H. Vouse

ACRS SM-0088

PDR 5/1/79

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

April 28, 1979

Mr. Etherington
Dr. Okrent
Dr. Plesset
Dr. Carbon
Dr. Kerr
Dr. Siess
Dr. Mark
Dr. Catton
Dr. Lipinski
Mr. Michelson

SUBJECT: INFORMATION PROVIDED BY GPU ON TMI-2 SHUTDOWN PROCEDURES AND ON SEQUENCE OF EVENTS OF TMI-2 ACCIDENT

Attached is a copy of Metropolitan Edison Company's shutdown procedures and of GPU's preliminary sequence of events associated with the first 22 hours of the TMI-2 accident.

Thomas G. McCreless

Thomas G. McCreless, Chief
Project Review Branch No. 2

Attachment: as stated

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ACRS

GPU Service

TMI Recovery Team
GPU Service Corporation
260 Cherry Hill Road
Parsippany New Jersey 07054
201 263-4900
TELEX 136-482

April 24, 1979

Mr. T. McCrearless
ACRS
Washington, D.C.

Dear Mr. McCrearless:

Per your request to the Metropolitan Edison Company Safety & Licensing Group, attached are the following:

- Three Mile Island Unit #2

  Emergency Procedure 2202-1.1 (Revision 6 10/25/78)
  Reactor Trip

  Emergency Procedure 2202-1.3 (Revision 11 10/06/78)
  Loss of Reactor Coolant/Reactor Coolant System Pressure

  Emergency Procedure 2202-2.1 (Revision 7 6/21/78)
  Station Blackout

- Preliminary Sequence of Events Report

R. C. ARNOLD
General Operations Manager
GPU

RCA:bas
Attachment

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THREE MILE ISLAND NUCLEAR STATION
UNIT #2 EMERGENCY PROCEDURE 2202-1.1
REACTOR TRIP

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Unit 1 Staff Recommends Approval

Approval NA Date —
Cognizant Dept. Head

Unit 2 Staff Recommends Approval

Approval NA Date —
Cognizant Dept. Head

Unit 1 PORC Recommends Approval

NA Date —
Chairman of PORC

Unit 2 PORC Recommends Approval

R P Warren Date 10/25/78
V- Chairman of PORC

Unit 1 Superintendent Approval

NA Date —

Unit 2 Superintendent Approval

J. L. Seelinger Date 10/25/78

Manager Generation Quality Assurance Approval NA Date —

TMI 88-A Rev 8/77

THREE MILE ISLAND NUCLEAR STATION

UNIT #2 EMERGENCY PROCEDURE 2202-1.1

REACTOR TRIP

1.0 SYMPTOMS

1.1 Reactor trip may be due to any of the following:

a. Nuclear power > 105.5% of rated power.

b. Nuclear power > 1.05 times reactor coolant flow (%) minus power imbalance reduction.

c. Nuclear Power > 50.9% of rated power during operation with one R.C. Pump operating per loop.

d. Loss of two Reactor Coolant Pumps in one reactor coolant loop.

e. Reactor coolant pressure > 2355 psig.

f. Reactor coolant pressure < 1900 psig.

g. Reactor coolant pressure < (13.00 T_{out}-5887)

h. Reactor coolant outlet temperature > 619°F.

i. Reactor building pressure > 4 psig.

j. Manual reactor trip actuation.

1.2 Individual and group "In Limit" lights actuate.

1.3 Rapid decrease in neutron level as indicated by the Nuclear Instrumentation.

1.4 Main turbine master trip alarm energized.

1.5 Rapid decrease in Unit Load.

2.0 IMMEDIATE ACTION

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2.1 Automatic Action

a. All rods insert (except Group 8)

b. Turbine trip, stop valves close

c. Generator breakers open

d. Turbine by-pass valves open

e. Source range nuclear instrumentation high voltage energizes at 5 X 10^{-10} amps on N1-3 or N1-4.

2.2 Manual Action

a. Manually TRIP the reactor

b. Verify all "in-limit" lights are actuated (except group 8)

c. Verify that turbine has tripped and generator breakers are open - if turbine has NOT tripped - manually TRIP the turbine, start lift pumps & turning gear oil pump.

d. CLOSE letdown isolation valve MU-V376.

e. START second make-up pump. Open MU-V-16B as necessary to maintain 100" in PZR.

f. Verify turbine bypass control valves are maintaining header pressure at 1010 psig.

g. If any feedwater stations are in hand, run stations back to maintain OTSG at 30".

h. Verify PZR Htrs are off @ 80" in PZR.

i. If PZR level gets to 20" open DH-V5B and start 3rd make-up pump and open MU-V16C/D to increase PZR level.

j. If any of the following ICS stations are in Hand (Steam Generator/Reactor Demand, either Feedwater Demand, Main or Startup Feedwater Valve Demand, Feedpump Speed, Reactor Master, and/or Diamond) runback the appropriate ICS stations.

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3.0 FOLLOW-UP ACTION

3.1 Announce-on page system - Reactor Trip

3.2 Initiate emergency boration per 2203-1.1 (Loss of Boron) if reactor power is not below 10% in 1 minute.

3.3 Monitor make-up tank level and maintain level greater than 55" by using Waste Transfer Pumps (WDL-P5A/B) and feeding from an RCBT with boron concentration greater or equal to RCS concentration.

3.4 Verify that the pressurizer heaters and spray have returned RCS pressure to normal operating pressure of 2155 psig.

3.5 Reduce pressurizer level setpoint to 100" (25%).

3.6 Verify normal electrical lineup, i.e., no substation or in-plant distribution breakers are open (except generator breakers).

3.7 Check that all RMS channels are normal and that no unplanned or uncontrolled radioactive release is in progress.

3.8 Compute shutdown margin calculations per 2103-1.9 (Reactivity Balance Calculations). If shutdown margin is less than 1%, boron should be added to the RCS.

3.9 If reactor start-up is not intended within four hours raise OTSG level to 97-99% on the operating range using the feedwater valve bypass and tube sheet drains for level control.

3.10 Fill out a Reactor Trip report.

3.11 Notify H.P./Chemistry to sample R.C. Letdown for Dose Equivalent Iodine between 2 and 6 hours after power change of greater than 15% within one hour period per Surveillance Procedure #2304-3D2.

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THREE MILE ISLAND NUCLEAR STATION

UNIT #2 EMERGENCY PROCEDURE 2202-1.3

LOSS OF REACTOR COOLANT/REACTOR COOLANT SYSTEM PRESSURE

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R D Warren Date 10/6/78

V-Chairman of PORC

Unit 1 Superintendent Approval

N/A Date —

Unit 2 Superintendent Approval

J F Stefano Date 10/6/78

Manager Generation Quality Assurance Approval N/A Date —

TMI 55 A Rev 8/77

THREE MILE ISLAND NUCLEAR STATION

UNIT #2 EMERGENCY PROCEDURE 2202-1.3

LOSS OF REACTOR COOLANT/REACTOR COOLANT SYSTEM PRESSURE

A. Leak or Rupture Within Capability of System Operation.

1.0 SYMPTOMS

1.1 Initial loss of reactor coolant pressure & decrease in pressurizer level becoming stable after short period of time.

1.2 Possible reactor building high radiation and/or temp. alarm.

1.3 Possible reactor building sump high level alarm.

1.4 Make-up tank level decreasing > 1" in 3 min.

1.5 Possible makeup line high flow alarm.

1.6 RB Fan Drip Pan Level Hi Alarms.

NOTE: The operator may distinguish between a loss of coolant inside containment, an OTSG tube rupture and a steam line break by the following symptoms which are unique to the aforementioned accidents.

1. Loss of coolant inside Rx Bldg. - particulate, iodine & gas monitor alarm on HP-R-227 "Reactor Building Air Sample".
2. OTSG tube rupture - gas monitor alarm on VA-R-748.
3. Steam line break
   (1) Low condensate storage tank level alarm - and or low hot well level alarm.
   (2) FW Latch System Actuation.

2.0 IMMEDIATE ACTION

2.1 Automatic Action:

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2.1.1 MU-V17 will open to compensate for reduced pressurizer level.

2.1.2 Additional pressurizer heaters will come on in response to reduced reactor coolant pressure.

2.2 Manual Action

2.2.1 Verify MU-V17 open and pressurizer heaters on.

2.2.2 "CLOSE" MU-V376 letdown isolation valve, & "START" the backup MU pump, if required.

2.2.3 Reduce load at 10% minute & proceed with normal shutdown.

2.2.4 "LINE-UP" waste transfer pump from a R.C. Bleed Holdup Tank & pump to the makeup tank to maintain required level.

2.2.5 If for any reason the operator cannot maintain Make-up Tank and Pressurizer levels above their respective low level alarm setpoints, "TRIP" the reactor, "INITIATE" Safety Injection manually (push buttons on panel 3), & then "Close" MU-V12.

