REVISED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**38-7878**
SRP Section:	**07.05 – Information Systems Important to Safety**
Application Section:	**7.5**
Date of RAI Issue:	**06/18/2015**

Question No. 07.05-01

APR1400 FSAR Tier 2, Section 7.5.1.1 does not provide the basis or analysis for the selection of the accident monitoring instrumentation (AMI) variables.

10 CFR Part 50, Appendix A, General Design Criteria 13, "Instrumentation and Controls," requires, in part, instrumentation to be provided to monitor variables and systems over their anticipated ranges for normal operation, anticipated operational occurrences, and accident conditions. APR1400 FSAR Tier 2, Table 7.5-1, "Accident Monitoring Instrumentation Variables," identifies a list of AMI variables and states that the design conforms to RG 1.97, Revision 4, in APR1400 FSAR Tier 2, Section 7.5.1.1. However, the applicant did not clearly demonstrate how they conform with RG 1.97, Revision 4, for each variable, including the analysis or basis for the variable. Provide the basis for the AMI variable selection in accordance with RG 1.97, Revision 4. If alternative criteria to RG 1.97, Revision 4 are used, identify that criteria and the justification for why it provides a comparable level of safety to the guidance in RG 1.97, Revision 4.

Response – (Rev. 2)

The AMI variables were selected according to the selection criteria in IEEE 497-2002, which is endorsed by RG1.97, Rev.4.

The basis and analysis for selecting each AMI variable are described as follows:

Type A

Type A variables are those variables that provide the primary information required to permit the control room operating staff to:

a) Take specific planned manually-controlled actions for which no automatic control is provided and that are required for safety systems to perform their safety-related functions as assumed in the plant Accident Analysis Licensing Basis.

b) Take specific planned manually-controlled actions for which no automatic control is provided and that are required to mitigate the consequences of an AOO.

KHNP's response to the Request for Additional Information (RAI) 294-8302, Question 07.05-6 (ref. KHNP submittal MKD/NW-16-0584L, dated June 1, 2016) provided the basis and analysis for the APR1400 Type A variables.

Type B

Type B variables are those variables that provide primary information to the control room operators to assess the plant critical safety functions.

Any plant critical safety functions addressed in the emergency operation guidelines (EOGs) that are in addition to those identified above are also included.

In order to select Type B variables for meeting the requirements in IEEE Std. 497-2002 (endorsed by RG 1.97, Rev. 4), the EOGs are reviewed. The plant critical safety functions described in the EOGs include those of IEEE Std.497-2002. EOGs provide the plant critical safety functions to be verified for each event and the criteria for deciding the plant critical safety functions.

The plant critical safety functions described in the EOG are as follows:

- Reactivity control
- Maintenance of vital auxiliaries
- Reactor coolant system (RCS) inventory control
- RCS pressure control
- Core heat removal
- RCS heat removal
- Containment isolation
- Containment temperature and pressure control
- Containment combustible gas control

Type C

Type C variables are those variables that provide primary information to the control room operators to indicate the potential for breach, or the actual breach of the three fission product barriers (extended range): fuel cladding, reactor coolant system pressure boundary, and containment pressure boundary.

The selection of these variables represents a minimum set of plant variables that provide the most direct indication of the integrity of the three fission product barriers and provide the capability for monitoring beyond the normal operating range.

Type D

Type D variables are those variables that are required in procedures and licensing basis documentation to:

- Indicate the performance of those safety systems and auxiliary supporting features necessary for the mitigation of design basis events (DBEs).
- Indicate the performance of other systems necessary to achieve and maintain a safe shutdown condition.
- Verify safety system status.

The Type D variables are based upon the plant accident analysis licensing basis and those necessary to implement the EOGs.

The resource tree of the EOG functional recovery guides describes the systems, including instruments and components, that are required for recovering the plant critical safety functions. Those instruments and components, as well as the variables required for verifying the system-base safety function performance, were selected as Type D variables.

Type E

Type E variables are those variables required for use in determining the magnitude of the release of radioactive materials and continually assessing such releases.

The selection of these variables include, but are not limited to the following:

- Monitor the magnitude of releases of radioactive materials through identified pathways (e.g., secondary safety valves, and condenser air ejector).
- Monitor the environmental conditions used to determine the impact of releases of radioactive materials through identified pathways (e.g., wind speed, wind direction, and air temperature).
- Monitor radiation levels and radioactivity in the plant environs.
- Monitor radiation levels and radioactivity in the control room and selected plant areas where access may be required for plant recovery.

Below is a listing of the AMI variables from APR1400 DCD Tier 2, Table 7.5-1, along with the variables' type classifications and their justifications.

Table 2.5.3-2 of APR1400 DCD Tier 1, Section 7.5 of APR1400 DCD Tier 2 has been revised as indicated in the attachment to the Rev. 1 response and Table 2.5.3-2, Table 2.5.4-6 of APR1400 DCD Tier 1, and Section 7.5 of APR1400 DCD Tier 2 will be revised as indicated in the attachments to this response.

Technical Specification Table 3.3.11-1 and the associated Bases for 3.3.11 Chapter 16 of the APR1400 DCD Tier 2 will be revised as indicated in the attachment associated with this response.

The Safety I&C System Technical Report, APR1400-Z-J-NR-14001-NP, and APR1400-Z-J-NR-14002-NP, will be revised as indicated in the attachment associated with this response.

Variable	Type	Basis and analysis
Pressurizer Pressure (Wide Range)	A, B	Pressurizer Pressure (Wide Range) is required for manual operator action based on the Accident Analyses (Type A) Pressurizer Pressure (Wide Range) is a primary variable for monitoring critical safety function (Type B)
Pressurizer Level	A, B, D	Pressurizer Level is required for manual operator action based on the Accident Analyses. (Type A) Pressurizer Level is a primary variable for monitoring critical safety function. (Type B) Pressurizer Level verifies the status of a safety system. (Type D)
Hot Leg Temperature (Wide Range)	A, B, D	Hot Leg Temperature (Wide Range) is required for manual operator action based on the Accident Analyses. (Type A) Hot Leg Temperature (Wide Range) is a primary variable for monitoring critical safety function. (Type B) Hot Leg Temperature (Wide Range) verifies the status of a safety system. (Type D)
Cold Leg Temperature (Wide Range)	A, B, D	Cold Leg Temperature (Wide Range) is required for manual operator action based on the Accident Analyses (Type A) Cold Leg Temperature (Wide Range) is a primary variable for monitoring critical safety function (Type B) Cold Leg Temperature (Wide Range) verifies the status of a safety system. (Type D)
Steam Generator Pressure	A, B, D	Steam Generator Pressure is required for manual operator action based on the Accident Analyses (Type A) Steam Generator Pressure is a primary variable for monitoring critical safety function (Type B) Steam Generator Pressure verifies the status of a safety system. (Type D)
Steam Generator Level (Wide Range)	A, B, D	Steam Generator Level (Wide Range) is required for manual operator action based on the Accident Analyses (Type A) Steam Generator Level (Wide Range) is a primary variable for monitoring critical safety function (Type B) Steam Generator Level (Wide Range) verifies the status of a safety system. (Type D)
RCS Saturation Margin	A, B	RCS Saturation Margin is required for manual operator action based on the Accident Analyses (Type A) RCS Saturation Margin is a primary variable for monitoring critical safety function (Type B)
CET Saturation Margin	A, B	CET Saturation Margin is required for manual operator action based on the Accident Analyses (Type A) CET Saturation Margin is a primary variable for monitoring critical safety function (Type B)

Variable	Type	Basis and analysis
RV Upper Head Saturation Margin	B	RV Upper Head Saturation Margin is a primary variable for monitoring critical safety function (Type B)
Hydrogen Concentration	B	Hydrogen Concentration is a primary variable to support containment combustible gas control of critical safety function. (Type B)
Core Exit Temperature (CET)	B, C	Core Exit Temperature (CET) is a primary variable for monitoring critical safety function (Type B) Core Exit Temperature (CET) is an indicator for probable breach of cladding. (Type C)
Reactor Vessel Level (RV Closure Head Level/RV plenum Level)	B	Reactor Vessel Level (RV Closure Head Level/RV plenum Level) is a primary variable for monitoring critical safety function. (Type B)
RCS Pressure	C, D	RCS Pressure is a primary variable for monitoring RCPB integrity and breach of the RCPB (Type C) RCS Pressure verifies the status of a safety system. (Type D)
Holdup Volume Tank Level	B	Holdup volume tank level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. RCS pressure control, inventory control and RCS heat removal are included in the critical safety functions. (Type B)
Containment Water Level	B	Containment level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. RCS pressure control, inventory control and RCS heat removal are included in the critical safety functions. (Type B)
Containment Pressure (Wide Range)	B, D	Containment Pressure (Wide Range) is a primary variable for monitoring critical safety function. (Type B) Containment Pressure (Wide Range) is a primary variable for monitoring the operating status for a safety system. (Type D)
Reactor Cavity Level	B	Reactor cavity level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. RCS pressure control, inventory control and RCS heat removal are included in the critical safety functions. (Type B)
Containment Isolation Valve Position	B, D	Containment Isolation Valve Position is a primary variable for monitoring critical safety function (Type B) Containment isolation valves are variables to monitor the containment integrity status. (Type D)
Logarithmic Reactor Power (Neutron Flux)	A, B	Logarithmic Reactor Power (Neutron Flux) is required for manual operator action based on the Accident Analyses. (Type A) Logarithmic Reactor Power (Neutron Flux) is a primary variable for monitoring critical safety function (Type B)

Variable	Type	Basis and analysis
CEA Position	D	These variables monitor the performance of CEDMs that affect the core reactivity. (Type D)
Containment Pressure (Extended Wide Range)	C	Containment Pressure is a primary variable for monitoring the integrity of protection barrier against fission product release. (Type C)
Containment Operating Area Radiation (For Fuel Handling Accident)	C	Containment operating area radiation is a variable for monitoring fueling handling accident during refueling operation inside containment. A breach of fuel cladding is detected by this variable. (Type C)
Spent Fuel Pool Radiation	C	Spent fuel pool radiation is a variable for monitoring fueling handling accident. A breach of fuel cladding is detected by this variable. (Type C)
Containment Upper Operating Area Radiation	C	Containment upper operating area radiation is a variable to monitor loss of coolant accident (LOCA). A breach of RCPB is detected by this variable. (Type C)
IRWST Level	B, D	IRWST is the borated water source of safety injection system (SIS) and containment spray system (CSS) during the accident. IRWST level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. (Type B) IRWST level is a monitoring variable for indicating the performance of SIS and CSS necessary for the mitigation of DBEs. (Type D)
IRWST Temperature	B, D	IRWST is the borated water source of SIS and CSS during the accident. IRWST temperature is a variable to monitor RCS pressure control, inventory control and RCS heat removal. (Type B) IRWST temperature is a monitoring variable for indicating the performance of SIS and CSS necessary for the mitigation of DBEs. (Type D)
Main Steam Automatic Depressurization Valve (MS ADV) Position	B, D	MS ADV position is a monitoring variable for verifying the RCS heat removal. Therefore, this variable meets the criteria for the selection of Type B variable in IEEE 497-2002. (Type B) MS ADV position is the monitoring variable to verify safety system status. (Type D)

