Davis-Besse Loss of All Feedwater

Chapter 16.0
B&W Cross-Training Course
R-326C

OBJECTIVES

1. List the indications of a “Loss of Heat Transfer” event.
2. Explain what operator actions and equipment failures led to the “Loss of Heat Transfer” event at Davis-Besse.
3. Explain the protection provided in an event that exceeds the design bases of the unit.
4. Describe how the “Feed and Bleed” method of core cooling is used to remove decay heat following a reactor trip.
5. State why an operator/supervisor may be reluctant to use this method of decay heat removal.

Appendix – Sequence of Events

<u>Initial Conditions</u>

- Unit operating at 90% power
- #1 MFP operating in automatic (ICS) control
- #2 MFP operating in manual control
- One source range NI inoperable
- Both channels of the SPDS inoperable

<u>Transient Initiator</u>

01:35:00 #1 MFP trips. Control system causes MFP flow increase; MFP turbine trips on overspeed.

Appendix – Sequence of Events

<u>Partial Loss of Main Feedwater</u>

01:35:01	Unit runback at 50%/min toward 55%.
01:35:21	Manual increase of #2 MFP speed. PZR spray valve opened to 100% in manual.
01:35:30	Reactor/turbine trip from 80% caused by high RCS pressure (2300 psig).
01:35:31	SFRCS low level trip - channel 2.
01:35:31	Both MSIVs start to close.
01:35:34	SFRCS actuation signal clears automatically.
01:35:36	MSIV #2 close.
01:35:37	MSIV #1 closed. The main steam supply to #2 MFP is isolated. Steam from the MSR and MS piping will drive the turbine for about 4-1/2 minutes.
01:35:45	PZR spray valve closed.
01:35:56	OTSGs on low level limits (35 in.).
01:40:00	OTSG levels begin to drop below low level limits.

Appendix – Sequence of Events

Complete Loss of Main Feedwater

01:41:04 SFRCS OTSG #1 low level (26.5 in.) actuation. #1 AFW turbine being supplied with steam from and supplying feedwater to #1 OTSG.

01:41:08 Operator manually actuates SFRCS on low OTSG pressure. The low pressure actuation is in both SFRCS channels, and the system senses " steam ruptures" in both OTSGs. The following equipment changes due to the manual actuation:

1. #1 AFW turbine is aligned to be supplied from #2 OTSG.
2. #2 AFW turbine is aligned to be supplied from #1 OTSG.
3. #1 OTSG AFW containment isolation valve is automatically closed.
4. #2 OTSG AFW containment isolation valve is automatically closed.
5. The AFW cross-connect valves open.

01:41:13 SFRCS channel 2 low level trip. Pressure trip has priority.

01:41:31 #1 AFW turbine trips on overspeed.

01:41:44 #2 AFW turbine trips on overspeed.

01:42:00 Manual reset of SFRCS. The AFW containment isolation valves should have re-opened automatically, but did not. An attempt was made to re-open the valves from the main control panel, but the valves did not respond.

Appendix – Sequence of Events

01:42:00 PZR spray valve opened.

01:43:55 "Initiate reset and block" of SFRCS attempted in an effort to re-open AFW containment isolation valves. Valves did not open.

01:44: + Equipment operators dispatched to the plant to operate the following equipment:

1. Two operators to the AFW turbines to restore AFW pumps to service.
2. The assistant shift supervisor left the control room to place the startup feed pump in service.
3. Two operators were sent to open the AFW containment isolation valves.

01:44:50 Makeup flow decreases as pressurizer level increases above the normal setpoint of 200 in.

01:45:50 #2 AFW turbine overspeed trip reset locally.

01:45:29 OTSG #1 atmospheric vent valve opened.

01:46:30 #1 AFW turbine throttle valve relatched and valve opened (overspeed trip not cleared). Speed controlled locally throughout event

01:47:33 OTSG #1 below 960 psig and decreasing.

01:47:48 OTSG #2 AFW containment isolation valve opened locally.

01:48:08 OTSG #1 atmospheric vent valve closed.

01:48:49 PZR PORV opens at 2433 psig (2425 psig setpoint).

01:48:51 OTSG #2 pressure <960 psig and decreasing. Both OTSGs now " dried out." Procedures require MU/HPI core cooling. MU/HPI core cooling is also called " feed and bleed" core cooling.