3.0 FOLLOW UP ACTION

3.1 Safety Injection Not Initiated.

3.1.1 Initiate unit shutdown & cooldown per 2102-3.1 and 2102-3.2 respectively.

3.2 Safety Injection Manually Initiated (HPI and LPI).

3.2.1 Verify that the Makeup Pumps & Decay Heat Removal Pumps start satisfactorily.

3.2.1.1 Close MU-V12 and MU-V18.

3.2.2 Bypass the SAFETY INJECTION by DEPRESSING the Group Reset Pushbuttons & "THROTTLE" MU-V16A/B/C/D as necessary to maintain 220" pressurizer level and not exceed 250 GPM/HPI flow leg.

3.2.3 If MU pump flow drops below 95 GPM, trip excess MU pumps.

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NOTE: HPI String A flow is the sum of MU 23 FE1&2. HPI String B flow is the sum of MU23 FE 3&4.

3.2.4 Verify that Safety Injection equipment is in its ESF position as shown in Table A-1.

3.2.5 CAUTION: Continued operation depends upon the capability to maintain pressurizer level and RCS pressure above the 1640 PSIG Safety Injection Actuation setpoint.

1. If pressurizer level can be maintained above the low level alarm point and the RCS pressure above the Safety Injection Actuation point, then proceed to step 3.2.6.
2. If pressurizer level cannot be maintained above the low level alarm point and the RCS pressure above the Safety Injection Actuation point, then the plant has suffered a major rupture and operation should continue according to Part B - Leak or Rupture of Significant Size Such that Engineered Safety Features Systems are Automatically Initiated.

3.2.6 With the pressurizer level and RCS pressure being maintained within allowable limits, initiate plant shutdown and cooldown per 2102-3.1 and 2102-3.2, respectively.

NOTE: The HPI System is being used for makeup control and valves MU-V16A/B/C/D will have to be throttled to maintain pressurizer level. As RCS pressure decreases, it may be possible to return to the normal makeup flowpath and secure HPI. If MU pump flow drops below 95 GPM as a result of throttling, "Open" MU-V36 & 37 to provide MU pump recirculation path to MU Tank. Monitor MU Tank level and open MU-V12 as required.

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3.2.7 At the time the DH System is to be brought on line for normal cooling only one DH string should be used for decay heat removal (i.e. - recirculation from the RC System). The other DH string should be maintained on standby for use in recirculating water from the RB sump to the RC system.

NOTE: Trip Reactor Coolant Pumps before R.C. Pressure decreases below pump NPSH (See figure 1 of 2102-3.1/3.2.

3.2.8 When the Borated Water Storage Tank level decreases to 12' as indicated on panel 8, Shift the MU/HPI pump(s) suction from the BWST to the RB sump if RCS Pressure is greater than 200 psig as follows: (assume DH string A(B) is being used for decay heat removal and DH string B(A) is being maintained on standby):

3.2.8.1 If not already done, "THROTTLE" HPI string(s) flow rate to at least 500 gpm each < 250 gpm per leg) using control valves MU-V16A/B/C/D (or MU-V17 if flow has been returned to the normal makeup flow path). Flow rate indication and valve control in control room on Panel 8 and 3, respectively.

3.2.8.2 "OPEN" valve DH-V7B(A) in crossover line from LPI String B(A) to HPI string B(A) (suction of HPI pumps)..

"REPOSITION" HPI flow control valves MU-V16A/B/C/D (or MU-V17 if flow has been returned to the normal makeup flowpath). HPI flow would increase because of increased HPI pump suction pressure.

3.2.8.3 When the BWST level decreases to 7', verify automatic transfer to the RB sump is initiated. Verify OPEN suction valve for string B(A), DH-V6B(A) from the RB sump.

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3.2.8.4 When the suction valve from the RB sump DH-V6 B(A), is fully open, then "CLOSE" the ECCS suction valve, DH-V5B(A), from the BSWT (valve controls and position indication in control room). The ECCS B(A) string is now in "piggy-Back" operation providing makeup to the RCS from the RB sump as required.

3.2.9 After R.C.S. pressure decreases to = 200 psig, throttle HPI discharge flow by throttling MU-V16A/B/C/D. Observe that LPI pumps now deliver water to RCS via DH-V4A/B.

3.2.10 When MU-V16A/B/C/D (HPI flow valves) are closed, stop the Hi pressure injection pumps & close DH-V7A & 7B from the LPI pump discharge. Injection flow path is now as follows:

Spill coolant to RB sump, RB sump to LPI pumps,
LPI pumps to RCS via DH-V4A/B.

3.2.11 Throttle DH-V128A & B as required to maintain 220" pressurizer level and max. LPI pump flow of 3000-3300 gpm. Within about 24 hours, establish a long-term cooling circulation mode as described in 2104-1.3 and listed below.

Mode 1 Forced circulation using decay Heat drop line.

Mode 2 Gravity draining reactor coolant hot leg to the Reactor Building sump via the D.H. drop line.

Mode 3 Hot leg injection using Pressurizer Auxiliary Spray Line.

Mode 4 Reverse flow through the Decay Heat Drop line into "B" Reactor Coolant Loop Hot Leg.

3.2.12 Evaluate radiation levels & initiate action for Site Emergency as outlined in the TMI radiation emergency plan.

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3.2.13 Reactor Building Isolation Initiated

1. Refer to Section B, 3.0 & complete all steps.

B. LEAK OR RUPTURE OF SIGNIFICANT SIZE SUCH THAT ENGINEERED SAFETY FEATURES SYSTEMS ARE AUTOMATICALLY I"ITIATED.

1.0 SYMPTOMS

1.1 Rapid continuing decrease of reactor coolant pressure.

(1) Lo alarm 2055 psig.

(2) Lo-Lo-alarm 1700 psig.

(3) Safety Injection actuation at 1640 psig.

1.2 Rapid continuing decrease of pressurizer level.

(1) Lo alarm 200".

(2) Lo-Lo alarm 80" (Interlock heater shutoff).

1.3 Hi radiation alarm in Reactor Building.

1.4 Reactor Building Ambient Temperature Alarm.

1.5 Hi Reactor Building Sump level.

1.6 Hi Reactor Building pressure (R.C.S or main steam line rupture).

1.7 Rapidly decreasing make-up tank level.

1.8 Both core flood tanks levels & pressures are decreasing.

NOTE: The operator may distinguish between a loss of coolant inside containment, an OTSG tube rupture and a steam line break by the following symptoms which are unique to the aforementioned accidents.

1. Loss of coolant inside Rx Bldg. - particulate, iodine gas monitor alarm on HP-R-227 "Reactor Building Air Sample."

2. OTSG tube rupture - Gas monitor alarm on VA-R-748.

3. Steam break inside Rx Bldg:

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(1) Low condensate storage tank level alarm - and or low hot well level alarm.

(2) FW Latch System Actuation.

2.0 IMMEDIATE ACTION

2.1 Automatic Action.

2.1.1 Reactor trip 1900 psig.

2.1.2 Turbine Trip.

2.1.3 Safety Injection initiated @ 1600 psig R.C.S pressure, or 4 psig Reactor Building pressure.

2.1.4 Both Core Flood Tank levels & pressures may decrease depending upon rupture size and R.C.S. pressure. ($\leq$ 600 psig).

2.1.5 Reactor Building Isolation & Cooling initiated. (R.B. Press. $\geq$ 4 psig).

2.1.6 Reactor Building Spray if the Reactor Building pressure is greater than 30 psig.

2.2 Manual Action.

2.2.1 "CLOSE" MU-V12 and MU-V18.

2.2.2 Small Break LOCA Response

2.2.2.1 Within 2 minutes of the LOCA the CRO dedicated to recognition of a small break LOCA must complete the following:

a. Verify that small break LOCA with single failure symptoms exist.

Symptoms: 1. SFAS initiation and only one MUP started, or

2. SFAS initiation and loss of 2-1E or 2-2E

b. DISPATCH designated LOCA Response Primary A.O. to OPEN MUP Discharge Cross-connect.

c. PROCEED to MU-V16A & B or MU-V16C & D.

d. Within 5 minutes of the LOCA the MUP discharge cross connect valve must be opened off its closed seat and one of the MU-V16 valves on the side of the single failure must be opened 2 turns.

2.2.2.2 CRO at MU-V16A & B or MU-V16C & D must ESTABLISH communications with the Control Room.

2.2.2.3 Once in communication with the control room the CRO at MU-V16A & B or C & D continue to open the valves to establish 125 gpm per leg; while the control room CRO THROTTLES MU-V16C & D or A & B to prevent pump runout.

NOTE: If the LOCA was E.S. with loss of MUP all MU-V16 valves would initially be open. The operator at the controls must in this case throttle all 4 MU-V16 valves to 125 gpm/leg. Also in this case the CRO dedicated to Small Break LOCA would not need to go to the MU-V16 valves. He should go to the MUP discharge cross connect valves and assist the A.O. to speed up the opening of the MUP discharge cross connect.