Variable	Type	Basis and analysis
Auxiliary Feedwater Flow	B, D	Auxiliary feedwater flow meters are designed as safety-related and seismic Category I. It is an important parameter for monitoring the cooling capability of the RCS which is a critical safety function. Therefore, this variable meets the criteria for the selection of Type B variable in IEEE 497-2002. (Type B) Auxiliary feedwater flow is the monitoring variable of safety system to achieve a safety shutdown condition. (Type D)
POSRV Position	D	POSRV Position verifies the status of a safety system. (Type D)
CS Flow	D	Containment spray flow is a variable for monitoring containment spray operation. Containment spray flow indicates the performance of CSS necessary for the mitigation of DBEs. (Type D)
Containment Atmosphere Temperature	B, D	Containment atmosphere temperature is a variable to monitor containment atmospheric conditions. (Type B) Containment atmosphere temperature is a variable for monitoring accomplishment of cooling. This variable is used to monitor the performance of safety systems for the mitigation of DBEs. (Type D)
SI Hot Leg Injection Flow Rate	D	SI hot leg injection flow rate is a variable that monitors the operation status of safety injection pump (hot leg injection) in case of an accident. It is an indicator to monitor the operating status for a safety system. This variable is included in EOG functional recovery guide. (Type D)
Safety Injection Tank(SIT) Level	D	Safety Injection Tank(SIT) Level is a primary variable for monitoring the operating status for a safety system. (Type D)
Safety Injection Tank(SIT) Pressure	D	Safety Injection Tank(SIT) Pressure is a primary variable for monitoring the operating status for a safety system. (Type D)
Emergency Ventilation Damper Position	D	Emergency ventilation damper position is used to monitor the performance of safety systems for the mitigation of design basis events. (Type D)
Auxiliary Feedwater Storage Tank Level	D	The auxiliary feedwater storage tanks are designed to have sufficient feedwater to allow an orderly plant cooldown to shutdown cooling initiation without additional makeup. During normal plant operation, the main purpose of this variable is to confirm sufficient inventory of auxiliary feedwater for accident conditions. If an accident occurs, it is not necessary to monitor water level for additional makeup to the auxiliary feedwater storage tanks. Therefore, this variable meets the criteria for the selection of Type D variable in IEEE 497-2002. (Type D)

Variable	Type	Basis and analysis
DC Bus Voltage	D	DC bus voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Instrument Power Bus Voltage	D	Instrument power bus voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Emergency Diesel Generator Voltage	D	Emergency diesel generator voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Emergency Diesel Generator Current	D	Emergency diesel generator current is a variable for monitoring Electrical Power supplies for safety systems and safe shutdown systems. (Type D)
4.16 kV Switchgear Voltage	B, D	4.16 kV switchgear voltage is a primary variable to monitor maintenance of vital auxiliaries. Maintenance of vital auxiliaries is included in the critical safety functions. (Type B) 4.16 kV switchgear voltage is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
4.16 kV Switchgear Current	D	4.16 kV switchgear current is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
480 V L/C Voltage	D	480 V L/C voltage is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
480 V L/C Current	D	480 V L/C current is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
CCW Temperature	D	Component cooling water (CCW) system removes heat from all safety-related components necessary for the safe shutdown and the mitigation of DBEs. CCW temperature is a variable for monitoring CCW operation. This variable indicates the performance of the CCW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
CCW Flow	D	CCW system removes heat from all safety-related components necessary for the safe shutdown and the mitigation of DBEs. CCW flow is a variable for monitoring CCW operation. This variable indicates the performance of the CCW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)

Variable	Type	Basis and analysis
ESW Temperature	D	Essential service water (ESW) system removes heat from the CCW heat exchangers and transfers to the UHS. ESW temperature is a variable for monitoring ESW operation. This variable indicates the performance of the ESW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
ESW Flow	D	ESW system removes heat from the CCW heat exchangers and transfers to the UHS. ESW Flow is a variable for monitoring ESW operation. This variable indicates the performance of the ESW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
Charging Line Flow	D	Charging Line Flow is a primary variable for monitoring the status of boric acid flow to the RCS. (Type D)
Charging Line Pressure	D	Charging Line Pressure is a primary variable for monitoring the operating status for a safety system. (Type D)
Shutdown Cooling Heat Exchange Outlet Temperature	D	Shutdown Cooling Heat Exchange Outlet Temperature is a primary variable for monitoring the operating status for a safety system. (Type D)
Shutdown Cooling Pump Flow Rate	D	Shutdown Cooling Pump Flow Rate is a primary variable for monitoring the operating status for a safety system. (Type D)
SIT Discharge Isolation	D	SIT Discharge Isolation provides information of operating status for a safety system. (Type D)
CREACS Emergency ACU flow	D	CREACS Emergency ACU flow verifies the status of a safety system. (Type D)
ABCAEES Emergency ACU flow	D	ABCAEES Emergency ACU flow verifies the status of a safety system. (Type D)
FHAEES Emergency ACU flow	D	FHAEES Emergency ACU flow verifies the status of a safety system. (Type D)
SIP DVI Flow Rate	B, D	SIP DVI Flow Rate is a primary variable for monitoring critical safety function. (Type B) SIP DVI Flow Rate is a primary variable for monitoring the operating status for a safety system. (Type D)
Containment Purge Effluent	E	Containment purge effluent is used to monitor gaseous effluent in containment building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
Auxiliary Building Controlled Area HVAC Effluent	E	Auxiliary building controlled area HVAC effluent is used to monitor gaseous effluent of controlled area in auxiliary building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)

Variable	Type	Basis and analysis
Compound Building HVAC Effluent	E	Compound building HVAC effluent is used to monitor gaseous effluent in compound building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
Condenser Vacuum Vent Effluent Radiation	E	Condenser vacuum vent effluent radiation is used to monitor SG tube leakage. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
MCR and TSC Area Radiation	E	MCR and TSC area radiation is used to monitor radiation level and radioactivity in the control room. (Type E)
Normal primary sample Room Area Radiation	E	Normal primary sample room area radiation is used to monitor selected plant areas where access is required for plant recovery. (Type E)
Radiochemistry Lab. Area Radiation	E	Radiochemistry laboratory area radiation is used to monitor selected plant areas where access is required for plant recovery. (Type E)
Wind Direction	E	Wind direction is required to monitor environmental conditions used to determine the impact of releases of radioactive materials through identified pathways. (Type E)
Wind Speed	E	Wind speed is required to monitor environmental conditions used to determine the impact of releases of radioactive materials through identified pathways. (Type E)
Atmosphere Stability Temperature Difference	E	Atmosphere stability temperature difference is required to monitor environmental conditions used to determine the impact of releases of radioactive materials. (Type E)
Main Steam Line Radiation	E	Main steam line radiation is used to monitor the magnitude of releases of radioactive materials through identified pathways. (Type E)
High Energy Line Break Area ACU Inlet Radiation	E	High Energy Line Break Area ACU Inlet Radiation is used to monitor radiation releases from the breaks of high energy piping. (Type E)
Auxiliary Building Controlled Area (I,II) HVAC Normal/Emergency Exhaust ACU Inlet Radiation	E	Auxiliary Building Controlled Area (I,II) HVAC Normal/Emergency Exhaust ACU Inlet Radiation is used to monitor radiation leakage in the gaseous effluent from the controlled area. (Type E)
Containment Air Radiation	E	Containment Air Radiation is used to monitor the unidentified leakage from RCS. (Type E)
Fuel Handling Area HVAC Effluent Radiation	E	Fuel Handling Area HVAC Effluent Radiation is used to monitor the radioactivity in the HVAC effluents from the fueling handling area. (Type E)

Variable	Type	Basis and analysis
Compound Building Hot Machine Shop Radiation	E	Compound Building Hot Machine Shop Radiation is used to monitor radioactive releases of identified pathways from the hot machine shop. (Type E)
Steam Generator Blowdown Radiation	E	Steam Generator Blowdown Radiation is used to monitor radioactive leakage of identified pathways from SG blowdown stream. (Type E)
Post-accident Primary Sample Room Radiation	E	Post-accident Primary Sample Room Radiation is used to monitor selected plant area where access is required for plant recovery. (Type E)

Impact on DCD

Table 2.5.3-2 and Table 2.5.4-6 of the APR1400 DCD Tier 1 and Section 7.5 of APR1400 DCD Tier 2 will be revised as indicated in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

Table 3.3.11-1 and the Bases for TS 3.3.11 of the APR1400 DCD Tier 2 will be revised as indicated in the Attachment.

Impact on Technical /Topical/Environmental Reports.

The Safety I&C System Technical Report, APR1400-Z-J-NR-14001-NP and APR1400-Z-J-NR-14002-NP, will be revised as indicated in the Attachment.

Table 2.5.3-2

Accident Monitoring Instrumentation Variables

Variable
Pressurizer pressure (wide range)
Pressurizer level
Cold leg temperature (wide range)
Hot leg temperature (wide range)
Steam generator pressure
Steam generator level (wide range)
Core exit temperature
RCS ~~subcooling~~ saturation margin
CET ~~subcooling~~ saturation margin
Reactor vessel upper head ~~subcooling~~ saturation margin
Safety injection pump DVI flow rate
Reactor vessel level (RV closure head level/RV plenum level)
Reactor coolant system pressure (wide range)
IRWST level
IRWST temperature
Holdup volume tank level
Containment water level
Containment pressure (wide range)
Reactor cavity level
Containment isolation valve position
Logarithmic reactor power (neutron flux)
Containment upper operating area radiation
Containment pressure (extended wide range)
Containment operating area radiation (for fuel handling accident)
Spent fuel pool radiation
MS ADV position
Auxiliary feedwater flow
Hydrogen concentration
4.16 kV switchgear voltage
Containment atmosphere temperature

Table 2.5.4-6

<u>Control for Credited Manual Operator Action</u>

Variables	Operator Action	Control/Component
- Pressurizer Pressure (Wide Range) - Pressurizer Level	Close letdown line containment isolation valve (Diagnosis of letdown line break)	[CVCS] - Letdown Line CIV
- Pressurizer Pressure (Wide Range) - Pressurizer Level - SG Pressure - SG level (Wide Range)	Isolation of SG atmospheric dump valve of affected SG (Diagnosis of steam generator tube rupture (SGTR))	- SG 1 MSADV - SG 2 MSADV
- Pressurizer Pressure (Wide Range) - Pressurizer Level - SG Pressure - SG Level (Wide Range) - Hot Leg Temperature (Wide Range) - Cold Leg Temperature (Wide Range) - Reactor Coolant System (RCS) ~~Subcooling~~ Saturation Margin - Core Exit Temperature (CET) ~~Subcooling~~ Saturation Margin	Termination of safety injection for SGTR	[Stop SIP-1,2,3,4] - SI Pump 1 - SI Pump 2 - SI Pump 3 - SI Pump 4
- SG Pressure - SG Level (Wide Range)	Termination of auxiliary feedwater (AFW) for main steam line break and main feedwater line break	[Stop AFWPs] - AFW Pump A Motor Driven - AFW Pump B Motor Driven - AFW Turbine A Reset - AFW Turbine B Reset
- Logarithmic Reactor Power (Neutron Flux)	Stop charging pump (Terminate chemical and volume control system (CVCS) charging flow for boron dilution event)	[Stop Charging Pump 1,2] - Charging Pump A - Charging Pump B

LIST OF TABLES

NUMBER	TITLE	PAGE
Table 7.1-1	Regulatory Requirements Applicability Matrix	7.1-36
Table 7.2-1	Reactor Protection System Operating Bypass Permissive	7.2-38
Table 7.2-2	Reactor Protection System Monitored Plant Variable Ranges	7.2-39
Table 7.2-3	Reactor Protection System Sensors	7.2-40
Table 7.2-4	Reactor Protection System Design Inputs	7.2-41
Table 7.2-5	Reactor Protective Instrumentation Response Time	7.2-43
Table 7.2-6	Critical Function Success Path Diversity	7.2-45
Table 7.2-7	Failure Modes and Effects Analysis for the Plant Protection System	7.2-46
Table 7.3-1	ESFAS Operating Bypass Permissive	7.3-38
Table 7.3-2	Design Basis Events Requiring ESF System Action	7.3-39
Table 7.3-3	Monitored Variables for ESFAS Signals	7.3-40
Table 7.3-4	ESFAS Sensors	7.3-41
Table 7.3-5A	NSSS ESFAS Setpoints and Margins to Actuation	7.3-42
Table 7.3-5B	BOP ESFAS Setpoints and Margins to Actuation	7.3-43
Table 7.3-6	ESFAS Variable Ranges	7.3-44
Table 7.3-7	ESF Response Time	7.3-45
Table 7.3-8	Failure Modes and Effects Analysis for the Engineered Safety Features-Component Control System	7.3-48
Table 7.4-1	Remote Shutdown Console Instrumentation and Controls for Hot Shutdown	7.4-14
Table 7.4-2	Remote Shutdown Console Instrumentation and Controls for Cold Shutdown	7.4-18
Table 7.5-1	Accident Monitoring Instrumentation Variables	7.5-18
Table 7.6-1	Shutdown Cooling System and Safety Injection Tank Interlock	7.6-18
Table 7.6-2	CCW Supply and Return Header Tie Line Isolation Interlocks	7.6-19
Table 7.7-1	Control Groups for the NSSS Control Functions	7.7-43
Table 7.7-2	Control Limit and Interlocks on Digital Rod Control System	7.7-44

Table 7.5-2 Basis and Analysis of Selection for AMI Variables

7.5.1.1 Accident Monitoring Instrumentation

The AMI listed in Table 7.5-1 is provided to allow the operator to assess the state of the plant following design basis events by monitoring instruments, equipment, or systems that provide automatic action.