• Appendix – Sequence of Events

01:48:52 PORV closed at 2377 psig. (2375 setpoint)

01:49:28 OTSG #1 AFW containment isolation valve opened manually.

01:50:09 PORV opens at 2434 psig.

01:50:12 PORV closes at 2369 psig.

01:50:13 OTSG #1 atmospheric vent valve opened; OTSG pressure drops rapidly to 750 psig.

01:51:17 OTSG #1 level drops below 8 in. (MU/HPI cooling criterion)

01:51:18 PORV opens at 2435 psig and does not close.

01:51:23 Startup feedwater pump motor started.

01:51:30 Obtained flow from startup feedpump to OTSG #1.

01:51:42 Operator started to close the PORV block valve as pressure fell through 2140 psig.

01:51:42 RCS loop #1 reaches a minimum pressure of 2081 psig. Loop #1 T_{hot}=588.6°F, T_{ave}=587.5°F.

01:51:43 PZR spray valve closed.

01:51:49 Acoustic monitor indicates <20% flow through the PORV and PORV block valve.

01:53:00 T_{hot} reaches maximum value of 593.5°F.

01:53:22 AFW train #2 has significant flow, with control locally via the trip-throttle valve.

Appendix – Sequence of Events

01:53:25 RCS Tave reaches maximum of 592.3°F.

01:53:25 RCS Tave reaches maximum of 592.3°F.

01:53:35 OTSG #2 returns to above 960 psig.

01:53:56 PORV block valve re-opened.

01:54:45 OTSG #1 returns to above 960 psig.

01:54:46 AFW train #1 has significant flow.

01:56:58 OTSG #2 atmospheric vent valve open. Pressure <960 psig.

01:57:05 OTSG #1 <960 psig.

01:57:53 Low suction pressure developed on #1 AFW pump.

01:58: + Tave passed through the normal post-trip value. The cooldown (due to feedwater) has lowered RCS pressure to about 1720 psig. The operators have manually started #1 HPI pump in the piggy back mode of operation to maintain pressurizer level. About 50 gallons of water is injected.

01:58:08 RCS pressure reaches a minimum of 176 psig. T_{hot}=546°F, T_{ave}=546.2°F.

01:58:27 AFW pump suction pressure returns to normal.

01:58:28 OTSG #1 atmospheric vent valve closed.

01:58:33 AFW flow to #1 OTSG reduced to control level.

01:58:40 AFW #1 suction transfers to service water. Manual realignment to CST.

01:58:57 AFW pump turbine overspeed trip reset.