SMALL BREAK LOCA ACTION TIMES

EVENT	TIME From Occurance
Recognition	$\leq$ 2 minutes
CRO to MU-16's	$\leq$ 4.5 minutes

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EVENT	TIME From Occurance
AO to MUP Discharge X-Connects	≤ 3.5 minutes
Communications Established With CRO at MU-V16's	≤ 5.0 minutes
One of the Single Failure Side MU-V16's Open 2 turns	≤ 5.0 minutes
Discharge X-Connect OFF Closed Seat	≤ 5.0 minutes
Discharge X-Connect Open	≤ 10.0 minutes
MU-V16's Throttled to 125 gpm/leg	≤ 10.0 minutes

2.2.3 Verify Hi pressure injection is operating properly as evidenced by injection flow in all four legs. (MU-V16A/B/C/D). Flow indicated on MU23 FE1,2,3,4.

2.2.4 "TRIP" reactor coolant pumps before reaching 1200 psig.

2.2.5 Verify Reactor Building Cooling and Isolation is operating properly.

3.0 FOLLOW UP ACTION

3.1 Verify that all E.S.F. equipment is in its ESF position, by observing that all equipment status lights indicate as shown in Table B-1.

3.1.1 Check locked valve status book and verify closed or close the following manual containment isolation valves MU-V330, MU-V364, CF-V114A, CFV114B, CF-V145, CF-V146, DH-V187, and DW-V28.

NOTE: Should any component not operate properly, attempt to actuate it at its remote switch in the Control Room. If it still does not operate, & the component has a local control station attempt to operate the component locally.

3.2 Notify Shift Foreman, who notifies all Station personnel over the cross-tied PA system that a site emergency has occured.

3.3 0 to 20 or 30 minutes past LOCA until sump recircualtion is initiated: Control Room operator continuously monitors the following:

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3.3.1 Liquid levels in the:

1. Borated Water Storage Tank, DH-T1, (DH-3-LI 1/2).
2. Sodium Hydroxide Tank, DH-T2, (DH-7-LI).

3.3.2 Safety Features flow rate in each of the following:

1. Two Low Pressure (Decay Heat) Injection lines, DH-1-FI 1 and 2.
2. Four High Pressure (Makeup) Injection lines, MU-23-FI 1, 2, 3, and 4.
3. Two Reactor Building Spray injection lines, BS-1-FI and 2.
4. Four of five reactor building emergency cooling river water lines AH-FI-5620, 5621, 5522, 5623, or 5624 respectively.

3.3.3 Reactor Building environmental indications:

1. Temperature, recorder on Panel 25.
2. Pressure, recorder on Panel 3.

3.4 "DEFEAT" any <u>two</u> channels of Reactor Building Isolation and Cooling, then bypass all three Safety Injection Channels.

<u>CAUTION</u>: If normal power is lost while operating in the injection Mode from the BWST, RB Isolation and Cooling must be manually initiated, when either the BUS 2-1E or 2-2E Undervoltage alarm is received to ensure proper diesel generator load sequencing.

3.5 "THROTTLE" as required to prevent pump runout:

1. Hi press. inj. flow (MU-16A/B/C/D) 0-250 GPM/LEG.

<u>CAUTION</u>: If MU pump flow drops below 95 GPM trip the excess MU pumps.

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2. Lo Press. Inj. Flow (DH-V128A/B) 3000-3300 GPM/PMP.

3. Building spray flow (BS-V1A/B) 1400-1700 GPM/PMP.

NOTE: Hi flow alarms should actuate as a warning to throttle flows.

CAUTION: The actions to be taken for switching suction from the BWST to the R.B. sump depend upon the number of operating ECCS injection strings and the delivered flowrates in these injection strings. Based upon the existing situation, in the ECCS, proceed as outlined below to perform switch over of suction to the RB sump:

	Situation	Go to Step
1.	Both LPI strings are operating and indicated flow in each is above 750 gpm.	3.6
2.	Both LPI strings are operating but indicated flow in each is below 750 gpm.	3.7
3.	One LPI string is inoperative.	3.8

NOTE: The main objective when switching suction from the BWST to the RB sump is to maintain ECCS flow through two flow paths.

3.6 Both LPI Strings are Operating and Indicated Flow in Each is Above 750 GPM.

3.6.1 When the BWST level reaches approximately 12', initiate the following steps:

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3.6.2 If not already done "THROTTLE" LPI strings flow rates back to 3000 GPM each using control valves DH-V128 A &B (flow rate indication and valve control in control room).

3.6.2.1 If not already done, THROTTLE BS pump's flows back to 1600 gpm per pump. This must be done prior to taking suction from the RB sump.

3.6.3 "SHUT OFF" HPI pumps (pump control in control room).

3.6.4 Verify the ECCS suction valves DH-V6A & B from RB sump automatically open at BWST level of 7'.

3.6.5 When suction valves from RB sump are full open, "CLOSE the ECCS suction valves (DH-V5A & B) from the BWST.

3.6.6 "REPOSITION" LPI flow control valves (DH-V128 A&B) to obtain 3000 GPM each string if necessary. (Flow rate could change due to change in suction sources).

3.6.7 Proceed to step 3.9.

3.7 Both LPI Strings Are Operating But Indicated Flow In Each Is Below 750 GPM.

3.7.1 When the BWST level reaches approximately 12', initiate the following steps.

3.7.2 If not already done, "THROTTLE" HPI strings' flow rates back to 500 GPM per pump each using control valves MU-V16A, B, C, and D (flow rate indication and valve control in control room).

3.7.2.1 If not already done, THROTTLE BS pump's flows back to 1600 GPM per pump. This must be done prior to taking suction from the RB sump.

3.7.3 "OPEN" valves DH-V7A and B in crossover line from LPI line to suction of HPI pumps (valve control and position indication in control room). "Reposition" HPI flow control valves (MU-V16A,B,C, & D) to obtain 500 GPM each string. (HPI flow would increase because of increased HPI pump suction pressure).

3.7.4 VERIFY the ECCS suction valves (DH-V6A & B) from RB sump automatically open at BWST level of 7'.

3.7.5 When suction valves from RB sump are fully open, "Close" the ECCS suction valves (DH-V5A & B) from the BWST. The ECCS is now in "piggy-back" operation.

3.7.6 Proceed to step 3.9.

NOTE: Once the flow in each LPI string exceeds 750 gpm, the HPI pumps can be "SHUT OFF" and valves DH-V7A & B can be "CLOSED".

3.8 One LPI String is Inoperative

3.8.1 The BWST 7' automatic transfer to the RB sump is reached in approximately 55-80 minutes from initiation of ECCS injection, depending upon reason for string failure (i.e. - local LPI failure or diesel failure). Prior to actuation of the lo-lo level alarm, initiate the following steps.

3.8.2 Using the controls in the control room, attempt to "START UP" the non-operating LPI String. If successful, proceed to step 3.6. If not successful, proceed to step 3.8.3 below.

3.8.3 If step 2 was unsuccessful, initiate opening the DH cross-connect isolation valves (DH-V193 A & B) as follows:

3.8.3.1 ENSURE SN-V188 is closed then OPEN DH-V112 A & B to fill the inoperable string.

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NOTE: If offsite power is lost DHV193 A & B must be manually opened.

3.8.3.2 Obtain the keys for the DH cross-connect isolation valves' (DH-V193A and DH-V193B) breakers from the shift supervisor.

3.8.3.3 Proceed to 480V MCC 2-32B and MCC 2-42B.

3.8.3.4 Remove the locks from the isolation valve breakers for the DH cross-connect line.

NOTE: Local control stations for DH-V193A and are located in the Aux Bldg at Elev. 280'6" near the DH vaults.

3.8.3.5 "OPEN" the DH cross-connect isolation valve (e.g. DH-V-193A(B)) next to the operating LPI String.

3.8.3.6 "OPEN" the second isolation valve (DH-V193A(B)).

3.8.3.7 While opening the second decay heat cross-connect isolation valve, "THROTTLE" either DH-V128A or DH-V128B in the control room as required to achieve essentially equal flow rates in both D.H. injection lines. (Approximately 1500 gpm per LPI string).

3.8.3.8 If flow is established at greater than 750 gpm through each LPI string, then proceed to step 3.8.5.

3.8.3.9 If flow cannot be established through each LPI string in excess of 750 gpm using the cross-connect line before ECCS suction must be switched to the RB sump, then proceed to step 3.9.4.

3.8.4 If opening the DH cross-connect line fails to provide flow in each LPI string in excess of 750 gpm, then place one HPI string in a modified "Piggy-Back" mode with the operating LPI string as follows (assume LPI string "A"(B) is the operating string):

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3.8.4.1 If not already done, "THROTTLE" HPI string "A"(B) flow rate back to 500 GPM using control valve MU-V16A and V16B.

3.8.4.2 "THROTTLE" LPI string "A"(B) flow rate to 3000 GPM using control valve DH-V128A(B).

3.8.4.3 "OPEN" valve DH-V7A(B) in crossover line from LPI line to suction of the operating HPI pump.

3.8.4.4 "REPOSITION" HPI flow control valves MU-V16A&B to otbain 250 GPM per leg HPI flow and reposition LPI flow control valve DH-V128A to obtain 2500 GPM LPI flow. The LPI pump is pumping design flow of 3000 GPM (2500 GPM LPI plus 500 GPM HPI).

3.8.4.5 "SHUT OFF" HPI pump in HPI string "B"(A).

3.8.4.6 Proceed to step 3.8.6.

3.8.5 "SHUT OFF" HPI pumps (pump control in control room).