The AMI is designed to meet the guidance of NRC Regulatory Guide (RG) 1.97 (Reference 1), as depicted in Figure 7.5-1 and as follows:

a. The qualified indication and alarm system - P (QIAS-P) is dedicated to continuously monitor and display AMI Type A, B and C variables. The QIAS-P in each division (A or B) has one flat panel display, which is mounted on a safety console in the MCR.

b. The qualified indication and alarm system - non-safety (QIAS-N) is designed to support continuous plant operation if the information processing system (IPS) becomes unavailable. The function of the QIAS-N also includes displaying AMI Type A, B, C, and selected sets of Type D and E variables.

c. The IPS provides displays for all AMI variables. The IPS also has a historical data storage, retrieval, and trending capability.

The combined license (COL) applicant is to provide a description of the site-specific AMI variables such as wind direction, wind speed, and atmosphere stability temperature difference (COL 7.5(1)).

Insert "A" on following pages

Qualified Indication and Alarm System – P

The QIAS-P provides the continuous display of AMI Type A, B and C variables. The QIAS-P fulfills the requirements in NUREG-0737, Item II.F.2 (Reference 2), and NRC RG 1.97. To address these requirements, the ICC monitoring and display of the QIAS-P performs the following functions:

a. Core exit thermocouple (CET) temperature signal processing and display

b. Primary coolant ~~subcooling~~ saturation margin calculation and display

c. Heated junction thermocouple (HJTC) signal processing, display and HJTC heater power control

Basis and Analysis to Select AMI Variables

The Table 7.5-2 provides basis and analysis of selection for AMI variables. AMI variables are selected in accordance with IEEE Std. 497-2002, which is endorsed by RG 1.97, Rev. 4.

The basis and analysis for selecting each AMI variable are described as follows:

Type A

Type A variables are those variables that provide the primary information required to permit the control room operating staff to:

a) Take specific planned manually-controlled actions for which no automatic control is provided and that are required for safety systems to perform their safety-related functions as assumed in the plant Accident Analysis Licensing Basis.

b) Take specific planned manually-controlled actions for which no automatic control is provided and that are required to mitigate the consequences of an AOO.

"A"

Type B

Type B variables are those variables that provide primary information to the control room operators to assess the plant critical safety functions.

Any plant critical safety functions addressed in the emergency operation guidelines (EOGs) that are in addition to those identified above are also included.

In order to select Type B variables for meeting the requirements in IEEE Std.497-2002 (endorsed by RG 1.97, Rev. 4), the EOGs are reviewed. The plant critical safety functions described in the EOGs include those of IEEE Std.497-2002. EOGs provide the plant critical safety functions to be verified for each event and the criteria for deciding the plant critical safety functions.

The plant critical safety functions described in the EOG are as follows:

- Reactivity control
- Maintenance of vital auxiliaries
- Reactor coolant system (RCS) inventory control
- RCS pressure control
- Core heat removal
- RCS heat removal
- Containment isolation
- Containment temperature and pressure control
- Containment combustible gas control

Type C

Type C variables are those variables that provide primary information to the control room operators to indicate the potential for breach, or the actual breach of the three fission product barriers (extended range): fuel cladding, reactor coolant system pressure boundary, and containment pressure boundary.

The selection of these variables represents a minimum set of plant variables that provide the most direct indication of the integrity of the three fission product barriers and provide the capability for monitoring beyond the normal operating range.

"A" (Cont.)

Type D

Type D variables are those variables that are required in procedures and licensing basis documentation to:

- Indicate the performance of those safety systems and auxiliary supporting features necessary for the mitigation of design basis events (DBEs).
- Indicate the performance of other systems necessary to achieve and maintain a safe shutdown condition.
- Verify safety system status.

The Type D variables are based upon the plant accident analysis licensing basis and those necessary to implement the EOGs.

The resource tree of the EOG functional recovery guides describes the systems, including instruments and components, that are required for recovering the plant critical safety functions. Those instruments and components, as well as the variables required for verifying the system-base safety function performance, were selected as Type D variables.

Type E

Type E variables are those variables required for use in determining the magnitude of the release of radioactive materials and continually assessing such releases.

The selection of these variables includes, but are not limited to the following:

- Monitor the magnitude of releases of radioactive materials through identified pathways (e.g., secondary safety valves, and condenser air ejector).
- Monitor the environmental conditions used to determine the impact of releases of radioactive materials through identified pathways (e.g., wind speed, wind direction, and air temperature).
- Monitor radiation levels and radioactivity in the plant environs.
- Monitor radiation levels and radioactivity in the control room and selected plant areas where access may be required for plant recovery.

"A" (Cont.)

The QIAS-P provides an unambiguous indication of ICC and advanced warning of the approach of ICC.

saturation

The QIAS-P calculates a representative CET temperature from the CETs.

The QIAS-P calculates reactor coolant ~~subcooling~~ margins based on the CET temperatures, the hot and cold leg temperatures, the HJTC temperature measurements from the reactor vessel head region, and pressurizer pressure. The QIAS-P controls the power for the HJTC heaters. The heater power control devices are located in the QIAS-P cabinet. Heater control for the HJTC is manually switched from the QIAS-P channel A only to the diverse indication system (DIS) via DIS switch on safety console. The QIAS-P also calculates the reactor vessel level based on the HJTC signals.

The QIAS-P provides backup displays for the ICC variables. The primary displays for ICC variables are implemented in the safety parameter display and evaluation system + (SPADES+) within the IPS.

The QIAS-P receives Type A, B and C variables from the plant protection system (PPS), engineered safety features - component control system (ESF-CCS) via a safety system data network (SDN) and auxiliary process cabinet - safety (APC-S) and process instrumentation via a hardwired connection.

The QIAS-P has divisionalized cabinets for divisions A and B. The QIAS-P cabinets for each division are physically located in divisionalized I&C equipment rooms to meet the requirements of IEEE Std. 603 (Reference 3).

The QIAS-P generates alarms and sends them to the QIAS-N and IPS.

Qualified Indication and Alarm System – Non-Safety

The QIAS-N displays the safety parameters and key operating parameters to be used by the operators during both normal operation and accidents. The QIAS-N displays parameter values and alarms using signal validation, alarm filtering, alarm suppression, and alarm prioritization.

The QIAS-N consists of the following equipment:

a. QIAS-N redundant processors

saturation

The signals from the resistance temperature detectors (RTDs), unheated thermocouples in the HJTC system, CET temperature, and pressure sensors are used to calculate the loss of ~~subcooling,~~ occurrence of saturation, and achievement of a subcooled condition following core recovery.

The reactor vessel level monitors provide information to the operator on the decreasing liquid inventory in the reactor vessel (RV) regions above the fuel alignment plate (FAP), as well as the increasing RV liquid inventory above the FAP following core recovery from the ICC.

The CETs monitor the increasing RCS temperatures associated with the ICC and the decreasing RCS temperature associated with recovery from the ICC.

SPADES+ is designed to meet the criteria for SPDS set forth in NUREG-0696 (Reference 4) and NUREG-0737, Supplement No. 1 (Reference 5). The SPADES+ displays ICC variables as a primary display. The QIAS-P provides a backup display of the ICC variables as a backup.

a. Primary ICC displays

The ICC variables are incorporated into the SPADES+ and alarm logic of the IPS. The SPADES+ is a computer applications program of the IPS, and provides a primary display of ICC information.

The critical safety functions are monitored by a set of algorithms that process the measured plant variables to determine the plant safety status relative to safety function control. If any of the critical functions are violated (by exceeding logic setpoints), a critical function alarm is initiated. The calculated ICC outputs are incorporated into the core heat removal critical function alarm logic.

The SPADES+ of the IPS has an ICC summary page as part of the core heat removal control critical function, and more detailed display pages for each of the ICC variables.

saturation

The summary page includes the following information:

1) RCS/RV upper head ~~subcooling~~ margin – the lower value of either the RCS ~~subcooling~~ margin or RV upper head ~~subcooling~~ margin

2) Reactor vessel level above the core

3) Representative core exit temperature

b. Backup ICC displays

The QIAS-P provides Class 1E backup displays for ICC variables, and is seismically and environmentally qualified. The displays of ICC variables are dedicated and integrated following the guidance of the Style Guide (Reference 6).

The QIAS-P displays are designed as follows:

1) To provide display of ICC variables

2) To provide indications in the event that the primary display becomes inoperable

3) To provide confirmatory indication to the primary display

The following information is available on the QIAS-P display pages:

1) RCS/RV upper head ~~subcooling~~ saturation margin

2) Reactor vessel level above the core

3) Representative core exit temperature

7.5.1.3 Bypassed and Inoperable Status Indication

The bypass and inoperable status indication (BISI) is a non-safety system because it is not required to operate during design basis accident (DBA) conditions to mitigate the accidents.

System-level automatic bypass indication is provided based on the guidance of NRC RG 1.47 (Reference 7). Compliance with NRC RG 1.47 is described as follows:

a. Flags are provided to indicate, at the system level, the bypass or deliberate inoperability of a protection system. The system-level alarms are actuated when a component actuated by a protection system is bypassed or deliberately rendered inoperable.

Table 7.5-1 (1 of 6)

Accident Monitoring Instrumentation Variables

Variable	Range	Monitored Function or System(1)	Number of Sensors	Type	Ambiguity (Division)
Pressurizer Pressure (Wide Range)	0 to 210.9 kg/cm^2A (0 to 3,000 psia)	Pressurizer	2	A, B	C,D (PPS OM)
Pressurizer Level	0 to 100 % (0 to 562.15 in)	Pressurizer	2	A, B, D	C (IPS)
Hot Leg Temperature (Wide Range)	0 to 400°C (32 to 752 °F)	RCS	4	A, B, D	C,D (PPS OM)
Cold Leg Temperature (Wide Range)	0 to 400°C (32 to 752 °F)	RCS	4	A, B, D	C,D (PPS OM)
Steam Generator Pressure	0 to 105 kg/cm^2A (0 to 1,494 psia)	Steam Generator	2/SG	A, B, D	C,D (PPS OM)
Steam Generator Level (Wide Range)	0 to 100 % (0 to 1117.6cm (0 to 440 in tap span)	Steam Generator	2/SG	A, B, D	C,D (PPS OM)
Core Exit Temperature	0 to 1260 °C (32 to 2,300 °F)	Inadequate Core Cooling	2	B, C	Validation (QIAS-P)
RCS ~~Subcooling~~ Satruation Margin	Temp. Margin : -399 to 358.3°C Press. Margin : -225.5 to 210.9 kg/cm^2	Inadequate Core Cooling	2	A, B	Validation (QIAS-P)
CET ~~Subcooling~~ Saturation Margin	Temp. Margin : -1,260 to 368.3°C Press. Margin : -225.5 to 210.9 kg/cm^2	Inadequate Core Cooling	2	A, B	Validation (QIAS-P)
RV Upper Head ~~Subcooling~~ Saturation Margin	Temp. Margin : -1,260 to 368.3°C Press. Margin : -225.5 to 210.9 kg/cm^2	Inadequate Core Cooling	2	B	Validation (QIAS-P)
Reactor Vessel Level (RV closure head level/RV plenum level)	0 to 100 %	RCS	2	B	Validation (QIAS-P)
Hydrogen Concentration	0 to 15 %	Combustible gas control	2	B	Validation (QIAS-P)