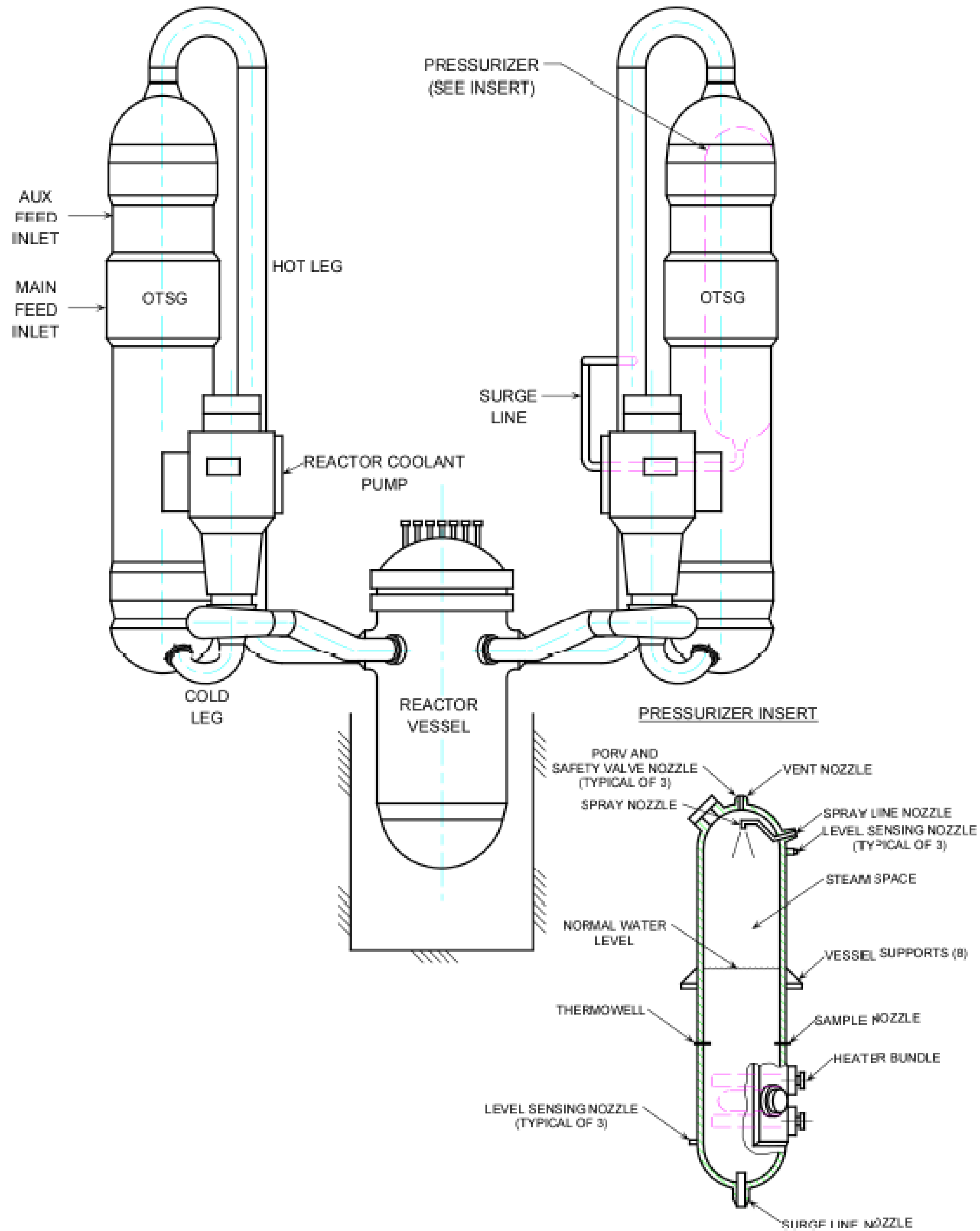
02:01: + When AFW turbine #2 was returned to service, the control room operator controlled the pump in manual rather than returning it to auto.

Appendix – Sequence of Events

