAIR_TIME <= 0.
      PRINT 1 LINE THUS
---- INPUT ERROR:  MEAN_DG_REPAIR_TIME MUST BE GREATER THAN 0
      ADD 1 TO ERROR_CHECK
   ALWAYS
   IF ERROR_CHECK > 0.
      PRINT 2 LINES WITH ERROR_CHECK THUS

---- PROGRAM TERMINATION DUE TO *** INPUT ERRORS  ----
      STOP
   OTHERWISE
   RETURN
END '' READ_DATA
```

C R O S S - R E F E R E N C E

NAME	TYPE			MODE	LINE NUMBERS OF REFERENCES						
DCA_INITIAL_STATE	GLOBAL VARIABLE	ARR	49	INTEGER	5	22	54*				
DCB_INITIAL_STATE	GLOBAL VARIABLE	ARR	52	INTEGER	5	22	58*				
DGA_INITIAL_STATE	GLOBAL VARIABLE	ARR	4	INTEGER	5	22	42*				
DGB_INITIAL_STATE	GLOBAL VARIABLE	ARR	1	INTEGER	5	22	46*				
DG_CCF_RUNNING	GLOBAL VARIABLE	ARR	8	INTEGER	5	22	50*				
DG_REPAIR_TIME_BOUND	GLOBAL VARIABLE	ARR	53	DOUBLE	5	22	78				
ERROR_CHECK	RECURSIVE VARIABLE	WORD	1	INTEGER	4	41	44*	48*	52*	56*	60*
					64*	68*	72*	76*	80*	84*	88*
					90	91					
FAILURE_CHANGE_TIME	GLOBAL VARIABLE	ARR	25	DOUBLE	5	22	74				
INVERSE_EARLY_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	5	DOUBLE	5	22	66				
INVERSE_LATE_DG_FAILURE_RATE	GLOBAL VARIABLE	ARR	13	DOUBLE	5	22	70				
MEAN_DG_ARRIVAL_TIME	GLOBAL VARIABLE	ARR	21	DOUBLE	5	22	82				
MEAN_DG_REPAIR_TIME	GLOBAL VARIABLE	ARR	18	DOUBLE	5	22	86				
MEAN_OP_RECOVERY_TIME	GLOBAL VARIABLE	ARR	30	DOUBLE	5	22	62				
NUMBER_OF_RUNS	GLOBAL VARIABLE	ARR	[illegible]	INTEGER	5	22					
READ_DATA	ROUTINE			INTEGER	3						