Table 7.5-1 (2 of 6)

Variable	Range	Monitored Function or System[(1)]	Channel Number	Type	Ambiguity (Division)
RCS Pressure	0 to 281.2 kg/cm^2G (0 to 4,000 psig)	RCS	2	C, D	Pressurizer Pressure A, B, C, D (PPS OM)
IRWST Level	0 to 100 %	IRWST	4	B, D	C,D (ESCM)
IRWST Temperature	10 to 177 °C (50 to 350 °F)	IRWST	4	B, D	C,D (ESCM)
Holdup Volume Tank Level	0 to 100 %	IRWST	4	B	C,D (ESCM)
Containment Water Level	0 to 100 %	Containment monitoring system	2	B	C,D (ESCM)
Containment Pressure (Wide Range)	-400 to 5,600 cmH_2O (-5.7 to 79.5 psig)	Maintaining containment integrity	2	B, D	C,D (PPS OM)
Reactor Cavity Level	0 to 100%	Maintaining containment integrity	4	B	C,D (ESCM)
Containment Isolation Valve Position	N/A	Maintaining containment integrity	1 pair/ valve	B, D	Validation (QIAS-P)
Logarithmic Reactor Power (neutron flux)	2×10^{-8} to 200 % power	Reactor power	2	A, B	C,D (PPS OM)
CEA Position	0 to 381 cm (0 to 150 in)	Reactivity control	1/rod	D	N/A
Containment Pressure (Extended Wide Range)	-500 to 14,500 cmH_2O (-7.1 to 206.2 psig)	Fission product release	2	C	PPS Containment pressure A,B,C,D (PPS OM)
Containment Operating Area Radiation (For Fuel Handling Accident)	Refer to range information for Tag No. RE-231A and RE-232B in Table 12.3-6.	Monitoring fueling handling accident	2	C	C,D (ESCM)
Spent Fuel Pool radiation	Refer to range information for Tag No. RE-241A and RE-242B in Table 12.3-6.	Monitoring fueling handling accident	2	C	C,D (ESCM)

Table 7.5-1 (3 of 6)

Variable	Range	Monitored Function or System[(1)]	Channel Number	Type	Ambiguity (Division)
Containment Upper Operating Area Radiation	Refer to range information for Tag No. RE-233A and RE-234B in Table 12.3-6.	Monitoring LOCA	2	C	C,D (ESCM)
MS ADV Position	N/A	Monitoring position of MS ADV actuation	4	B,D	A, B, C, D
Auxiliary Feedwater Flow	0 to 3,600 lpm (0 to 950 gpm)	Monitoring auxiliary feedwater flow	4	B, D	A, B, C, D
POSRV Position	N/A	Verifying status of a safety system	1/valve	D	N/A
CS Flow	0 to 28,400 lpm (0 to 7,500 gpm)	Monitoring CS operation	2	D	N/A
Containment Atmosphere Temperature	4.44 to 204.44 °C (40 to 400 °F)	Monitoring accomplishment of cooling	13	B, D	N/A
SI Hot Leg Injection Flow Rate	0 to 5,678 lpm (0 to 1,500 gpm)	Monitoring the operating status for a safety system	2	D	N/A
Safety Injection Tank Level	0 to 100 % (402 inch full scale)	Monitoring a boron injection potential	4	D	N/A
Safety Injection Tank Pressure	0 to 53 kg/cm^2g (0 to 750 psig)	Monitoring a boron injection potential	4	D	N/A
Emergency Ventilation Damper Position	N/A	Prevention of radiation effluent release	1 pair/ damper	D	N/A
Auxiliary Feedwater Storage Tank Level	0 to 100%	Monitoring level of auxiliary feedwater storage tank	2	D	N/A
DC Bus Voltage	0 to 150 Vdc	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
Instrument Power Bus Voltage	0 to 150 Vdc	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
CREACS Emergency ACU flow	0 to 13,592 cmh (0 to 8,000 cfm)	Verifying the status of a safety system	4	D	N/A

Table 7.5-1 (4 of 6)

Variable	Range	Monitored Function or System[(1)]	Channel Number	Type	Ambiguity (Division)
ABCAEES Emergency ACU flow	0 to 5,097 cmh (0 to 3,000 cfm)	Verifying the status of a safety system	4	D	N/A
FHAEES Emergency ACU flow	0 to 8,495 cmh (0 to 5,000 cfm)	Verifying the status of a safety system	2	D	N/A
Emergency Diesel Generator Voltage	0 to 5,250 Vac	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
Emergency Diesel Generator Current	0 to 2,000 Amps	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
4.16 kV Switchgear Voltage	0 to 5,250 Vac	Electrical power supplies for safety system and safe shutdown system	4	B, D	N/A
4.16 kV Switchgear Current	0 to 2,000 Amps	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
480 V L/C Voltage	0 to 600 Vac	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
480 V L/C Current	0 to 3,000 Amps	Electrical power supplies for safety system and safe shutdown system	4	D	N/A
CCW Temperature	0 to 100 °C (32 to 212 °F)	Monitoring CCWS operation	1/division	D	N/A
CCW Flow	0 to 110% design flow	Monitoring CCWS operation	1/pump	D	N/A
ESW Temperature	0 to 50 °C (32 to 122 °F)	Monitoring ESW operation	1/division	D	N/A
ESW Flow	0 to 120% design flow	Monitoring ESW operation	1/pump	D	N/A
Charging Line Flow	0 to 750 lpm (0 to 198 gpm)	Monitoring the status of boric acid flow to RCS	1	D	N/A
Charging Line Pressure	0 to 220 kg/cm^2G (0 to 3,129 psig)	Monitoring the status of boric acid flow to RCS	1	D	N/A

Table 7.5-1 (5 of 6)

Variable	Range	Monitored Function or System(1)	Channel Number	Type	Ambiguity (Division)
Shutdown Cooling Heat Exchange Outlet Temperature	0 to 200°C (40 to 392°F)	Monitor the operating status for a safety system	2	D	N/A
Shutdown Cooling Pump Flow Rate	0 to 25,000 lpm (0 to 6,604 gpm)	Monitor the operating status for a safety system	2	D	N/A
SIT Discharge Isolation	N/A	Monitor the operating status for a safety system	4	D	N/A
SIP DVI Flow Rate	0 to 5,678 lpm (0 to 1,500 gpm)	Monitor the operating status for a safety system	4	B, D	Validation (QIAS-P)
Containment Purge Effluent	Refer to range information for Tag No. RE-037 in Table 11.5-1.	Monitoring gaseous effluent in containment building	1	E	N/A
Auxiliary Building Controlled Area HVAC Effluent	Refer to range information for Tag No. RE-015, 016, 019, and 020 in Table 11.5-1.	Monitoring gaseous effluent of controlled area in AUX. building	2	E	N/A
Compound Building HVAC Effluent	Refer to range information for Tag No. RE-08~~3~~2 in Table 11.5-	Monitoring gaseous effluent in compound building	1	E	N/A
Condenser Vacuum Vent Effluent Radiation	Refer to range information for Tag No. RE-063 in Table 11.5-1.	Monitoring SG tube leakage	1	E	N/A
MCR and TSC Area Radiation	Refer to range information for Tag No. RE-275 and RE-279 in Table 12.3-6.	Monitoring area radiation level	1	E	N/A
Normal Primary Sample~~ing~~ Room Area Radiation	Refer to range information for Tag No. RE-285 in Table 12.3-6.	Monitoring area radiation level	1	E	N/A
Radiochemistry Lab. Area Radiation	Refer to range information for Tag No. RE-257 in Table 12.3-6.	Monitoring area radiation level	1	E	N/A
Wind Direction	0 to 360°	Release assessment	1	E	N/A
Wind Speed	0 to 50 mph	Release assessment	1	E	N/A

Table 7.5-1 (6 of 6)

Variable	Range	Monitored Function or System(1)	Channel Number	Type	Ambiguity (Division)
Atmosphere Stability Temperature Difference	-22.78 to -7.78°C (-9 to +18°F) Delta-T	Release assessment	2	E	N/A
Main Steam Line Radiation	Refer to range information for Tag No's. RE-217 through RE-220 in Table 11.5-1.	Monitoring leakage of steam generator	4	E	N/A
High Energy Line Break Area ACU Inlet Radiation	Refer to range information for Tag No. RE-007 in Table 11.5-1.	Monitoring gaseous effluent of high-energy line break area in AUX building	1	E	N/A
Auxiliary Building Controlled Area (I,II) HVAC Normal/Emergency Exhaust ACU Inlet Radiation	Refer to range information for Tag No. RE-013,014,017, and 018 in Table 11.5-1.	Monitoring gaseous effluent of controlled area in AUX.building	2	E	N/A
Containment Air Radiation	Refer to range information for Tag No. RE-039A and 40B in Table 11.5-1.	Monitoring the un identified leakage from RCS	2	E	N/A
Fuel Handling Area HVAC Effluent Radiation	Refer to range information for Tag No. RE-043 in Table 11.5-1.	Monitoring gaseous effluent of fuel handling area in AUX.building	1	E	N/A
Compound Building Hot Machine Shop Radiation	Refer to range information for Tag No. RE-293 in Table 12.3-6.	Monitoring gaseous effluent of hot machine shop in compound building	1	E	N/A
Steam Generator Blowdown Radiation	Refer to range information for Tag No. RE-104 in Table 11.5-2.	Monitoring SG tube leakage	1	E	N/A
Post-accident Primary Sample Room Radiation	Refer to range information for Tag No. RE-205 in Table 12.3-6.	Monitoring area radiation level	1	E	N/A

(1) Parameters to monitor critical safety functions in SPADES+ as described in Section 7.7 are confirmed by functional requirements analysis as described in Section 18.3

Insert "B" on following pages

"B" → Table 7.5-2

Basis and Analysis of Selection for AMI Variables

Variable	Type	Basis and analysis
Pressurizer Pressure (Wide Range)	A, B	Pressurizer Pressure (Wide Range) is required for manual operator action based on the Accident Analyses. (Type A) Pressurizer Pressure (Wide Range) is a primary variable for monitoring critical safety function. (Type B)
Pressurizer Level	A, B, D	Pressurizer Level is required for manual operator action based on the Accident Analyses. (Type A) Pressurizer Level is a primary variable for monitoring critical safety function. (Type B) Pressurizer Level verifies the status of a safety system. (Type D)
Hot Leg Temperature (Wide Range)	A, B, D	Hot Leg Temperature (Wide Range) is required for manual operator action based on the Accident Analyses. (Type A) Hot Leg Temperature (Wide Range) is a primary variable for monitoring critical safety function. (Type B) Hot Leg Temperature (Wide Range) verifies the status of a safety system. (Type D)
Cold Leg Temperature (Wide Range)	A, B, D	Cold Leg Temperature (Wide Range) is required for manual operator action based on the Accident Analyses (Type A) Cold Leg Temperature (Wide Range) is a primary variable for monitoring critical safety function (Type B) Cold Leg Temperature (Wide Range) verifies the status of a safety system. (Type D)
Steam Generator Pressure	A, B, D	Steam Generator Pressure is required for manual operator action based on the Accident Analyses. (Type A) Steam Generator Pressure is a primary variable for monitoring critical safety function. (Type B) Steam Generator Pressure verifies the status of a safety system. (Type D)
Steam Generator Level (Wide Range)	A, B, D	Steam Generator Level (Wide Range) is required for manual operator action based on the Accident Analyses. (Type A) Steam Generator Level (Wide Range) is a primary variable for monitoring critical safety function. (Type B) Steam Generator Level (Wide Range) verifies the status of a safety system. (Type D)
RCS Saturation Margin	A, B	RCS Saturation Margin is required for manual operator action based on the Accident Analyses. (Type A) RCS Saturation Margin is a primary variable for monitoring critical safety function. (Type B)