3.8.6 If not already done, THROTTLE BS pump's flows back to 1600 GPM per pump. This must be done prior to taking suction from the RB sump.

3.8.6.1 When the BWST level decreases to 7' VERIFY the ECCS suction valves (DH-V6A & B) from RB sump automatically open.

3.8.7 When suction valves from RB sump are full open (position indication in control room), "CLOSE" the ECCS suction valves (DH-V5A & B) from the BWST.

3.8.8 "REPOSITION" LPI flow control valve(s) (DH-V128A and/or B) as required to obtain proper string flowrates. (Flow rates could change due to change in suction sources).

3.9 When the Sodium Hydroxide Tank level reaches approximately 3 ft. "CLOSE" DH-V8A & B.

3.10 Actuate Environmental Barrier System by opening EB-V11.

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3.11 Within 24 hours of ECCS initiation, establish one of the long-term cooling circulation modes described in 2104-1.3 - Decay Heat Removal System, and listed below:

Mode 1 Forced circulation using decay heat drop line.

Mode 2 Gravity draining reactor coolant hot leg to the Reactor Building sump via the D.H. drop line.

Mode 3 Hot leg injection using pressurizer auxiliary spray line.

Mode 4 Reverse flow through the decay heat drop line into "B" Reactor Coolant Loop Hot leg.

4.0 LONG TERM ACTION

4.1 Verify all previous actions and carry out additional actions as outlined below.

4.2 Evaluate symptoms and determine if possible the cause of the loss of coolant.

4.3 Secure turbine, feed water, and steam systems when time permits.

4.4 Monitor for H_2 buildup and assure actuation of H_2 recombiner per 2104-6.4, Hydrogen Recombiner Operations.

4.5 Monitor R.B. Sump for pH and add Sodium Hydroxide as required thru the decay heat removal system.

4.6 As conditions permit, evaluate unit conditions, and return all non-essential equipment to its normal line up.

NOTE: Refer to the following instructions and procedures for additional information as required.

1. Radiation emergency plan site emergency in the emergency plan.
2. 2104-5.4 - Control Building HVAC.

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TABLE A-1

ESF EQUIPMENT - ESF POSITION IN THE CONTROL ROOM
PANEL 13

The white light for each component should be lit to indicate that the component is in its ESF position, unless otherwise noted.

ACTUATION A

SAFETY INJECTION GP. 1	
Equipment	ESF Position
DC-P-1A	ON
G2-12 (Note 1)	CLOSED
MU-P-1A (Note 2)	ON
NR-P-1A (Note 3)	ON
NS-P-1A (Note 4)	ON
T1E-2E2	OPEN
T3E-4E2	OPEN
T11E-21E2	OPEN
DC-V96A	CLOSED

SAFETY INJECTION GP. 2	
Equipment	ESF Position
NR-V9A	CLOSED
DH-V4A	OPEN
DH-V5A	OPEN
DH-V8A	OPEN
DH-V100A	CLOSED
DH-V102A	OPEN
MU-P-1B (Note 2)	ON
NR-V40A	OPEN
NS-P-1C	ON
T12-22E-2	OPEN
MU-V28	CLOSED

ACTUATION B

SAFETY INJECTION GP. 1	
Equipment	ESF Position
DC-P-1B	ON
G22-12 (Note 1)	CLOSED
MU-P-1B (Note 2)	ON
NR-P-1C (Note 3)	ON
NS-P-1B (Note 4)	ON
T2E-1E2	OPEN
T4E-3E2	OPEN
T21E-11E2	OPEN
DC-V96B	CLOSED

SAFETY INJECTION GP. 2	
Equipment	ESF Position
NR-V9B	CLOSED
DH-V4B	OPEN
DH-V5B	OPEN
DH-V8B	OPEN
DH-V100B	CLOSED
DH-V102B	OPEN
MU-P-1C	ON
NR-V40B	OPEN
NS-P-1C (Note 4)	ON
T22E-12E-2	OPEN
HY-V55	CLOSED

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TABLE A-1

ACTUATION A

SAFETY INJECTION GP. 3	
Equipment	ESF Position
MU-V36	CLOSED
MU-V16A	OPEN
MU-V16B	OPEN
DH-P-1A	ON
NR-P-1B (Note 3)	ON
T31E-41E-2	OPEN
NS-V84B	CLOSED
NR-V42A	OPEN

ACTUATION B

SAFETY INJECTION GP. 3	
Equipment	ESF Position
MU-V37	CLOSED
NS-V32	CLOSED
NS-V67	CLOSED
DH-P-1B	ON
MU-V16C	OPEN
MU-V16D	OPEN
NR-P-1D (Note 3)	ON
T41E-31E-2	OPEN
NS-V84A	CLOSED
NR-V42B	OPEN

PANEL 8

Equipment	ESF Position	Status Light Indicator
NS-V83A	OPEN	R
NS-V83B	OPEN	R
NS-V215	CLOSED	G
NS-V216	CLOSED	G

NOTE 1: Diesel Generator Breaker will only be closed if Normal Power is lost; otherwise status indication will be Open (white).

NOTE 2: MU-P-1B will be running if normal power is available for the Actuation, for the pump that it is selected to backup.
If normal power is lost, MU-P-1B will be running, if the pump that it is selected to backup fails to start or is inoperable.

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TABLE A-1

NOTE 3: The NR pump in each neader selected for ES or standby will start if a pump is not operating in that header; otherwise the operating pump will remain in service.

NOTE 4: Normally NS-P-1A and 1B will start; however, NS-P-1C will start if either NS-P-1A or B (depending upon which pump it is selected to backup) fails to start or is inoperable.

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TABLE B-1

ESF EQUIPMENT - ESF POSITION IN THE CONTROL ROOM
PANEL 13

The White light for each component should be lit to indicate that the component is in its ESF position, unless otherwise noted.

ACTUATION A

SAFETY INJECTION GP. 1	
Equipment	ESF Position
DC-P-1A	ON
G2-12 (Note 1)	CLOSED
MU-P-1A (Note 2)	ON
NR-P-1A (Note 3)	ON
NS-P-1A (Note 4)	ON
T1E-2E2	OPEN
T3E-4E2	OPEN
T11E-21E2	OPEN
DC-V96A	CLOSED

SAFETY INJECTION GP. 2	
Equipment	ESF Position
NR-V9A	CLOSED
DH-V4A	OPEN
DH-V5A	OPEN
DH-V8A	OPEN
DH-V100A	CLOSED
DH-V102A	OPEN
MU-P-1B (Note 2)	ON
NR-V40A	OPEN
NS-P-1C	ON
T12-22E-2	OPEN
MU-V28	CLOSED

ACTUATION B

SAFETY INJECTION GP. 1	
Equipment	ESF Position
DC-P-1B	ON
G22-12 (Note 1)	CLOSED
MU-P-1B (Note 2)	ON
NR-P-1C (Note 3)	ON
NS-P-1B (Note 4)	ON
T2E-1E2	OPEN
T4E-3E2	OPEN
T21E-11E2	OPEN
DC-V96B	CLOSED

SAFETY INJECTION GP. 2	
Equipment	ESF Position
NR-V9B	CLOSED
DH-V4B	OPEN
DH-V5B	OPEN
DH-V8B	OPEN
DH-V100B	CLOSED
DH-V102B	OPEN
MU-P-1C	ON
NR-V40B	OPEN
NS-P-1C (Note 4)	ON
T22E-12E-2	OPEN
HY-V55	CLOSED

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TABLE B-1

ACTUATION A	
SAFETY INJECTION GP. 3	
Equipment	ESF Position
MU-V36	CLOSED
MU-V16A	OPEN
MU-V16B	OPEN
DH-P-1A	ON
NR-P-1B (Note 3)	ON
T31E-41E-2	OPEN
NS-V84B	CLOSED
NR-V42A	OPEN

ACTUATION B	
SAFETY INJECTION GP. 3	
Equipment	ESF Position
MU-V37	CLOSED
NS-V32	CLOSED
NS-V67	CLOSED
DH-P-1B	ON
MU-V15C	OPEN
MU-V16D	OPEN
NR-P-1C (Note 3)	ON
T41E-31E-2	OPEN
NS-V84A	CLOSED
NR-V42B	OPEN

R.B. ISOLATION AND COOLING GP. 1	
Equipment	Position
AH-V81	CLOSED
AH-V101	CLOSED
AH-V102	CLOSED
AH-V105	CLOSED
AH-V107	CLOSED
CF-V144	CLOSED
DH-V3	CLOSED
NM-V52	CLOSED
NR-V51A	CLOSED
RR-V2A	OPEN
RR-V2B	
RR-V5A	OPEN
RR-V5B	OPEN

R.B. ISOLATION AND COOLING GP 1	
Equipment	Position
AH-E-11D	ON
AH-V80	CLOSED
AH-V103	CLOSED
AH-V104	CLOSED
AH-V106	CLOSED
AH-V108	CLOSED
CF-V115	CLOSED
DH-V2	CLOSED
NM-V104	CLOSED
NR-V51B	CLOSED
RR-V2C	OPEN
RR-V2D	OPEN