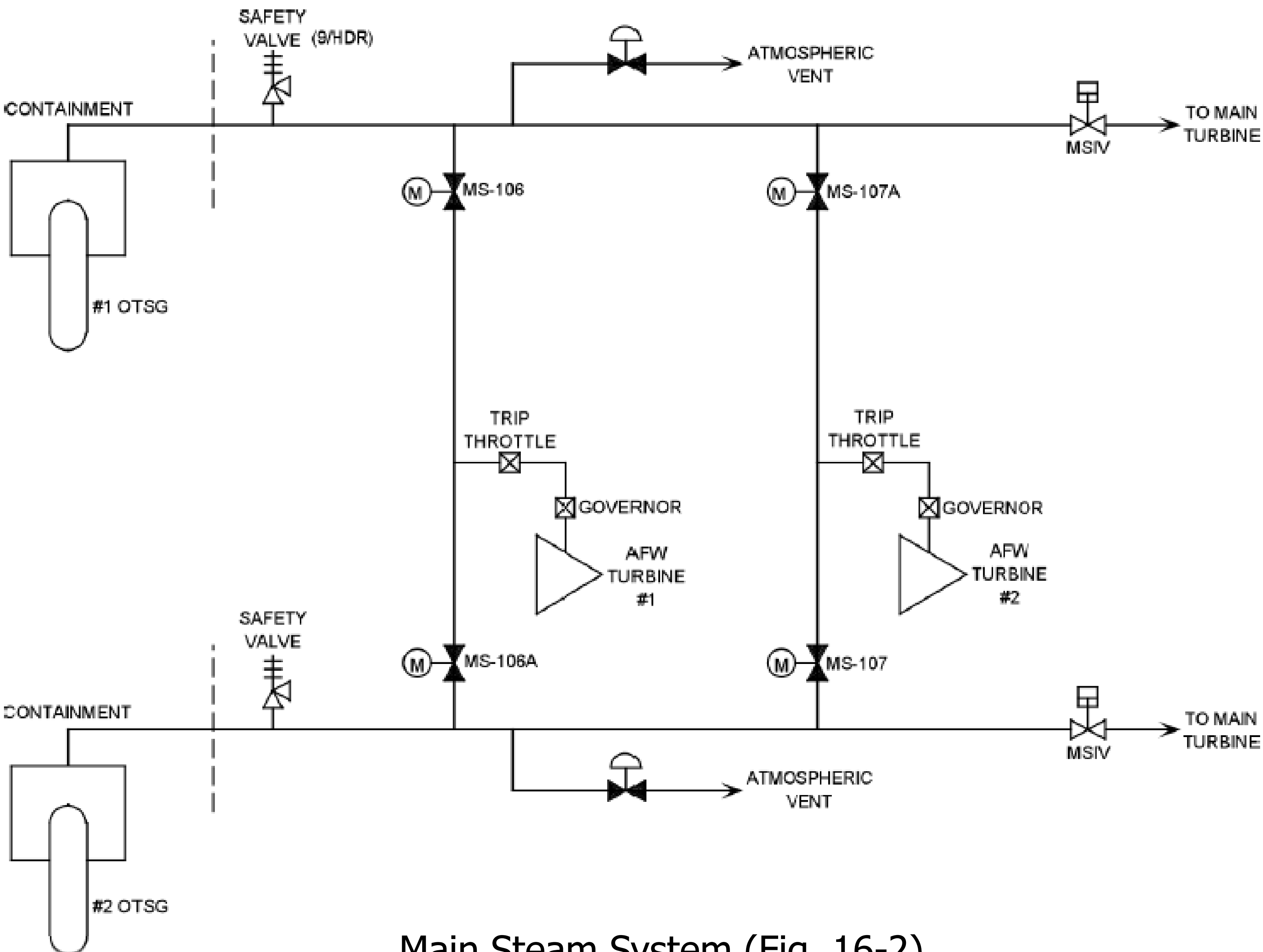
02:01:13 AFW train #2 flow reduced.
02:02:27 OTSG #1 pressure >960 psig.
02:02:30 OTSG #2 pressure >960 psig.
02:04: Plant conditions essentially stable.