"B" (Cont.) Table 7.5-2

Basis and Analysis of Selection for AMI Variables

Variable	Type	Basis and analysis
CET Saturation Margin	A, B	CET Saturation Margin is required for manual operator action based on the Accident Analyses. (Type A) CET Saturation Margin is a primary variable for monitoring critical safety function. (Type B)
RV Upper Head Saturation Margin	B	RV Upper Head Saturation Margin is a primary variable for monitoring critical safety function. (Type B)
Hydrogen Concentration	B	Hydrogen Concentration is a primary variable to support containment combustible gas control of critical safety function. (Type B)
Core Exit Temperature (CET)	B, C	Core Exit Temperature (CET) is a primary variable for monitoring critical safety function. (Type B) Core Exit Temperature (CET) is an indicator for probable breach of cladding. (Type C)
Reactor Vessel Level (RV Closure Head Level/RV plenum Level)	B	Reactor Vessel Level (RV Closure Head Level/RV plenum Level) is a primary variable for monitoring critical safety function. (Type B)
RCS Pressure	C, D	RCS Pressure is a primary variable for monitoring RCPB integrity and breach of the RCPB. (Type C) RCS Pressure verifies the status of a safety system. (Type D)
Holdup Volume Tank Level	B	Holdup volume tank level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. RCS pressure control, inventory control and RCS heat removal are included in the critical safety functions. (Type B)
Containment Water Level	B	Containment level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. RCS pressure control, inventory control and RCS heat removal are included in the critical safety functions. (Type B)
Containment Pressure (Wide Range)	B, D	Containment Pressure (Wide Range) is a primary variable for monitoring critical safety function. (Type B) Containment Pressure (Wide Range) is a primary variable for monitoring the operating status for a safety system. (Type D)
Reactor Cavity Level	B	Reactor cavity level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. RCS pressure control, inventory control and RCS heat removal are included in the critical safety functions. (Type B)

"B" (Cont.)

Table 7.5-2

Basis and Analysis of Selection for AMI Variables

Variable	Type	Basis and analysis
Containment Isolation Valve Position	B, D	Containment Isolation Valve Position is a primary variable for monitoring critical safety function (Type B) Containment isolation valves are variables to monitor the containment integrity status. (Type D)
Logarithmic Reactor Power (Neutron Flux)	A, B	Logarithmic Reactor Power (Neutron Flux) is required for manual operator action based on the Accident Analyses. (Type A) Logarithmic Reactor Power (Neutron Flux) is a primary variable for monitoring critical safety function. (Type B)
CEA Position	D	These variables monitor the performance of CEDMs that affect the core reactivity. (Type D)
Containment Pressure (Extended Wide Range)	C	Containment Pressure is a primary variable for monitoring the integrity of protection barrier against fission product release. (Type C)
Containment Operating Area Radiation (For Fuel Handling Accident)	C	Containment operating area radiation is a variable for monitoring fueling handling accident during refueling operation inside containment. A breach of fuel cladding is detected by this variable. (Type C)
Spent Fuel Pool Radiation	C	Spent fuel pool radiation is a variable for monitoring fueling handling accident. A breach of fuel cladding is detected by this variable. (Type C)
Containment Upper Operating Area Radiation	C	Containment upper operating area radiation is a variable to monitor loss of coolant accident (LOCA). A breach of RCPB is detected by this variable. (Type C)
IRWST Level	B, D	IRWST is the borated water source of safety injection system (SIS) and containment spray system (CSS) during the accident. IRWST level is a variable to monitor RCS pressure control, inventory control and RCS heat removal. (Type B) IRWST level is a monitoring variable for indicating the performance of SIS and CSS necessary for the mitigation of DBEs. (Type D)
IRWST Temperature	B, D	IRWST is the borated water source of SIS and CSS during the accident. IRWST temperature is a variable to monitor RCS pressure control, inventory control and RCS heat removal. (Type B) IRWST temperature is a monitoring variable for indicating the performance of SIS and CSS necessary for the mitigation of DBEs. (Type D)

"B" (Cont.)

Table 7.5-2

Basis and Analysis of Selection for AMI Variables

Variable	Type	Basis and analysis
Main Steam Automatic Depressurization Valve (MS ADV) Position	B, D	MS ADV position is a monitoring variable for verifying the RCS heat removal. Therefore, this variable meets the criteria for the selection of Type B variable in IEEE 497-2002. (Type B) MS ADV position is the monitoring variable to verify safety system status. (Type D)
Auxiliary Feedwater Flow	B, D	Auxiliary feedwater flow meters are designed as safety-related and seismic Category I. It is an important parameter for monitoring the cooling capability of the RCS which is a critical safety function. Therefore, this variable meets the criteria for the selection of Type B variable in IEEE 497-2002. (Type B) Auxiliary feedwater flow is the monitoring variable of safety system to achieve a safety shutdown condition. (Type D)
POSRV Position	D	POSRV Position verifies the status of a safety system. (Type D)
CS Flow	D	Containment spray flow is a variable for monitoring containment spray operation. Containment spray flow indicates the performance of CSS necessary for the mitigation of DBEs. (Type D)
Containment Atmosphere Temperature	B, D	Containment atmosphere temperature is a variable to monitor containment atmospheric conditions. (Type B) Containment atmosphere temperature is a variable for monitoring accomplishment of cooling. This variable is used to monitor the performance of safety systems for the mitigation of DBEs. (Type D)
SI Hot Leg Injection Flow Rate	D	SI hot leg injection flow rate is a variable that monitors the operation status of safety injection pump (hot leg injection) in case of an accident. It is an indicator to monitor the operating status for a safety system. This variable is included in EOG functional recovery guide. (Type D)
Safety Injection Tank (SIT) Level	D	Safety Injection Tank (SIT) Level is a primary variable for monitoring the operating status for a safety system. (Type D)
Safety Injection Tank (SIT) Pressure	D	Safety Injection Tank (SIT) Pressure is a primary variable for monitoring the operating status for a safety system. (Type D)
Emergency Ventilation Damper Position	D	Emergency ventilation damper position is used to monitor the performance of safety systems for the mitigation of design basis events. (Type D)

"B" (Cont.)

Table 7.5-2

Basis and Analysis of Selection for AMI Variables

Variable	Type	Basis and analysis
Auxiliary Feedwater Storage Tank Level	D	The auxiliary feedwater storage tanks are designed to have sufficient feedwater to allow an orderly plant cooldown to shutdown cooling initiation without additional makeup. During normal plant operation, the main purpose of this variable is to confirm sufficient inventory of auxiliary feedwater for accident conditions. If an accident occurs, it is not necessary to monitor water level for additional makeup to the auxiliary feedwater storage tanks. Therefore, this variable meets the criteria for the selection of Type D variable in IEEE 497-2002. (Type D)
DC Bus Voltage Instrument Power Bus Voltage	D D	DC bus voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D) Instrument power bus voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Emergency Diesel Generator Voltage	D	Emergency diesel generator voltage is variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
Emergency Diesel Generator Current	D	Emergency diesel generator current is a variable for monitoring Electrical Power supplies for safety systems and safe shutdown systems. (Type D)
4.16 kV Switchgear Voltage	B, D	4.16 kV switchgear voltage is a primary variable to monitor maintenance of vital auxiliaries. Maintenance of vital auxiliaries is included in the critical safety functions. (Type B) 4.16 kV switchgear voltage is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
4.16 kV Switchgear Current	D	4.16 kV switchgear current is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
480 V L/C Voltage	D	480 V L/C voltage is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)
480 V L/C Current	D	480 V L/C current is a variable for monitoring electrical power supplies for safety systems and safe shutdown systems. (Type D)

"B" (Cont.)

Table 7.5-2

Basis and Analysis of Selection for AMI Variables

Variable	Type	Basis and analysis
CCW Temperature	D	Component cooling water (CCW) system removes heat from all safety-related components necessary for the safe shutdown and the mitigation of DBEs. CCW temperature is a variable for monitoring CCW operation. This variable indicates the performance of the CCW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
CCW Flow	D	CCW system removes heat from all safety-related components necessary for the safe shutdown and the mitigation of DBEs. CCW flow is a variable for monitoring CCW operation. This variable indicates the performance of the CCW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
ESW Temperature	D	Essential service water (ESW) system removes heat from the CCW heat exchangers and transfers to the UHS. ESW temperature is a variable for monitoring ESW operation. This variable indicates the performance of the ESW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
ESW Flow	D	ESW system removes heat from the CCW heat exchangers and transfers to the UHS. ESW Flow is a variable for monitoring ESW operation. This variable indicates the performance of the ESW system necessary for the safe shutdown and the mitigation of DBEs. (Type D)
Charging Line Flow	D	Charging Line Flow is a primary variable for monitoring the status of boric acid flow to the RCS. (Type D)
Charging Line Pressure	D	Charging Line Pressure is a primary variable for monitoring the operating status for a safety system. (Type D)
Shutdown Cooling Heat Exchange Outlet Temperature	D	Shutdown Cooling Heat Exchange Outlet Temperature is a primary variable for monitoring the operating status for a safety system. (Type D)
Shutdown Cooling Pump Flow Rate	D	Shutdown Cooling Pump Flow Rate is a primary variable for monitoring the operating status for a safety system. (Type D)
SIT Discharge Isolation	D	SIT Discharge Isolation provides information of operating status for a safety system. (Type D)
CREACS Emergency ACU flow	D	CREACS Emergency ACU flow verifies the status of a safety system. (Type D)
ABCAEES Emergency ACU flow	D	ABCAEES Emergency ACU flow verifies the status of a safety system. (Type D)
FHAEES Emergency ACU flow	D	FHAEES Emergency ACU flow verifies the status of a safety system. (Type D)

Table 7.5-2

"B" (Cont.)