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TABLE B-1

ACTUATION A

R.B. ISOLATION & COOLING GP. 1	
Equipment	Position
RR-V5C	OPEN
SV-V55	CLOSED
WDL-V1095	CLOSED
DC-V114	CLOSED

R.B. ISOLATION & COOLING GP. 2	
Equipment	Position
AH-E-4A	ON
AH-E-11A	ON
RR-V25C	CLOSED
BS-V1A	OPEN
CA-V10	CLOSED
CA-V4A	CLOSED
CA-V9	CLOSED
RR-P-1B	ON
WDG-V199	CLOSED
WDL-V22	CLOSED
WDL-V1126	CLOSED
AH-D4092A & B	RECIRC
AH-D4092D & E	RECIRC
ED-4098	

ACTUATION B

R.B. ISOLATION & COOLING GP. 1	
Equipment	Position
RR-V6C	OPEN
RR-V6D	OPEN
RR-V6E	OPEN
SV-V54	CLOSED
WDL-V1092	CLOSED
DC-V103	CLOSED
DC-V115	CLOSED

R.B. ISOLATION & COOLING GP. 2	
Equipment	Position
AH-E-4B	ON
AH-E-11C	ON
RR-V25C	CLOSED
BS-V1B	OPEN
CA-V1	CLOSED
CA-V3	CLOSED
CA-V4B	CLOSED
CA-V8	CLOSED
CA-V6	CLOSED
RR-P-1D	ON
WDG-V2	CLOSED
WDL-V1125	CLOSED
WDL-V271	CLOSED
AH-D4092A & B	RECIRC
AH-D4092D & E	RECIRC
ED-4098	RECIRC

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TABLE B-1

ACTUATION A

R.B. ISOLATION & COOLING GP. 3

Equipment	Position
IC-V2	CLOSED
IC-V5	CLOSED
MU-V2A	CLOSED
MU-V2B	CLOSED
MU V377	CLOSED
NS-V72	CLOSED
NS-V81	CLOSED
NR-P-2A	ON
NR-V144A	OPEN
RR-P-1A	ON
RR-V25A	CLOSED
RR-V25B	CLOSED
IC-P-1A	OFF
AH-C-8A	ON
AH-E-11B	ON
AH-E-11C	ON
AH-P-1A	ON
AH-V1A	CLOSED
AH-V1B	CLOSED
AH-V4A	CLOSED
AH-V4B	CLOSED
AH-V5	CLOSED
AH-V60	CLOSED
AH-V102	CLOSED
AH-V72	CLOSED
* BS-P-1A	ON

ACTUATION B

R.B. ISOLATION & COOLING GP. 3

Equipment	Position
IC-V3	CLOSED
IC-V4	CLOSED
MU-V376	CLOSED
MU-V18	CLOSED
MU-V25	CLOSED
NS-V100	CLOSED
NR-P-2B	ON
RR-P-1C	ON
RR-V25D	CLOSED
RR-V25E	CLOSED
AH-C-8A	ON
AH-E-11E	ON
AH-P-1B	ON
AH-V2A	CLOSED
AH-V2B	CLOSED
AH-V3A	CLOSED
AH-V3B	CLOSED
AH-V6	CLOSED
AH-V61	CLOSED
AH-V61	CLOSED
AH-V63	CLOSED
AH-V71	CLOSED
IC-P-1B	OFF
* BS-P-1B	ON

* If RB Pressure >30 psig.

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PANEL 15

Equipment	ES Position	Indication
DH-V6A(1)	Close	G
DH-V6B(1)	Close	G
MU-V378(2)	Open	R
MS-V4A(3)	Open	R
MS-V4B(3)	Open	R
MS-7A(3)	Open	R
MS-V7B(3)	Open	R

(1) This valve must be opened for sump-switchover. Once opened, the Position/Indication becomes OPEN/R.

(2) This valve should be closed at the operator's first chance. Once closed, the Position/Indication becomes CLOSE/W.

(3) These valves should be closed when the steam system is secured. Once closed, the Position/Indication becomes CLOSE/G.

PANEL 25

Equipment	ES Position	Indication
AH-E12A	Off	G
AH-E12B	Off	G
AH-E19A	Off	G
AH-E19B	Off	G

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THREE MILE ISLAND NUCLEAR STATION
UNIT #2 EMERGENCY PROCEDURE 2202-2.1
STATION BLACKOUT

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Unit 1 Staff Recommends Approval

Approval NA Date ———
Cognizant Dept. Head

Unit 2 Staff Recommends Approval

Approval NA Date ———
Cognizant Dept. Head

Unit 1 PORC Recommends Approval

NA Date ———
Chairman of PORC

Unit 2 PORC Recommends Approval

J. F. Hilbish Date 6.20.78
Chairman of PORC

Unit 1 Superintendent Approval

NA Date ———

Unit 2 Superintendent Approval

J. J. Seelinger Date 6/21/78

Manager Generation Quality Assurance Approval NA Date ———

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TMI 55.A Rev 8/77

THREE MILE ISLAND NUCLEAR STATION
UNIT #2 EMERGENCY PROCEDURE #2202-2.1
STATION BLACKOUT

1.0 SYMPTOMS

1.1 Separation from the 230KV system and Turbine Generator trip as indication by:

1.1.1 Zero volts on 230KV BUS voltmeters on the Electric Control Console Panel No. 6A.

1.1.2 Generator breakers open as indicated by alarm on Control Room Panel No. 18.

2.0 IMMEDIATE ACTION

2.1 Automatic Action

2.1.1 Reactor trips due to loss of voltage to the Control Rod Drive System.

2.1.2 Turbine trips.

2.1.3 Control Room DC lighting is energized.

2.1.4 Turbine Driven Emergency Feedpump starts and commences to feed the OTSG's (Once Through Steam Generators).

2.1.5 Atmospheric steam dump valves, MS-V3A and 3B, control main steam pressure 1010 at psig.

CAUTION: If a primary to secondary leak is detected, immediately close the affected OTSG's atmospheric dump valve isolation valve (MS-V1A or 1B) to eliminate the potential of leakage and an unmonitored release path.

NOTE: The Instrument Air Compressors will not restart automatically. Therefore, the atmospheric steam dump valves, emergency feedwater regulation valves, pressurizer level control valve, and seal injection flow control valve will only function as long as the

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reserve air in the air receivers is available. The Instrument Air Compressors should be restarted manually as soon as possible.

2.1.6 Turbine Generator DC Emergency Seal Oil Pump starts.

2.1.7 Turbine Generator DC Turning Gear Oil Pump starts.

2.1.8 DC Emergency Bearing Oil Pump for the Main Feedpump Turbine starts.

2.1.9 The DC Oil Lift pumps for the RC pumps start.

2.1.10 The Emergency Diesel Generators start.
DH-V5A and 5B automatically open.

2.1.11 Both Motor Driven Emergency Feedpumps start.

2.1.12 Ventilation fans in the Control Room, Cable Room, Mechanical Equipment Room, River Water Pump House and Diesel Generator Building start.

2.1.13 Make-up pumps (MU-P-1A and 1C) start. (MU-P-1B may service as Backup to either MU-P-1A or 1C).

2.1.14 Nuclear Services River Water pumps start.

2.1.15 Nuclear Services Closed Cooling Water pumps start.

2.1.16 The Intermediate Closed Cooling Water pump starts.

2.2 Manual Action

2.2.1 Verify:

2.2.1.1 The Turbine Driven Emergency Feedpump starts.

2.2.1.2 Atmospheric Steam Dump valves open when steam pressure reaches 1010 psig.

2.2.1.3 The following DC pumps start.

2.2.1.3.1 Turbine Generator DC Emergency Seal Oil Pump.

2.2.1.3.2 Turbine Generator DC Turning Gear Oil Pump.

2.2.1.3.3 DC Emergency Bearing Oil Pump for the Main Feedpump Turbine.

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2.2.1.3.4 DC Oil Lift pumps for the RC pumps.

2.2.1.4 Both Diesel Generators start and the generator voltage is 4160 volts and the frequency is 59-61 Hertz.

2.2.1.5 The voltage available lights Unit Substations 2-11E, 2-12E, 2-21E, 2-22E, 2-31E and 2-41E energize.

2.2.1.6 Verify the following equipment has started and the associated systems are operating properly:

2.2.1.6.1 Nuclear Services Closed Cooling Water Pumps.

2.2.1.6.2 Motor Driven Emergency Feedwater Pumps.

2.2.1.6.3 Nuclear Services River Water Pumps.

2.2.1.6.4 Make-Up Pumps and DH-V5A and B open.

2.2.2 "START" both Instrument Air Compressors per 2104-2.3A. If the Instrument Air Compressors do not have sufficient capacity to maintain the air pressure above 85 psia, "CLOSE" the Turbine Building Instrument Air Isolation valve, IA-V29.

2.2.3 Verify the Intermediate Closed Cooling Water pumps start.

2.2.4 Verify the Emergency Feedwater Regulation valves, EF-V11A and B, are functioning properly and "CLOSE" EF-V32A and B. If EF-V11A and B are not operable maintain OTSG level by manually throttling EF-V32A and B.