Additional Complications

- Control room HVAC spuriously tripped to the emergency mode.
- Upon energization, the remaining source range NI failed off-scale low. All control rods were verified to be fully inserted, and emergency boration was initiated.
- The main turbine did not go on turning gear.
- The operator attempted to override the automatic close signal for one of the SU reg valves, but a burned out light bulb prevented reset indication.
- When vacuum was restored and the MSIVs opened, a water slug damaged one of the turbine bypass valves.

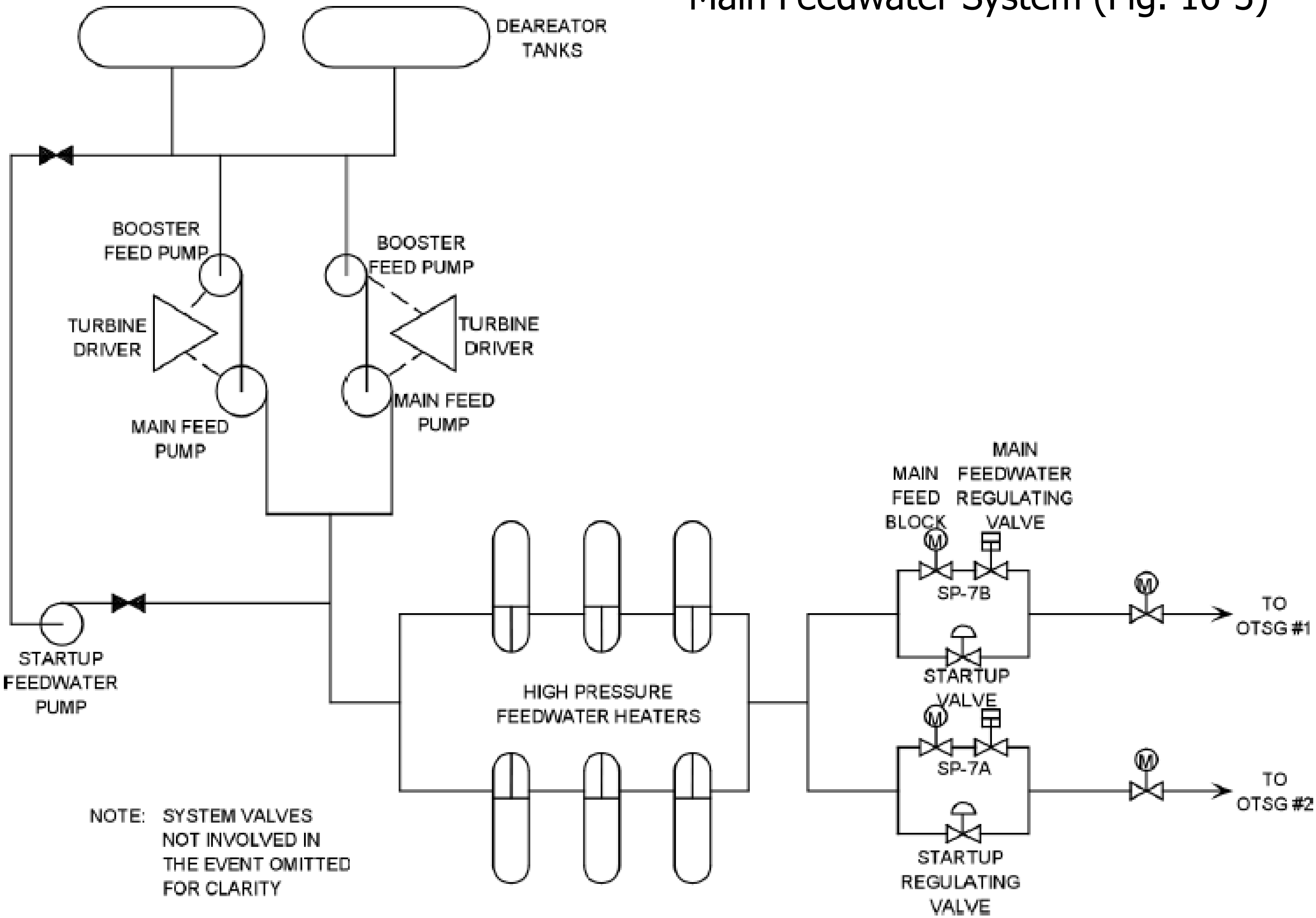


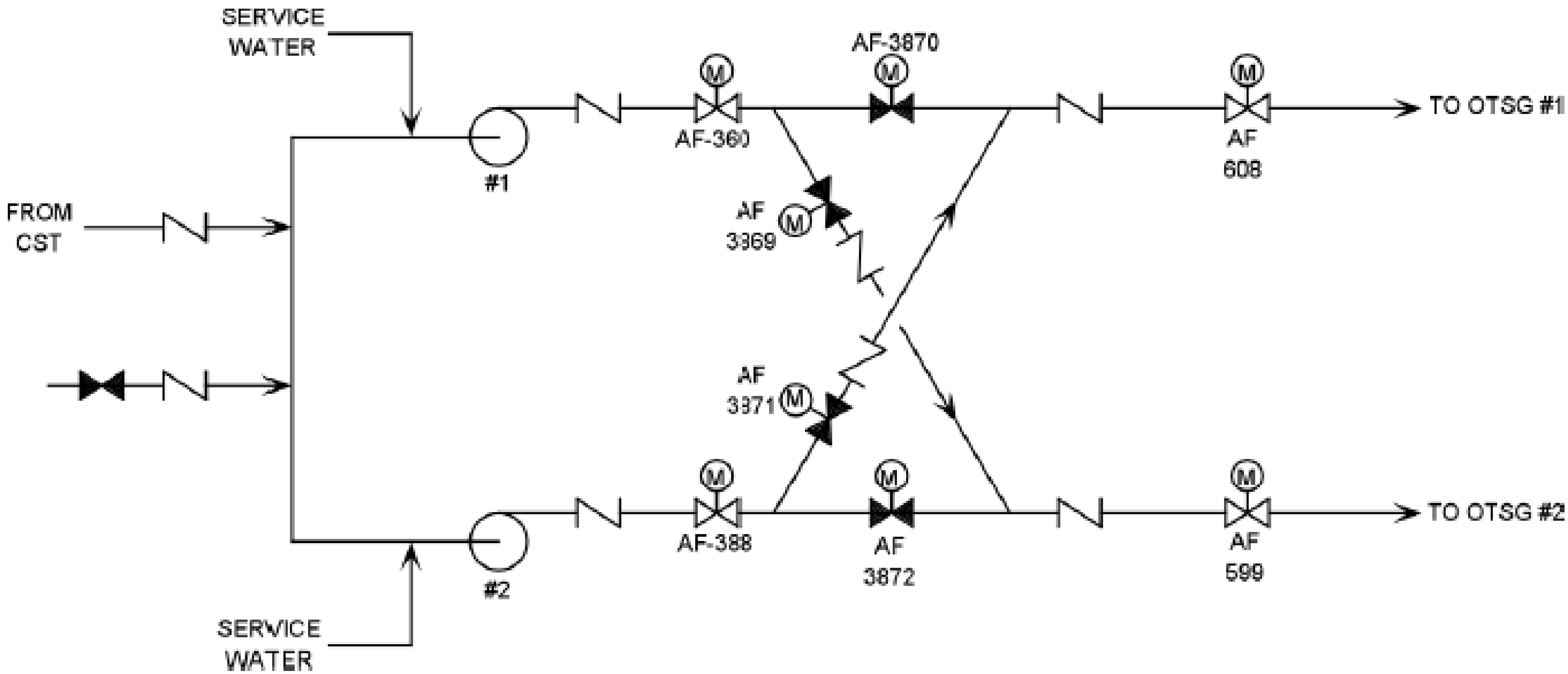
Davis-Besse NSSS
Fig. 16-1



Main Steam System (Fig. 16-2)

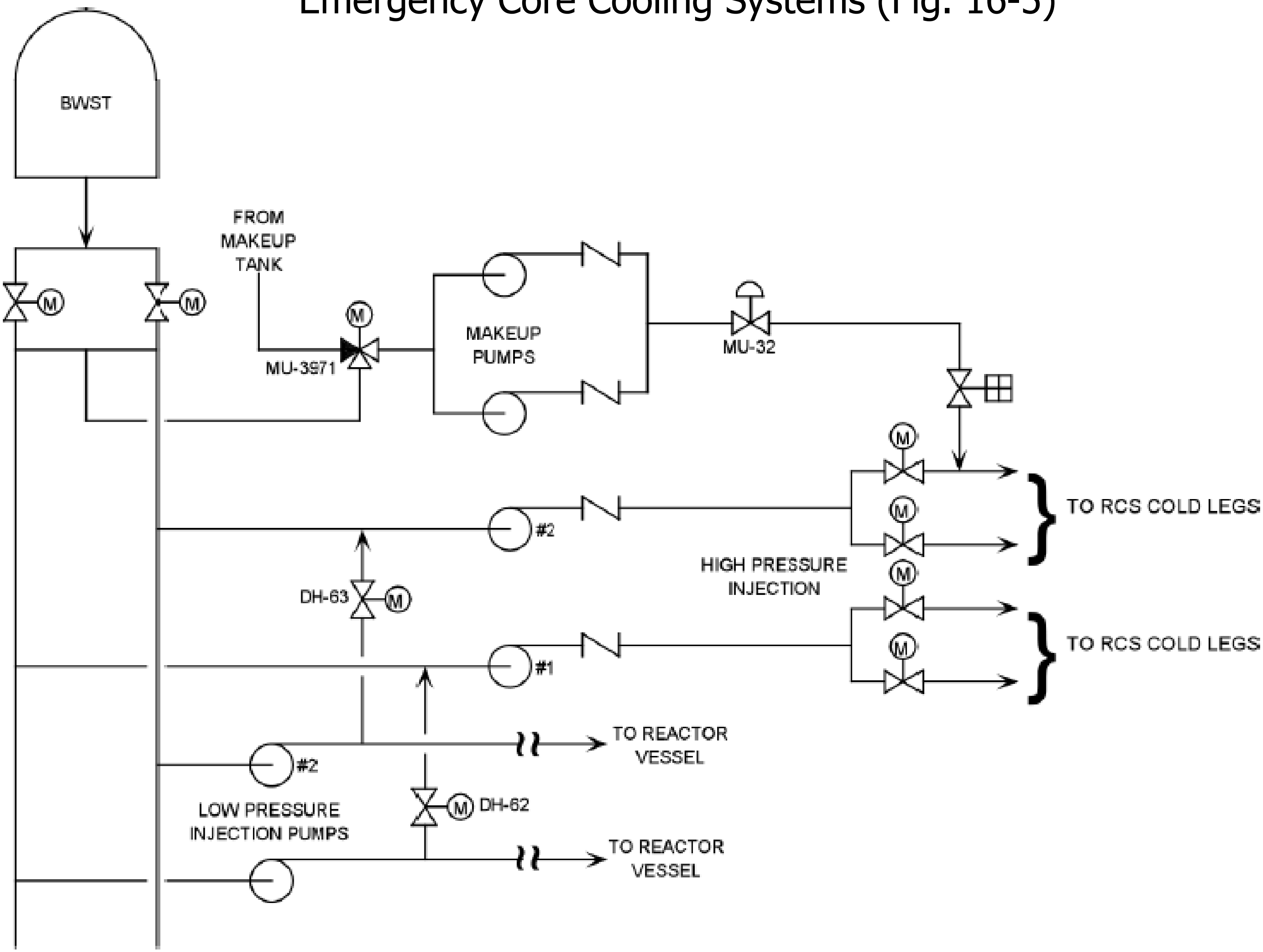
Main Feedwater System (Fig. 16-3)