Basis and Analysis of Selection for AMI Variables

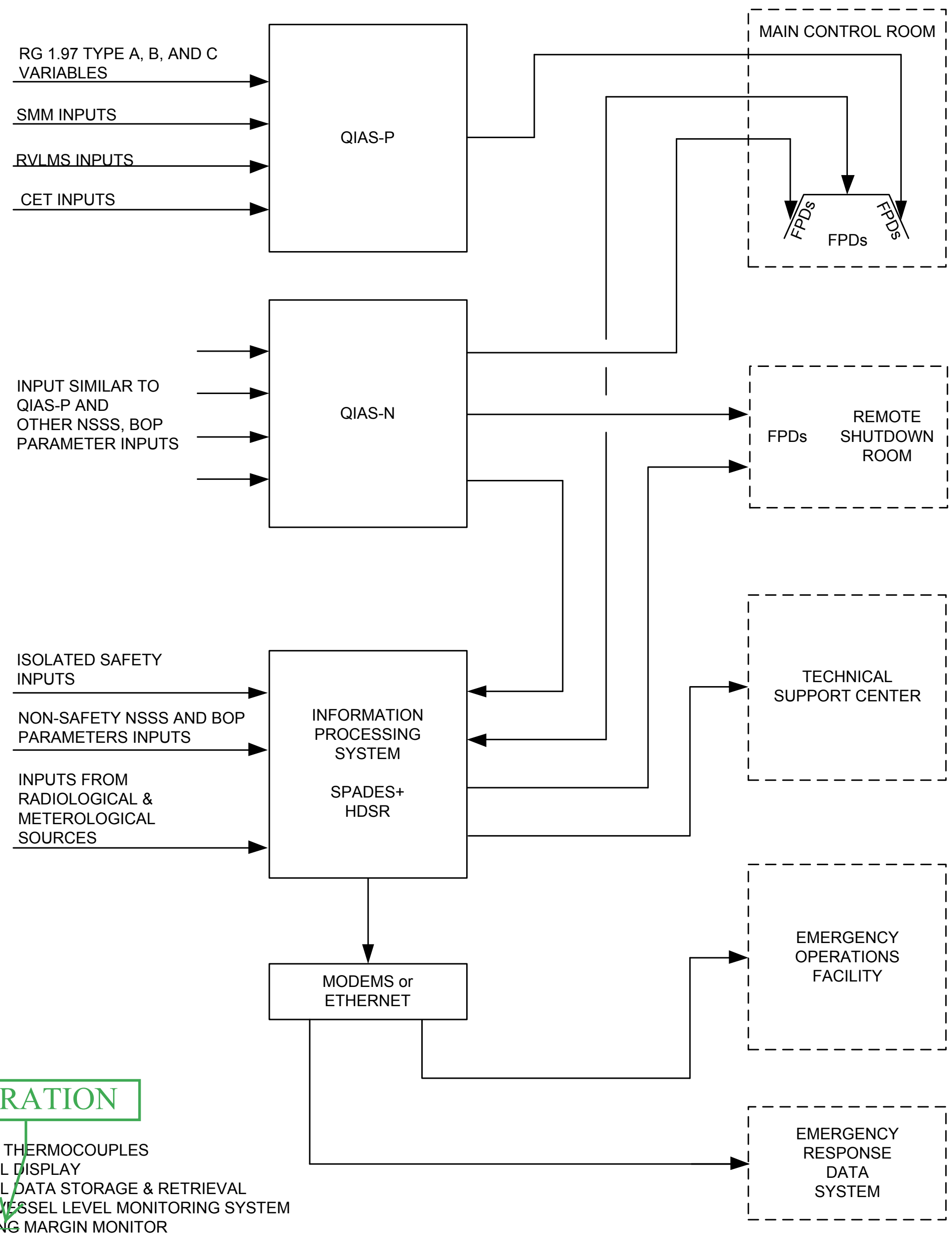
Variable	Type	Basis and analysis
SIP DVI Flow Rate	B, D	SIP DVI is a primary variable for monitoring critical safety function. (Type B) SIP DVI is a primary variable for monitoring the operating status for a safety system. (Type D)
Containment Purge Effluent	E	Containment purge effluent is used to monitor gaseous effluent in containment building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
Auxiliary Building Controlled Area HVAC Effluent	E	Auxiliary building controlled area HVAC effluent is used to monitor gaseous effluent of controlled area in auxiliary building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
Compound Building HVAC Effluent	E	Compound building HVAC effluent is used to monitor gaseous effluent in compound building. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
Condenser Vacuum Vent Effluent Radiation	E	Condenser vacuum vent effluent radiation is used to monitor SG tube leakage. This variable is required to monitor releases of radioactive materials through identified pathways. (Type E)
MCR and TSC Area Radiation	E	MCR and TSC area radiation is used to monitor radiation level and radioactivity in the control room. (Type E)
Normal primary sample Room Area Radiation	E	Normal primary sample room area radiation is used to monitor selected plant areas where access is required for plant recovery. (Type E)
Radiochemistry Lab. Area Radiation	E	Radiochemistry laboratory area radiation is used to monitor selected plant areas where access is required for plant recovery. (Type E)
Wind Direction	E	Wind direction is required to monitor environmental conditions used to determine the impact of releases of radioactive materials through identified pathways. (Type E)
Wind Speed	E	Wind speed is required to monitor environmental conditions used to determine the impact of releases of radioactive materials through identified pathways. (Type E)
Atmosphere Stability Temperature Difference	E	Atmosphere stability temperature difference is required to monitor environmental conditions used to determine the impact of releases of radioactive materials. (Type E)
Main Steam Line Radiation	E	Main steam line radiation is used to monitor the magnitude of releases of radioactive materials through identified pathways. (Type E)

"B" (Cont.)

Table 7.5-2

Basis and Analysis of Selection for AMI Variables

Variable	Type	Basis and analysis
High Energy Line Break Area ACU Inlet Radiation	E	High Energy Line Break Area ACU Inlet Radiation is used to monitor radiation releases from the breaks of high energy piping. (Type E)
Auxiliary Building Controlled Area (I,II) HVAC Normal/Emergency Exhaust ACU Inlet Radiation	E	Auxiliary Building Controlled Area (I,II) HVAC Normal/Emergency Exhaust ACU Inlet Radiation is used to monitor radiation leakage in the gaseous effluent from the controlled area. (Type E)
Containment Air Radiation	E	Containment Air Radiation is used to monitor the unidentified leakage from RCS. (Type E)
Fuel Handling Area HVAC Effluent Radiation	E	Fuel Handling Area HVAC Effluent Radiation is used to monitor the radioactivity in the HVAC effluents from the fueling handling area. (Type E)
Compound Building Hot Machine Shop Radiation	E	Compound Building Hot Machine Shop Radiation is used to monitor radioactive releases of identified pathways from the hot machine shop. (Type E)
Steam Generator Blowdown Radiation	E	Steam Generator Blowdown Radiation is used to monitor radioactive leakage of identified pathways from SG blowdown stream. (Type E)
Post-accident Primary Sample Room Radiation	E	Post-accident Primary Sample Room Radiation is used to monitor selected plant area where access is required for plant recovery. (Type E)



LEGEND

CET	-CORE EXIT THERMOCOUPLES
FPD	-FLAT PANEL DISPLAY
HDSR	-HISTORICAL DATA STORAGE & RETRIEVAL
RVLMS	-REACTOR VESSEL LEVEL MONITORING SYSTEM
SMM	-~~SUBCOOLING~~ SATURATION MARGIN MONITOR
SPD	-SAFETY PARAMETER DISPLAY
SPADES+	-SAFETY PARAMETER DISPLAY AND EVALUATION SYSTEM+

NOTE : FPDs INTERFACE WITH TRACKBALL UNITS FOR HSI

Figure 7.7-12 HSI Information Processing Block Diagram

Table 3.3.11-1 (Page 1 of 3)
Accident Monitoring Instrumentation

FUNCTION	REQUIRED MEASUREMENT CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION D.1
1. Logarithmic Reactor Power (neutron flux)	2	E
2. Hot Leg Temperature (Wide Range)	2 per loop	E
3. Cold Leg Temperature (Wide Range)	2 per loop	E
4. Reactor Coolant System Pressure (Wide Range)	2	E
5. Reactor Vessel Level (RV Closure Head Level/RV Plenum Level)	2	F
6. Reactor Cavity Level	4	E
7. Containment Pressure (Wide Range)	2	E
8. Containment Pressure (Extended Wide Range)	2	E
9. Containment Isolation Valve Position	1 per valve [(a),(b)]	E
10. Containment Upper Operating Area Radiation	2	E
11. Pressurizer Level	2	E
12. Steam Generator Level (Wide Range)	2 per Steam Generator	E
13. Holdup Volume Tank Level	4	E

(a) Not required for isolation valves whose associated penetration is isolated by at least one closed and deactivated automatic valve, closed manual valve, blind flange, or check valve with flow through the valve secured.

(b) Only one position indication channel is required for penetration flow paths with only one installed main control room indication channel.

Table 3.3.11-1 (Page 2 of 3)
Accident Monitoring Instrumentation

FUNCTION	REQUIRED MEASUREMENT CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION D.1
14. Core Exit Temperature – Quadrant 1	2[(c)]	E
15. Core Exit Temperature – Quadrant 2	2[(c)]	E
16. Core Exit Temperature – Quadrant 3	2[(c)]	E
17. Core Exit Temperature – Quadrant 4	2[(c)]	E
18. Steam Generator Pressure	2 per Steam Generator	E
19. RCS ~~Subcooling~~ Saturation Margin	2[(d)]	E
20. Core Exit Temperature ~~Subcooling~~ Saturation Margin	2[(e)]	E
21. Reactor Vessel Upper Head ~~Subcooling~~ Saturation Margin	2[(f)]	E
22. Pressurizer Pressure (Wide Range)	2	E

(c) A measurement channel consists of two or more core exit thermocouples.

(d) A measurement channel consists of Reactor Coolant Cold Leg Temperature (T-Cold) Wide Range, Reactor Coolant Hot Leg Temperature (T-Hot) Wide Range, and Pressurizer Pressure (Wide Range).

(e) A measurement channel consists of one or more Core Exit Temperature and Pressurizer Pressure (Wide Range).

(f) A measurement channel consists of Reactor Vessel Upper Head Temperature and Pressurizer Pressure (Wide Range).

Table 3.3.11-1 (Page 3 of 3)
Accident Monitoring Instrumentation

FUNCTION	REQUIRED MEASUREMENT CHANNELS	CONDITIONS REFERENCED FROM REQUIRED ACTION D.1
23. In-containment refueling water storage tank (IRWST) Level	4	E
24. IRWST Temperature	4	E
25. Containment Water Level	2	E
26. Containment Operating Area Radiation (For Fuel Handling Accident)	2	E
27. Spent Fuel Pool Radiation	2	E
28. Safety Injection Pump (SIP) Direct Vessel Injection (DVI) Flow Rate	2	E
29. Main Steam Atmospheric Steam Dump Valve Position	4	E
30. Auxiliary Feedwater Flow	4	E
31. Hydrogen Concentration	2	E
32. Containment Atmosphere Temperature	4	E
33. 4.16 kV Switchgear Voltage	4	E

BASES

LCO (continued)

Listed below are discussions of the specified instrument functions listed in Table 3.3.11-1. The following instruments are displayed on QIAS-P, QIAS-N, and IPS.

1. Logarithmic Reactor Power

Logarithmic Reactor Power indication is provided to verify reactor shutdown.

Inputs are provided by two safety channels with a minimum sensor and indicated range of 2E-8 to 200% power.

2, 3. Hot Leg Temperature (wide range) and Cold Leg Temperature (wide range)

Hot leg and cold leg temperatures are variables provided for verification of core cooling and long term surveillance. They are also inputs to the Reactor Coolant System ~~subcooling~~ saturation margin monitor.

Reactor coolant outlet and inlet temperature inputs to the AMI are provided by two fast response resistance elements and associated transmitters in each loop. The channels provide indication over a minimum sensor and indicated range of 0 to 400°C (32 to 752°F).

4. Reactor Coolant System Pressure

RCS pressure (wide range) is a variable, provided for verification of core cooling and RCS integrity long term surveillance. Wide range RCS loop pressure is measured by pressure transmitters with a minimum sensor and indicated range of 0 to 281.2 kg/cm^{2}G (0 to 4,000 psig). The pressure transmitters are located inside the containment. Redundant monitoring capability is provided by two trains of instrumentation.

BASES

LCO (continued)

18. Steam Generator Pressure

The steam generator pressure monitor is provided to monitor operation of the steam generators and verification of Reactor Coolant System (RCS) heat removal. There are two sensed channels of the steam generator pressure per steam generator. The minimum sensor range of these channels is 1.1 to 105.5 kg/cm^2A (15 to 1500 psia). The minimum indicated range of these channels is 0 to 105 kg/cm^2A (0 to 1494 psia).

19. RCS ~~Subcooling~~ Margin

RCS ~~Subcooling~~ Margin is provided for verification and analysis of plant conditions.

There are two sensed channels of RCS ~~Subcooling~~ Margin. RCS ~~Subcooling~~ Margin is calculated from Wide Range Pressurizer Pressure (minimum sensor range of 0 to 210.9 kg/cm^2 [0 to 3,000 psi]), Reactor Coolant Hot Leg and Cold Leg Temperatures (Minimum Sensor Range of 0 to 400°C [32 to 752°F]). RCS Temperature ~~Subcooling~~ Margin indicated range is from 358.3°C (677°F) ~~subcooling~~ to 399°C (750°F) superheated. RCS Pressure ~~Subcooling~~ Margin indicated range is from 210.9 kg/cm^2 ~~subcooling~~ to 225.5 kg/cm^2 superheated.

Saturation

20. CET ~~Subcooling~~ Margin

CET ~~Subcooling~~ Margin is provided for verification and analysis of plant conditions.