2.2.5 Verify the Turbine Driven Emergency Feedpump is functioning properly and "STOP" both Motor Driven Emergency Feedpumps.

2.2.6 Verify RCP seal temperatures did not exceed 185°F, and that seal leakage plus seal return flow does not exceed 1.9 gpm. If either condition exists, the RCP seals should be examined before further RCP operation.

2.2.7 If any of the following ICS Stations are in Hand, Steam Generator Reactor Demand, either Feedwater Demand, Main or Startup Feedwater Valve Demand, Feedpump Speed, Reactor Master and/or Diamond Station, runback the applicable ICS Station

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3.0 FOLLOW-UP ACTION

3.1.1 Attempt to restore one 230KV line and BUS based on direction from the Dispatcher. If at least one 230KV is re-energized, re-energize plant 6900V, 4160V and 480V switchgear through the auxiliary transformer to enable start of the Reactor Coolant Pumps and energization of the pressurizer heaters to enable a normal cooldown per 2102-3.2.

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3.1.2 If neither 230KV BUS can be energized, continue with cooldown by natural circulation using the emergency feedpumps, the OTSG's and the atmospheric dump valves to control the cooldown rate. Remain within the limits of the curve for cooldown by natural circulation (Figure #1).

NOTE: Pressurizer spray and heaters are not available for pressure control due to power loss. Primary system pressure decrease will be dictated by Pressurizer heat losses to ambient which will cause approximately 100 to 200 psi/hr decrease in primary system pressure.

3.2.1 If (2) MU pumps are running.

3.2.2 Close DH-V5A/B as required to maintain MU Tank level. Trip a MU pump as required to maintain pressurizer level.

3.3 Borate the Reactor Coolant System using the Borated Water Storage Tank as follows:

NOTE: Neither the Boric Acid Mix Tank, the Concentrated Waste Tank nor the Reclaimed Boric Acid Tank are available as a source of borated water during a Loss of Normal Power situation.

3.3.1 "OPEN" DH-V5A and 5B.

3.3.2 Manually "OPEN" the RC Letdown to Bleed Hold-up Tank Isolation Valve WDL-V46.

3.3.3 Determine to which R.C. Bleed Hold-up Tank the RC Letdown will flow and manually "OPEN" the RC Hold-up Tank Inlet Valve, either WDL-V963, WDL-V964 or WDL-V965.

CAUTION: These valves are located in a 3000 mr/hr radiation zone and exposure time must be minimized.

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3.3.4 Manually "POSITION" MU-V8 to the "BLEED" position.

3.3.5 "CLOSE" MU-V10.

3.3.6 "CLOSE" MU-V12.

3.3.7 Monitor RC Bleed Hold-up Tank and Borated Water Storage Tank levels.

3.4 Following the addition of boric acid, sample the Reactor Coolant for boron concentration and verify shutdown margin per 2103-1.9.

3.5 During cooldown by natural circulation observe the following limits:

3.5.1 Upper OTSG downcomer to cold leg maximum $\Delta T=25^{o}F$.

3.5.2 The maximum cooldown rate is $100^{o}F/hr$.

3.5.3 Pressure to temperature limits are dictated by the curve for cooldown by natural circulation, figure #1.

3.6 Manually "JACK" the Main Feedpump Turbines when they have stopped. The turbines should be jacked 180^{o} every 20 minutes.

3.7 Manually "JACK" the Main Turbine when it has stopped. The Main Turbine should be turned 180^{o} every 30 minutes.

3.8 "START" one Control Building Area Fan-coil unit, AH-C-50A or B.

CAUTION: Do not exceed a load of 3 MW on either Diesel Generator.

3.9 If the Reactor Building temperature exceeds $112^{o}F$ "START" one RB Normal Cooling Unit and three RB Cooling Fans per 2104-3.1.

3.10 If the RB penetration cooling air outlet temperatures exceed $140^{o}F$ "START" one RB Penetration Forced Air Cooling Unit, AH-C-48A or B, per 2104-1.7.

3.11 "START" one Control Building River Water Booster pump and one Control Building Chiller Unit if required.

3.12 Energize portions of the Heat Tracing System as required.

3.13 Between 1820 psig and 1600 psig RC System pressure, bypass all SFAS channels for Safety Injection.

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3.14 At 700 psig RC System pressure "CLOSE" CF-V1A and B, and "OPEN" and tag the power supplies to these valves.

3.15 At 500 psig RC System pressure rack out RB Spray pumps BS-P-1A and 1B, breakers to prevent unnecessary actuation and cut in low pressure instrumentation. (RC-3A-PI2).

3.16 At 275°F RC System temperature place the NDTT "AUTO-OFF" control switch for the electromatic relief valve RC-R2 to "AUTO" to actuate the 500 psig relief set point.

3.17 When the RC System temperature is below 250°F shift cooldown from the atmospheric dump valves to the Decay Heat Removal System as follows:

CAUTION: Do not exceed 3 MW load on either Diesel Generator.

3.17.1 Line up the Nuclear Services River Water System for Decay Heat Service Cooler Operation per 2104-3.1F.

CAUTION: Do not start a second NSRW pump in the operating header to prevent overloading a Diesel Generator.

3.17.2 "START-UP" the Decay Heat Closed Cooling Water Loop associated with the Decay Heat Service Cooler placed in operation per step 17a above. Refer 2104-3.3.

3.17.3 "START-UP" the Decay Heat Removal Loop associated with the operating Decay Heat Closed Cooling Water Loop. Refer to 2104-3.3.

3.18 When the Decay Heat Removal System is operating properly and is capable of removing all the decay heat generated in the Reactor, terminate heat removal with the OTSG's as follows:

3.18.1 "CLOSE" the Atmospheric Dump valves, MS-V3A and B.

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3.18.2 Fill the OTSG's to the proper shutdown level.

3.18.3 "STOP" the Turbine Driven Emergency Feedpump and "CLOSE" EF-V11A and B or EF-V32A and B.

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HEAT UP/COOLDOWN CURVE

Revision 6
03/30/78

CAUTION:
Operation below system pressure of 500 psig requires use of Figure and the use of the low range pressure instrument

Point	Temp °F	Press Psig
A	82	155
B	157	476
C	275	476
D	280	1319
E	389	2225

Instrument Error 50 psig -25 Assumed in TECH Spec -25 for installed recorder

2. Minimum RC pressure to maintain compression force on clad (natural circulation) inst. error +50 psig -12°F

3. Minimum RC pressure to maintain compression force on fuel (forced flow) inst. error +50 psig -12°F

4. Minimum pressure for Control rod drive operation inst. error +50 psig -12°F

5. Minimum RC pressure for single pump in a loop NPSH. (170,-17,-27) inst. error +50 psig -12°F

6. Minimum RC pressure for two pumps in a loop NPSH. (270, 0/2) inst. error +50 psig -12°F

RC PRESSURE psig

TEMPERATURE, °F

TEM 2/78

99 226

Attachment #1

GPU Service

April 16, 1979

Trailer City - TMI
GPU Service Corporation
260 Cherry Hill Road
Parsippany New Jersey 07054
201 263-4900
TELEX 136-482

TO: R. C. Arnold

FROM: R. L. Long

PRELIMINARY SEQUENCE OF EVENTS
TMI 2 ACCIDENT OF MARCH 28, 1979

Attached is a Preliminary Sequence of Events spanning the first approximately twenty hours following the TMI-2 accident which was initiated at 4:00 a.m. on March 28, 1979.

For this chronology of events, a reference clock was established with the time of the turbine trip, 0400:37, defined as time zero. The time of each event in the sequence is given as the number of hours, minutes and seconds relative to 0400:37, followed in parenthesis by the real time using a 24-hour clock. For example, 1:52:43 p.m. on March 28 would be written "9:52:06 (1352:43)." Depending upon the accuracy of the source of data for each event, the times appear alone or with the notation "approximate."

The sequence has been reconstructed from various information and data sources, including control room logs, strip chart recorders, alarm printouts and reactimeter printouts. Please note, however, that the alarm printer was out of service from 01:13:27 (0513:59) to 02:47:31 (0648:08) and during the course of the accident was running well behind the actual time of events. Efforts to annotate this chronology and to develop graphs of various plant parameters as a function of time are underway. This additional information will be provided as soon as it is available and we will keep you informed of our progress.

R. L. Long
GPU

CC: H. Dieckamp
J. Herbein
R. Wilson
Industrial Advisory Group
Data Reduction and Management
M. Bezilla
L. Harding
G. Kunder
J. Logan
G. Miller

99 227

PRELIMINARY SEQUENCE OF EVENTS
TMI 2 ACCIDENT OF MARCH 28, 1979
Issued April 16, 1979

-00:05:00 (0355:36) Three Mile Island Unit Two was at 97% power with the Integrated Control System in full automatic. Rod groups one thru five were fully withdrawn, rod groups six and seven were 95% withdrawn and rod group eight was 27% withdrawn. Reactor Coolant System total flow was approximately 107.5% of design flow and the Reactor Coolant System pressure was 2155 psig. Reactor Coolant Makeup Pump B (MU-P-1B) was in service supplying makeup and Reactor Coolant Pump Seal injection flow. The Reactor Coolant System soluble boron concentration was approximately 1030 parts per million. Pressurizer Spray Valve (RC-V1) and the pressurizer heaters were in manual control while spraying the pressurizer to equalize boron concentrations between the pressurizer and the remainder of the Reactor Coolant System. Normal Reactor Coolant System letdown flow was established.