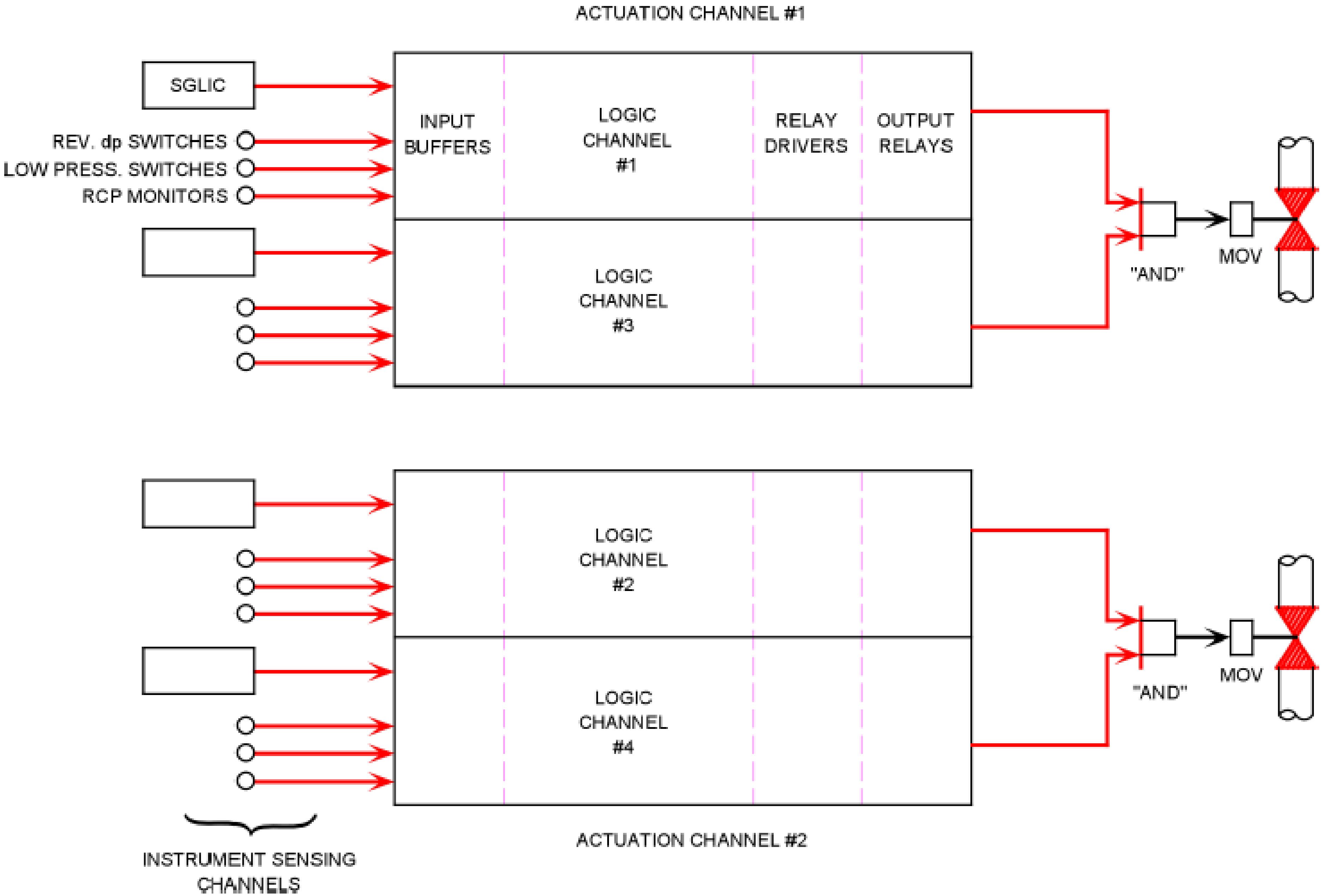




Auxiliary Feedwater System (Fig. 16-4)