There are two sensed channels of CET ~~Subcooling~~ Margin. CET ~~Subcooling~~ Margin is calculated from Wide Range Pressurizer Pressure (minimum sensor range of 0 to 210.9 kg/cm^2 [0 to 3,000 psi]) and Core Exit Temperatures (Minimum Sensor Range of 0 to 1,260.0°C [32 to 2,300°F]). CET Temperature ~~Subcooling~~ Margin indicated range is from 368.3°C (695°F) ~~subcooling~~ to 1,260.0°C (2,300°F) superheated. CET Pressure ~~Subcooling~~ Margin indicated range is from 210.9 kg/cm^2 ~~subcooling~~ to 225.5 kg/cm^2 superheated.

saturation

BASES

LCO (continued)

21. RV Upper Head ~~Subcooling~~ Margin

RV Upper Head ~~Subcooling~~ Margin is provided for verification and analysis of plant conditions.

There are two sensed channels of RV Upper Head ~~Subcooling~~ Margin. RV Upper Head ~~Subcooling~~ Margin is calculated from Wide Range Pressurizer Pressure (minimum sensor range of 0 to 210.9 kg/cm^2 [0 to 3,000 psi]) and Reactor Vessel Upper Head Temperature (Minimum Sensor Range of 0 to 1,260.0°C [32 to 2,300°F]). RV Upper Head Temperature ~~Subcooling~~ Margin indicated range is from 368.3°C (695°F) ~~subcooling~~ to 1,260.0°C (2,300°F) superheated. RV Upper Head Pressure ~~Subcooling~~ Margin indicated range is from 210.9 kg/cm^2 ~~subcooling~~ to 225.5 kg/cm^2 superheated.

Saturation

saturation

22. Pressurizer Pressure (wide range)

Pressurizer Pressure (wide range) is measured by pressure transmitters with a minimum sensor and indicated range of 0 to 210.9 kg/cm^{2}A (0 to 3,000 psia).

23. IRWST Level

The IRWST Level monitor is provided to sure water supply for emergency core cooling and containment spray. The in-containment refueling water storage tank (IRWST) consists of one torus-type tank inside containment. There are four 0 to 100% sensors and indicated range level channels.

24. IRWST Temperature

IRWST temperature is provided for verification of long term decay heat removal operation. There are four 10 to 176.7°C (50 to 350°F) sensors with an indicated range temperature channels.

25. Containment Level

The containment level monitor is provided for verification and long term surveillance of emergency core cooling and the containment level is measured by two instruments with a minimum sensor and indicated range of 0 to 100%.

BASES

LCO (continued)

30. Auxiliary Feedwater Flow

The Auxiliary Feedwater Flow is provided to verify the flow of Auxiliary Feedwater supplied to corresponding steam generator. The Auxiliary Feedwater System delivers the minimum required flow of 650 gpm to the affected steam generator within 60 seconds following an AFAS. The maximum rate of auxiliary feedwater flow delivered to the steam generator at 1,240 psia or less is equal to or less than 950 gpm. The flowrate is indicated range of 0 to 3,600 lpm (0 to 950 gpm).

Items 31,32 and 33 to be added as shown on the next page.

Two channels are required to be OPERABLE for all but one Function. Two OPERABLE channels ensure that no single failure within the AMI or its auxiliary supporting features or power sources, concurrent with failures that are a condition of or result from a specific accident, prevents the operators from obtaining from being presented the information necessary for them to determine the safety status of the plant and to bring the plant to and maintain it in a safe condition following that accident.

In Table 3.3.11-1 delineates that the exception to the two channel requirements is the containment isolation valve position.

Two OPERABLE channels of core exit thermocouples are required for each channel in each quadrant to provide indication of radial distribution of the coolant temperature rise across representative regions of the core. Power distribution symmetry is considered in determining the specific number and locations provided for diagnosis of local core problems. Therefore, two randomly selected thermocouples may not be sufficient to meet the two thermocouples per channel requirement in any quadrant. The two thermocouples in each channel must meet the additional requirement that one be located near the center of the core and the other near the core perimeter, such that the pair of core exit thermocouples indicates the radial temperature gradient across their core quadrant. Two sets of two thermocouples in each quadrant ensure a single failure will not disable the ability to determine the radial temperature gradient.

For loop and steam generator related variables, the required information is individual loop temperature and individual steam generator level. In these cases two channels are required to be OPERABLE for each loop of steam generator to redundantly provide the necessary information.

31. Hydrogen concentration

Hydrogen concentration is a variable to support containment combustible gas control during the accident. Two channel hydrogen concentration sensors are provided with a minimum sensor indication range of 0 to 15 % by volume.

32. Containment atmosphere temperature

Containment atmosphere temperature is a variable to support containment temperature control during the accident. Containment atmosphere temperatures are provided with a minimum sensor indication range of 4.4 to 204.4 °C (40 to 400 °F).

33. 4.16 kV Switchgear Voltage

The Class 1E 4.16 kV switchgear bus voltage is provided to verify adequate electric power which is available for ESF loads. For each bus, one voltage input is provided with a range of 0 to 5,250 V

BASES

LCO (continued)

Core outlet temperature is to be maintained at least 5.6°C (10°F) below saturation temperature so that no vapor bubble can form and possibly cause a natural circulation flow obstruction. The response of the RCS without the RCPs or SC pumps depends on the core decay heat load and the length of time that the pumps are stopped. As decay heat diminishes, the effects on RCS temperature and pressure diminish. Without cooling by forced flow, higher heat loads will cause the reactor coolant temperature and pressure to increase at a rate proportional to the decay heat load. Because pressure can increase, the applicable system pressure limits (pressure and temperature (P/T) limits or low temperature overpressure protection (LTOP) limits) must be observed and forced SC flow or heat removal via the SGs must be re-established prior to reaching the pressure limit. The circumstances for stopping both RCPs or SC pumps are to be limited to situations where:

a. Pressure and temperature increases can be maintained well within the allowable pressure (P/T limits and LTOP) and 5.6°C (10°F) ~~subcooling~~ saturation limits or

b. An alternate heat removal path through the SGs is in operation.

Note 2 requires, before an RCP is started with any RCS cold leg temperature less than or equal to the LTOP enable temperature specified in the PTLR, that secondary side water temperature in each SG is < 55.6°C (100°F) above each of the RCS cold leg temperatures.

Satisfying the above conditions will preclude a large pressure surge in the RCS when the RCP is started.

An OPERABLE RCS loop consists of at least one OPERABLE RCP and an SG that is OPERABLE in accordance with the steam generator tube surveillance program and has the minimum water level specified in SR 3.4.6.2.

Similarly, for the SC System (SCS), an OPERABLE SC train is composed of the OPERABLE SC pump capable of providing forced flow to the SC heat exchanger.

RCPs and SC pumps are OPERABLE if they are capable of being powered and are able to provide flow if required. Management of gas voids is important to SCS OPERABILITY.

BASES

LCO

The purpose of this LCO is to require at least one of the SC trains be OPERABLE and in operation with an additional SC train OPERABLE or secondary side water level of each SG shall be ≥ 25% wide range. One SC train provides sufficient forced circulation to perform the safety functions of the reactor coolant under these conditions. The second SC train is normally maintained OPERABLE as a backup to the operating SC train to provide redundant paths for decay heat removal. However, if the standby SC train is not OPERABLE, a sufficient alternate method to provide redundant paths for decay heat removal is two SGs with their secondary side water levels ≥ 25% wide range. Should the operating SC train fail, the SGs could be used to remove the decay heat.

Note 1 permits all SC pumps to be de-energized ≤ 1 hour per 8 hour period. The circumstances for stopping both SC trains are to be limited to situations where pressure and temperature increases can be maintained well within the allowable pressure (pressure and temperature (P/T) limits or low temperature overpressure protection (LTOP) limits) and 5.6°C (10°F) ~~subcooling~~ saturation limits, or an alternate heat removal path through the SG(s) is in operation.

This LCO is modified by a Note that prohibits boron dilution when SC forced flow is stopped because an even concentration distribution cannot be ensured. Core outlet temperature is to be maintained at least 5.6°C (10°F) below saturation temperature, so that no vapor bubble would form and possibly cause a natural circulation flow obstruction.

In this MODE, the SG(s) can be used as the backup for SC heat removal. To ensure their availability, the RCS loop flow path is to be maintained with subcooled liquid.

In MODE 5, it is sometimes necessary to stop all RCPs or SC forced circulation. This is permitted to change operation from one SC train to the other, perform surveillance or startup testing, perform the transition to and from the SC System, or to avoid operation below the RCP minimum net positive suction head limit. The time period is acceptable because natural circulation is acceptable for decay heat removal, the reactor coolant temperature can be maintained subcooled, and boron stratification affecting reactivity control is not expected.

B 3.4 REACTOR COOLANT SYSTEM (RCS)

B 3.4.8 RCS Loops – MODE 5 (Loops Not Filled)

BASES

BACKGROUND

In MODE 5 with the Reactor Coolant System (RCS) loops not filled, the primary function of the reactor coolant is the removal of decay heat and transfer of this heat to the shutdown cooling (SC) heat exchangers. The steam generators are not available as a heat sink when the loops are not filled. The secondary function of the reactor coolant is to act as a carrier for soluble neutron poison, boric acid.

In MODE 5 with loops not filled, only the SC System (SCS) can be used for coolant circulation. The number of trains in operation can vary to suit the operational needs. The intent of this LCO is to provide forced flow from at least one SC train for decay heat removal and transport. The other intent of this Limiting Condition for Operation (LCO) is to require that two paths be available to provide redundancy for heat removal.

This LCO permits limited periods without forced circulation. When the SC trains are not in operation, no alternate heat removal path exists. The response of the RCS without the SCS depends on the decay heat load and the length of time that the SC pumps are stopped. As decay heat diminishes, the effects on RCS temperature diminish. Without cooling by SCS, higher heat loads will cause the reactor coolant temperature to increase at a rate proportional to the decay heat load. Because pressure can increase, applicable system pressure limits (pressure and temperature limits or low temperature overpressurization limits) must be observed and forced SCS flow must be reestablished prior to reaching the pressure limit. Entry into a condition with no SCS train in operation stops heat removal and should only be considered for limited circumstances such as when switching from one SCS train to the other. With the SC pumps stopped, pressure and temperature could increase and pumps must be restored prior to exceeding pressure and ~~subcooling~~ saturation limits.

The SC System removes decay heat from the RCS and transfers the heat to the Component Cooling Water (CCW) System. During “Loops Not Filled” operations the interruption or loss of SCS flow, decay heat removal (DHR) capability, can lead to bulk boiling quite rapidly.

BASES

BACKGROUND (continued)

The minimum steady state water level in the pressurizer assures pressurizer heaters, which are required to achieve and maintain pressure control, remain covered with water to prevent failure, which could occur if the heaters were energized uncovered.

The requirement to have two groups of pressurizer heaters ensures that RCS pressure can be maintained. The pressurizer heaters maintain RCS pressure to keep the reactor coolant subcooled. Inability to control RCS pressure during natural circulation flow could result in a loss of single phase flow and a decreased capability to remove core decay heat.

APPLICABLE SAFETY ANALYSES

In MODES 1, 2, and 3, the LCO requirement for a steam bubble is reflected implicitly in the accident analyses. No safety analyses are performed in lower MODES. All analyses performed from a critical reactor condition assume the existence of a steam bubble and saturated conditions in the pressurizer. In making this assumption, the analyses neglect the small fraction of non-condensible gases normally present.

Safety analyses presented in FSAR do not take credit for pressurizer heater operation, however, an implicit initial condition assumption of the safety analyses is that the RCS is operating at normal pressure.

saturation

Although the heaters are not specifically credited in accident analysis, the need to maintain ~~subcooling~~ in the long term during loss of offsite power, as indicated in NUREG-0737 (Ref. 2), is the reason for inclusion. The requirement for emergency power supplies is based on NUREG-0737 (Ref. 2). The intent is to allow maintaining the reactor coolant in a subcooled condition with natural circulation at hot, high pressure conditions for an undefined, but extended, time period after a loss of offsite power. While loss of offsite power is a coincident occurrence with turbine trip assumed in many accident analyses, maintaining hot, high pressure conditions over an extended time period is not evaluated as part of the accident analyses.