Steam Generator parameters were as shown in the following table:

	Steam Generator A	Steam Generator B
Loop Feedwater	5.7459 MPPH*	5.7003 MPPH*
Operating Level	56%	57.4%
Startup Level	158.8 inches	163.4 inches
Steam Pressure	910 psig	889.6 psig
Feedwater Temperature	462.7F	462.7F

*MPPH is Million Pounds Per Hour

99 228

Steam Generator Feedwater Pumps (FW-P-1A and FW-P-1B) were in service, Condensate Booster Pumps (CO-P-2A, CO-P-2B and CO-P-2C) were in service, and Condensate Pumps (CO-P-1A and CO-P-1B) were in service. An attempt was being made to clear a clogged resin transfer line in the standby demineralizer.

-00:00:01 (0400:36) Condensate Pump A (CO-P-1A) stopped.

-00:00:01 (0400:36) Feedwater Pumps (FW-P-1A and FW-P-1B) stopped at essentially the same time resulting in a loss of feedwater flow to both steam generators.

00:00:00 (0400:37) Main Generator was tripped followed by a turbine trip.

00:00:00 (0400:37) Three Emergency Feedwater Pumps (EF-P-1, 2A, 2B) started.

00:00:03 (0400:40) Approximate The Electromatic Relief Valve (RC-RV2) opened at the setpoint of 2255 psig.

00:00:08 (0400:45) Reactor tripped on high pressure at 2345 psi. Setpoint is 2355 psi.

00:00:08 (0400:45) Approximate The operator placed the Pressurized Spray Valve (RC-V1) and pressurizer heaters under automatic control.

00:00:13 The operator started the Reactor Coolant Makeup Pump A (MU-P-1A), opened High Pressure Injection Isolation Valve A (MU-V16A) and isolated letdown flow in anticipation of the expected pressurizer level decrease.

99 229

00:00:13 (0400:50) Approximate — The Electromatic Relief (RC-RV2) solenoid de-energized giving a non-open indication to the control room operators. The Electromatic Relief Valve (RC-RV2) should have reseated at about this time (closure setpoint of 2205 psig).

00:00:14 (0400:51) — The Emergency Feed Pumps (EF-P1, 2A and 2B) achieved normal discharge pressure.

00:00:15 (0400:52) Approximate — Water hammer in the condensate piping occurred.

00:00:30 (0401:07) — Pressurizer Safety Valve (RC-RV1B) and Electromatic Relief Valve (RC-RV2) discharge line temperature alarms printed out.

00:00:38 (0401:15) Approximate — Steam Generator A level reached the 30-inch setpoint where the Emergency Feedwater Valves (EF-V11A and EF-V11B) open. Feedwater was not admitted because Emergency Feedwater Block Valves (EF-V12A and EF-V12B) were shut.

00:00:39 (0401:16) — Reactor Coolant Makeup Pump A (MU-P-1A) was stopped.

00:00:40 (0401:17) Approximate — Steam Generator B level reached the 30-inch setpoint where the Emergency Feedwater Valves (EF-V11A and EF-V11B) open. Feedwater was not admitted because Emergency Feedwater Block Valves (EF-V12A and EF-V12B) were shut.

00:00:41 (0401:18) — Reactor Coolant Makeup Pump A (MU-P-1A) was restarted. With Reactor Coolant Makeup Pumps A and B (MU-P-1A and MU-P-1B) operating, pressurizer level rate of decrease slowed.

99 230

00:01:00 (0401:37) Approximate	Pressurizer level started increasing. Reactor Coolant System hot leg and cold leg temperatures reached 575F. Reactor Coolant Drain Tank pressure was increasing.
00:01:00 (0401:37)	The Pressurizer Safety Valve (RC-RV1A) high discharge line temperature alarm was received.
00:01:26 (0402:03)	Reactor Coolant Drain Tank temperature normal alarm printed out.
00:01:45 (0402:22) Approximate	Steam Generators A and B have boiled dry at this time.
00:02:01 (0402:38)	Reactor Coolant Makeup Pump B (MU-P-1B) was stopped due to Engineered Safeguards actuation.
00:02:04 (0402:41)	High Pressure Injection Pump C (MU-P-1C) started automatically.
00:03:12 (0403:49) Approximate	Reactor Coolant Drain Tank Relief Valve (WDL-R1) lifted at 120 psig.
00:03:14 (0403:51)	High Pressure Injection portion of Engineered Safeguards was manually bypassed. Both Reactor Coolant Makeup Pumps A and C (MU-1P-1A and MU-P-1C) were operating.
00:03:26 (0404:03)	Reactor Coolant Drain Tank high temperature alarm received at 127.2F.
00:04:38 (0405:15)	Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.
00:04:38 (0405:15) Approximate	The operator throttled the High Pressure Injection Isolation Valves (MU-V16's).

99 231

00:04:52 (0405:29) Intermediate Closed Cooling Pump (IC-P-1A) started.

00:04:58 (0405:35) First alarm indication received that letdown had been secured.

00:05:06 (0405:43) Presurizer level stopped its sharp increase at 376 inches and began to turn down. It reached a minimum of 372 inches and then started back up at 5 minutes, 21 seconds into the transient.

00:05:15 (0405:52) Condensate Booster Pump B (CO-P-2B) tripped.

00:05:50 (0406:27) Approximate Reactor Coolant System pressure stopped its sharp decrease and began to turn up. Minimum value reached was approximately 1350 psig.

00:05:54 (0406:31) Pressurizer level increased beyond the range of the instrument indication.

00:06:58 (0407:35) Letdown flow of 71.4 gallons per minute was re-established.

00:07:31 (0408:06) Reactor Building Sump Pump A (WDL-P-2A) started.

00:08:00 (0408:37) Approximate Emergency Feedwater Block Valves (EF-V12A and EF-V12B) were opened.

00:08:15 (0408:52) Reactor Coolant System hot leg and cold leg temperatures began to decrease.

00:08:30 (0409:07) Reactor Coolant System pressure began to decrease.

00:10:00 (0410:37) Pressurizer level came on scale.

99 232

00:10:19 (0410:56) Reactor Building Sump Pump B (WDL-P-2B) started.

00:10:24 (0411:01) Reactor Coolant Makeup Pump A (MU-P-1A) tripped.

00:10:27 (0411:04) Reactor Coolant Makeup Pump A (MU-P-1A) was started.

00:10:28 (0411:05) Reactor Coolant Makeup Pump A (MU-P-1A) tripped.

00:10:40 (0411:25) Reactor Building Sump high level alarm received. Setpoint is 4.650 feet.

00:11:40 (0412:17) Reactor Coolant Makeup Pump A (MU-P-1A) was started.

00:14:50 (0415:27) The Reactor Coolant Drain Tank rupture diaphragm (WDL-U26) failed.

00:24:58 (0425:35 The operator requested computer printout of the Electromatic Relief Valve (RC-RV2) outlet temperature. The reading was 285.4F.

00:25:00 (0425:37) Approximate Intermediate Cooling System high radiation alarm annunciator received at the Radiation Monitor Panel.

00:36:09 (0436:41) Emergency Feedwater Pump 2B (EF-P-2B) was stopped.

00:38:10 (0438:47) Reactor Building Sump Pump A (WDL-P-2A) was stopped.

-00:38:11 (0438:48) Reactor Building Sump Pump B (WDL-P-2B) was stopped.

01:10:54 (0511:31) Reactor Building air cooling coils emergency discharge alarm printed out.

99 233

01:13:29 (0514:06)	Reactor Coolant Pump 2B (RC-P-2B) was stopped.
01:13:42 (0514:19)	Reactor Coolant Pump 1B (RC-P-1B) was stopped.
01:13:27 (0513:59)	The alarm printer became unavailable at this time and remained out of service until 02:47:31 (0648:08).
01:20:31	Operator requested printout of the Electromatic Relief Valve (RC-RV2) outlet temperature. The reading was 283.0F.
01:40:37 (0541:14)	Reactor Coolant Pump 2A (RC-P-2A) was stopped.
01:40:45 (0541:22)	Reactor Coolant Pump 1A (RC-P-1A) was stopped.
01:42:00 (0542:37) Approximate	Operator started raising Steam Generator A level from 30 inches on the Startup Range to 50% on Operating Range. Reactor Coolant System Loops A and B cold leg temperatures both started decreasing. Reactor Coolant System pressure started decreasing.
01:54:00 (0554:37) Approximate	Reactor Coolant System Loop A hot leg temperature began increasing.
02:00:00 (0600:37) Approximate	Steam Generator A level reached 50% on Operating Range.
02:00:00 (0600:37)	Reactor Coolant System Loop B hot leg temperature began increasing.
02:12:00 (0612:37)	Reactor Coolant System Loop B hot leg temperature increased to offscale at 620F.