The pressurizer satisfies the Criteria 2 and 3 of 10 CFR 50.36(c)(2)(ii).

BASES

LCO

The LCO requirement for the pressurizer to be OPERABLE with water level ≥ 25% and ≤ 56% ensures that a steam bubble exists. Limiting the maximum operating water level preserves the steam for pressure control. The minimum operating water level is established pressurizer heaters remain covered with water to prevent failure, which could occur if the heaters were energized uncovered in steam bubble region. The intent of the LCO is to ensure that a steam bubble exists in the pressurizer to minimize the consequences of potential overpressure transients.

The LCO requires two groups of OPERABLE pressurizer heaters, each with a capacity ≥ 200 kW (and capable of being powered from an emergency power supply). The minimum heater capacity required is sufficient to maintain the RCS near normal operating pressure when accounting for heat losses through the pressurizer insulation. By maintaining the pressure near the operating conditions, a wide ~~subcooling~~ saturation margin to saturation can be obtained in the loops. The exact design value of 300 kW is derived from the use of 6 heaters rated at 50 kW each. The amount needed to maintain pressure is dependent on the ambient heat losses.

APPLICABILITY

The need for pressurizer pressure control is most pertinent when core heat can cause the greatest effect on RCS temperature resulting in the greatest effect on pressurizer level and RCS pressure control. Thus, Applicability has been designated for MODES 1, 2, and 3. The purpose is to prevent solid water RCS operation during heatup and cooldown to avoid rapid pressure rises caused by normal operational perturbation, such as reactor coolant pump startup.

The LCO does not apply to MODE 5 (Loops Filled) because LCO 3.4.11, “Low Temperature Overpressure Protection (LTOP) System,” applies. The LCO does not apply to MODES 5 and 6 with partial loop operation.

In MODES 1, 2, and 3, there is the need to maintain the availability of pressurizer heaters capable of being powered from an emergency power supplies. In the event of a loss of offsite power, the initial conditions of these MODES give the greatest demand for maintaining the RCS in a hot pressurized condition with loop ~~subcooling~~ saturation for an extended period. For MODE 4, 5, or 6, it is not necessary to control pressure (by heaters) to ensure loop ~~subcooling~~ saturation for heat transfer when the shutdown cooling System is in-service and, therefore, the LCO is not applicable.

B 3.4 REACTOR COOLANT SYSTEM (RCS)

B 3.4.16 Reactor Coolant Gas Vent (RCGV) Function

BASES

BACKGROUND

The reactor coolant gas vent (RCGV) function is to provide a safety grade means of venting non-condensible gases and steam from the pressurizer and the reactor vessel closure head. The RCGV function is designed to be used during all design bases events for RCS pressure control purposes when Main Spray and Auxiliary Spray Systems are unavailable. The OPERABILITY of at least one RCGV path from the pressurizer and at least one RCGV path from the reactor vessel closure head to the IRWST ensures that this function can be performed.

The RCGV function is a manually operated safety grade system. It removes non-condensible gases or steam from the pressurizer and the reactor vessel closure head through vent lines to the in-containment refueling water storage tank (IRWST). Each vent line has two pairs of parallel isolation valves which are closed during normal operation. During shutdown or transient conditions, if the operator judges that non-condensible gases are collected in the pressurizer or in the reactor vessel closure head, the operator vents the gases by manually opening the RCGV valves from the main control room (MCR) according to operating procedures. The RCGV function will have the capability to be manually actuated, monitored, and controlled from the MCR as required by GDC 19.

The two isolation valves in each parallel path are normally powered from the 125 Vdc buses and emergency power is provided to the valves by batteries. The RCGV System is designed to maintain a vent path after a single failure of any single valve or its power source. This design feature satisfies the requirements of GDC 17 and GDC 34.

APPLICABLE SAFETY ANALYSES

The RCGV function provides a safety grade method of RCS depressurization that is credited during natural circulation. The operator uses the SI System, the pressurizer backup heaters, and the RCGV function to control RCS inventory and ~~subcooling.~~ saturation The pressurizer vent line is 5.0 cm (2.0 in) nominal diameter to meet the requirement to vent one-half the RCS volume in one hour.

4.5 Qualified Indication and Alarm System – P

4.5.1 Functions

The QIAS-P provides a continuous display of RG1.97, Rev. 4 AMI variables (Types A, B and C) and an unambiguous indication of the approach to and the recovery from ICC as a backup to the safety parameter display system (SPDS). The recording function for Type A, B and C variables is performed in the IPS.

The QIAS-P calculates representative core exit temperature, primary coolant ~~subcooling~~ saturation margins, and reactor vessel water level.

The QIAS-P provides output signals to the QIAS-P display via the SDN, to the MTP for the IPS (via unidirectional Ethernet datalink), and to the ITP for the QIAS-N (via the SDL). In all cases, these output signals are for display of sensor signals, ICC variables, and AMI variables.

The QIAS-P provides a backup for the SPDS for ICC variables. The SPDS is implemented in the SPADES+ application in the IPS.

Upon receipt of the analog and digital signals, the QIAS-P performs signal checking. The QIAS-P displays are a major part of the overall MCR information system used for accident monitoring. The QIAS-P configuration is presented in Figure 4-19.

4.5.2 Design Features

The QIAS-P has two divisionalized cabinets. The QIAS-P cabinet for each division is located in the divisionalized I&C equipment room. The QIAS-P receives AMI variables from the PPS and ESF-CCS via the SDN; and APC-S and process instrumentation via hard-wired connection. The QIAS-P also displays the status of CIVs from both QIAS-P divisions. The status of the other QIAS-P division CIVs are obtained from the ITP through the interdivisional SDL.

4.5.2.1 Calculation

The QIAS-P processes the AMI variables (Types A, B and C) as determined from RG 1.97, Rev.4, for accident monitoring guidelines.

The QIAS-P calculates representative core exit temperature from the core exit thermocouples (CETs). The QIAS-P calculates primary coolant ~~subcooling~~ saturation margins based on CET temperatures, hot and cold leg temperatures, heated junction thermocouple (HJTC) temperatures from the reactor vessel head region, and pressurizer pressure. The QIAS-P calculates reactor vessel level from the top of the core to the top of the reactor vessel (based on the signals from the HJTCs). The HJTCs are discrete level measurements throughout the height of the reactor vessel. Liquid uncovery of an HJTC is determined by the temperature difference between the heated and unheated thermocouple pair at a specific height location in the reactor vessel.

4.5.2.2 Displays

The QIAS-P has two FPDs on the SC. The QIAS-P division A(B) displays division A(B) variables except CIVs status.

The QIAS-P division A and B FPDs also display the CIVs status for all divisions to monitor the proper operation of CIVs to confirm the isolation of containment penetration to enhance plant safety. The compliance to DI&C-ISG-04 of the interdivisional SDL is addressed in Appendix C of this report.

The FPD displays provide backup displays for the ICC variables per NUREG-0737. The primary displays of ICC variables are implemented in the SPADES+ of the IPS.

Each FPD allows the operator to select the pages that display either:

- AMI variables or
- ICC variables

The QIAS-P displays output an unambiguous indication in accordance with Style Guide (Reference 16). The following ICC variables are calculated and validated using an algorithm executed by the QIAS-P PLC processor, and are displayed on the QIAS-P displays in the MCR.

- Primary coolant saturation margin (temperatures calculated from RTDs, HJTCs, CETs and PZR pressure)
- Coolant temperature at the core exit (calculated from CETs)
- Coolant level in the reactor vessel above the top of the core (calculated from HJTCs)

4.5.2.3 MTP Functions

The QIAS-P allows signal substitution for failed HJTC values, signal bypass for abnormal values by operator decision. The QIAS-P allows setpoint changes for ICC calculation parameters by the operator through the MTP to prevent software modifications for simple changes to the system. These functions are manually initiated from the MTP under administrative control.

4.5.2.4 Power Supply

Power distribution is assigned such that the loss of a single vital instrument power bus does not result in the loss of more than one QIAS-P division. Loss of electrical power to a QIAS-P FPD display results in a blank screen. The loss of electrical power to one QIAS-P controller processor results in an indication of an inactive state on the QIAS-P displays.

4.5.2.5 Alarms

The QIAS-P generates alarms (visual only) for ICC parameters and send them to the QIAS-N and IPS.:

- Low reactor vessel level-head
- Low reactor vessel level-plenum
- Low upper head temperature ~~subcooling~~ saturation margin (IPS only)

- Low upper head pressure ~~subcooling~~ margin (IPS only)
- Low RCS temperature ~~subcooling~~ margin (IPS only)
- Low RCS pressure ~~subcooling~~ margin (IPS only)
- Low CET temperature ~~subcooling~~ margin
- Low CET pressure ~~subcooling~~ margin (IPS only)
- Low RCS /RV upper head temperature ~~subcooling~~ margin
- Low RCS /RV upper head pressure ~~subcooling~~ margin (IPS only)
- High representative CET temperature

saturation

4.5.2.6 Redundancy

The QIAS-P consists of the redundant safety divisions A and B for signal processing and displays. Redundancy is provided for both the instrument divisions supplying the signal and the displays in the MCR. Instrument channels are electrically independent and physically separated from non-safety equipment by qualified isolation devices. The QIAS-P cabinets are located in separated I&C equipment rooms. Credited redundancy for the display of RG 1.97, Rev. 4, Type A, B and C variables is provided by the QIAS-P divisions. Type A, B and C variables are also displayed on the QIAS-N and IPS.

To prevent ambiguity of the information presented to the operator, additional sensors or diverse variables are used to ensure that the information presented to the operator is correct as described in Table 7.5-1 of the DCD.

The QIAS-P monitors two redundant AMI instrument channels (A and B) for each RG1.97, Rev. 4 Type A, B and C process parameters. For CIVs, the QIAS-P displays all divisions on each QIAS-P display.

4.5.3 System Interfaces

The QIAS-P cabinet interfaces with the following systems and equipment:

- Process instrumentation
- Auxiliary process cabinet - safety
- HJTC (HJTC temperatures)
- In-core instrumentation system (CET temperatures)
- DIS
- ESF-CCS
- PPS
- MTP (then to IPS),
- ITP (then to QIAS-N),

Table 4-6 Summary of QIAS-P I/O Signals

TS

The ESF system-level actuation and component-level MI switch signals are input to the CPM and then data linked to the ESF-CCS, i.e., the signals are susceptible to a postulated CCF.

c. Qualified Indication and Alarm System – P

The QIAS-P displays the RG 1.97, Rev. 4, Types A, B, and C variables. The Types A, B and C variables are displayed on the QIAS-P display device on the MCR safety console. The QIAS-P is implemented on the same platform as the safety I&C system, but the software is classified as ITS.

The variables displayed on QIAS-P display device are as follows:

i. Pressurizer Pressure (WR)

ii. Pressurizer Level

iii. RCS Hot Leg Temperature (WR)

iv. RCS Cold Leg Temperature (WR)

v. Steam Generator 1 Pressure

vi. Steam Generator 2 Pressure

vii. Steam Generator 1 Level (WR)

viii. Steam Generator 2 Level (WR)

ix. Logarithmic Reactor Power (WR)

x. Core Exit Temperature

xi. RCS ~~Subcooling~~ Saturation Margin

xii. CET ~~Subcooling~~ Saturation Margin

xiii. RV Upper Head ~~Subcooling~~ Saturation Margin

xiv. Reactor Vessel Level

xi.xv. RCS Pressure

xii. Heated Junction Temperature

xiii. Unheated Junction Temperature

xiv. Auxiliary Feedwater Storage Tank A Level

xv. Auxiliary Feedwater Storage Tank B Level

xvi. Containment Pressure (Extended Range)

xvii. Containment Pressure (WR)

xviii. Containment Water Level