99 234

02:17:53 (0618:30)	Operator requested Electromatic Relief Valve (RC-V2) outlet temperature. The reading was 228.7F.
02:22:00 (0622:37) Approximate	The Electromatic Relief Block Valve (RC-V2) was shut.
02:30:00 (0630:37)	Operator started increasing Steam Generator B from 30 inches on Startup Range to 50% on Operating Range.
02:45:00 (0645:37) Approximate	Several radiation alarms were received.
02:45:00 (0645:37) Approximate	Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.
02:45:00 (0645:37) Approximate	Operator opened Main Steam Isolation Valves (MS-V7B and MS-V7B)
02:50:00 (0650:37) Approximate	Site Emergency was declared. Notifications to offsite authorities and organizations were initiated.
02:51:57 (0652:34)	Operator attempted to start Reactor Coolant Pump 2A (RC-P-2A). Pump would not start.
02:53:19 (0653:53)	Operator attempted to start Reactor Coolant Pump 1B (RC-P-1B). Pump would not start.
02:54:09 (0654:46)	Operator started Reactor Coolant Pump 2B (RC-P-2B).
02:54:49 (0655:26)	High Pressure Injection Engineered Safeguards actuation logic reset on increasing Reactor Coolant System pressure.

99 235

02:56:19 (0656:56) Approximate — Steam Generator B was isolated. Main Steam Isolation Valves (MS-V4B and MS-V7B) were shut.

03:00:00 (0700:37) Approximate — Reactor Coolant System pressure increased to 2130 psig.

03:03:39 (0704:16) Approximate — Steam Generator A pressure control was shifted from the Turbine Bypass Valves (MSV-25A and B and MSV-26A and B) to the Power Operated Emergency Main Steam Dump Valves (MSV-3A and B).

03:10:27 (0711:04) — Emergency Feedwater Pump 2A (EF-P-2A) was stopped.

03:12:28 (0713:05) Approximate — Electromatic Relief Block valve (RC-V2) was opened.

03:12:53 (0712:53) — Reactor Coolant Pump 2B (RC-P-2B) was stopped.

03:20:13 (0720:41) — Reactor Coolant Makeup Pump C (MU-P-IC) was started. Reactor Coolant Makeup Pumps C and A (MU-P-C and A) were operating.

03:23:23 (0724:00) Approximate — General Emergency was declared. Notifications to offsite authorities and organizations were initiated.

03:30:00 (0730:37) Approximate — Electromatic Relief Block Valve (RC-V2) was shut.

03:35:08 (0735:43) — Emergency Feedwater Pump 2A (EF-P-2A) was started.

03:37:00 (0737:37) — Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

03:51:00 (0751:37) Approximate — Electromatic Relief Block Valve (RC-V2) was opened.

99 236

03:55:39 (0756:16) Engineered Safeguards actuated on low RCS pressure. Setpoint is 1640 psig.

03:55:39 (0756:16) The Reactor Building high pressure isolation signal actuated and isolated the Reactor Building. The Reactor Building isolation set point is 4 psig.

03:56:04 (0756:41) Reactor Coolant Makeup Pump C (MU-P-1C) was started.

03:59:23 (0800:00) Reactor Building Emergency Cooler B was shutdown.

03:59:53 (0800:30) Reactor Building Emergency Cooler B was started.

04:06:00 (0806:37) Electromatic Relief Block Valve (RC-V2) was shut.

04:08:37 (0809:14) Reactor Coolant Pump 1A (RC-P-1A) was started.

04:09:14 (0809:51) Reactor Coolant Pump 1A (RC-P-1A) was stopped.

04:17:17 (0817:54) Reactor Coolant Makeup Pump A (MU-P-1A) was stopped.

04:17:22 (0817:59) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped. No makeup pumps operating.

04:18:17 (0818:54) Operator attempted to start Reactor Coolant Makeup Pump A (MU-P-1A). The pump would not start.

04:18:30 (0819:07) Electromatic Relief Block Valve (RC-V2) was opened.

Approximate

99 237

04:21:53 (0818:30) Reactor Coolant Makeup Pump B (MU-P-1B) was started.

04:26:59 (0827:36) Approximate Reactor Coolant Makeup Pump C (MU-P-1C) was started, tripped, and was restarted.

04:30:00 (0830:37) Approximate The Electromatic Relief Block Valve (RC-V2) was shut.

04:30:45 (0831:22) Condenser Vacuum Pumps 1A and 1C (VA-P-1A and VA-P-1C) were stopped and vacuum was broken.

04:30:45 (0831:22) Approximate Power Operated Emergency Main Steam Dump Valve (MS-V3A) was opened.

04:54:00 (0854:37) Approximate The Electromatic Relief Block Valve (RC-V2) was opened.

05:18:00 (0918:37) The Electromatic Relief Block Valve (RC-V2) was shut.

05:54:00 (0954:37) Approximate Operator commenced filling Steam Generator A to 99% on the Operating Range instrumentation.

07:30:00 (1130:37) Approximate Electromatic Relief Block Valve (RC-V2) and the Pressurizer Spray Valve (RC-V1) were opened.

08:11:26 (1212:03) Core Flood Tank A high level alarm was received.

08:30:00 (1230:37) Power Operated Emergency Main Steam Dump Valve (MS-V3A) was shut.

99 238

08:31:06 (1231:43)	Decay Heat Removal Pumps 1A and 1B (DH-P-1A and DH-P-1B) were started.
08:54:56 (1255:33)	Core Flood Tank A alarm printed out at a level of 13.13 feet.
09:04:18 (1304:55)	Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.
09:49:44 (1350:21)	Reactor Building Isolation and Containment Spray were actuated by Engineered Safeguards. Engineered Safeguards actuation started Reactor Coolant Makeup Pump C (MU-P-1C) and Reactor Building Spray Pumps A and B (BS-P-1A and BS-P-1B).
09:49:50 (1350:27)	Reactor Building Spray Valves (BS-V1A and BS-V11B) opened.
09:49:58 (1350:35)	Reactor Coolant Pumps 1A and 1B (RC-P-1A and RC-P-1B) inlet air temperature high alarms annunciated and Pressurizer Safety Valves (RC-R1A and RC-R1B) discharge line temperature high alarms annunciated.
09:50:24 (1351:01)	Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.
09:55:30 (1356:07)	Reactor Building Spray Pumps A and B (BS-P-1A and BS-P-1B) were stopped.
09:56:58 (1357:35)	Decay Heat Removal Pumps A and B (DH-P-1A and DH-P-1B) were stopped.
10:24:00 (1424:37) Approximate	Reactor Coolant System hot leg Loop A temperature decreased to within the instrumentation range.

99 239

10:31:25 (1432:02) Reactor Coolant Makeup Pump C (MU-P-1C) was started. Reactor Coolant pressure was approximately 440 psig.

10:35:55 (1436:32) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

11:06:00 (1406:37) Approximate Pressurizer level started decreasing.

11:12:00 (1512:37) Approximate Reactor Coolant System cold leg Loop A temperature started to increase from 200F to 400F. Reactor Coolant System hot leg Loop A temperature decreased from above the instrument range to 560F.

11:18:34 (1519:11) Reactor Coolant Makeup Pump C (MU-P-1C) was started.

11:24:00 (1524:37) Approximate Pressurizer level stopped decreasing at 180 inches and started increasing, going off scale during the next hour.

11:28:12 (1528:49) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

11:32:37 (1533:14) Reactor Coolant Makeup Pump C (MU-P-1C) was started.

11:35:48 (1536:25) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

11:36:00 (1536:37) Approximate Operator commenced filling Steam Generator B to 97% on the Operating Range instrumentation.

12:00:00 (1600:37) Approximate Steam Generator A level was 97% on the Operating Range.

12:48:00 (1648:00) Approximate Pressurizer level came on scale.

99 240

13:02:23 (1703:00) Condenser Vacuum Pump 1C (VA-P-1C) was started.

13:08:22 (1708:59) Approximate Normal steam generator feedwater supply was put in service.

13:13:10 (1713:47) Condenser Vacuum Pump 1A (VA-P-1A) was started.

13:23:04 (1723:41) Reactor Coolant Makeup Pump C (MU-P-1C) was started.

14:43:15 (1843:52) Reactor Coolant Makeup Pump C (MU-P-1C) was stopped.

14:54:00 (1854:37) Approximate RCS pressure reached 2350 psig.

15:24:00 (1924:37) Reactor Coolant Pump 1A (RC-P-1A) was started.

15:24:10 (1924:47) Approximate Reactor Coolant Pump 1A (RC-P-1A) was stopped.

16:04:00 (2008:37) Reactor Coolant Pump 1A (RC-P-1A) was started.

22:15:00 (0215:37) Approximate Reactor Coolant System and Steam Generator conditions were:

Reactor Coolant System pressure = 1165 psig.

Pressurizer Temperature = 551F (pressurizer heaters maintaining temperature).

Pressurizer Level = 397 inches.

Reactor Coolant System cold leg Loop A temperature = 288F

Steam Generator A steaming to the Main Condenser.

99 241