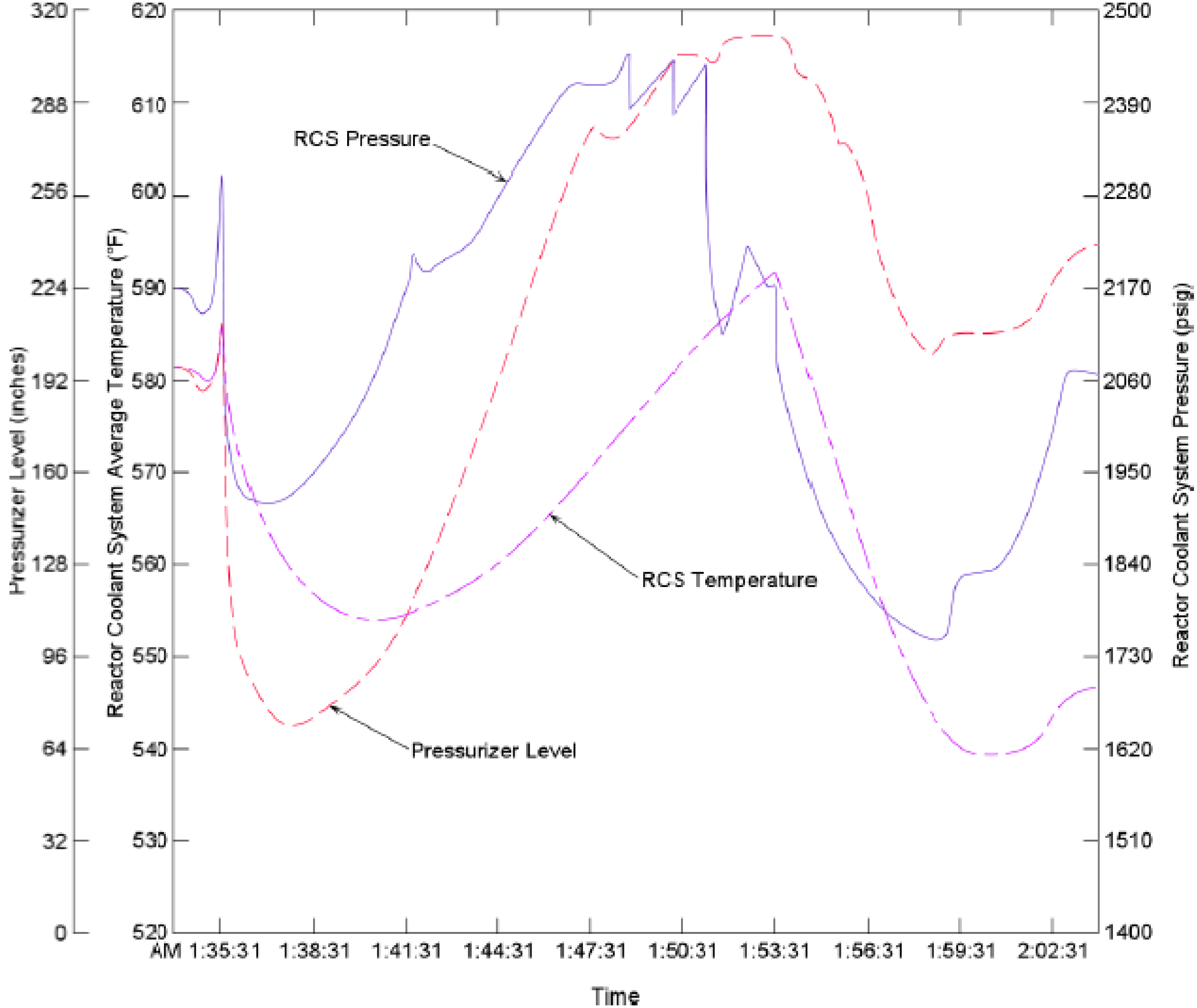
Emergency Core Cooling Systems (Fig. 16-5)

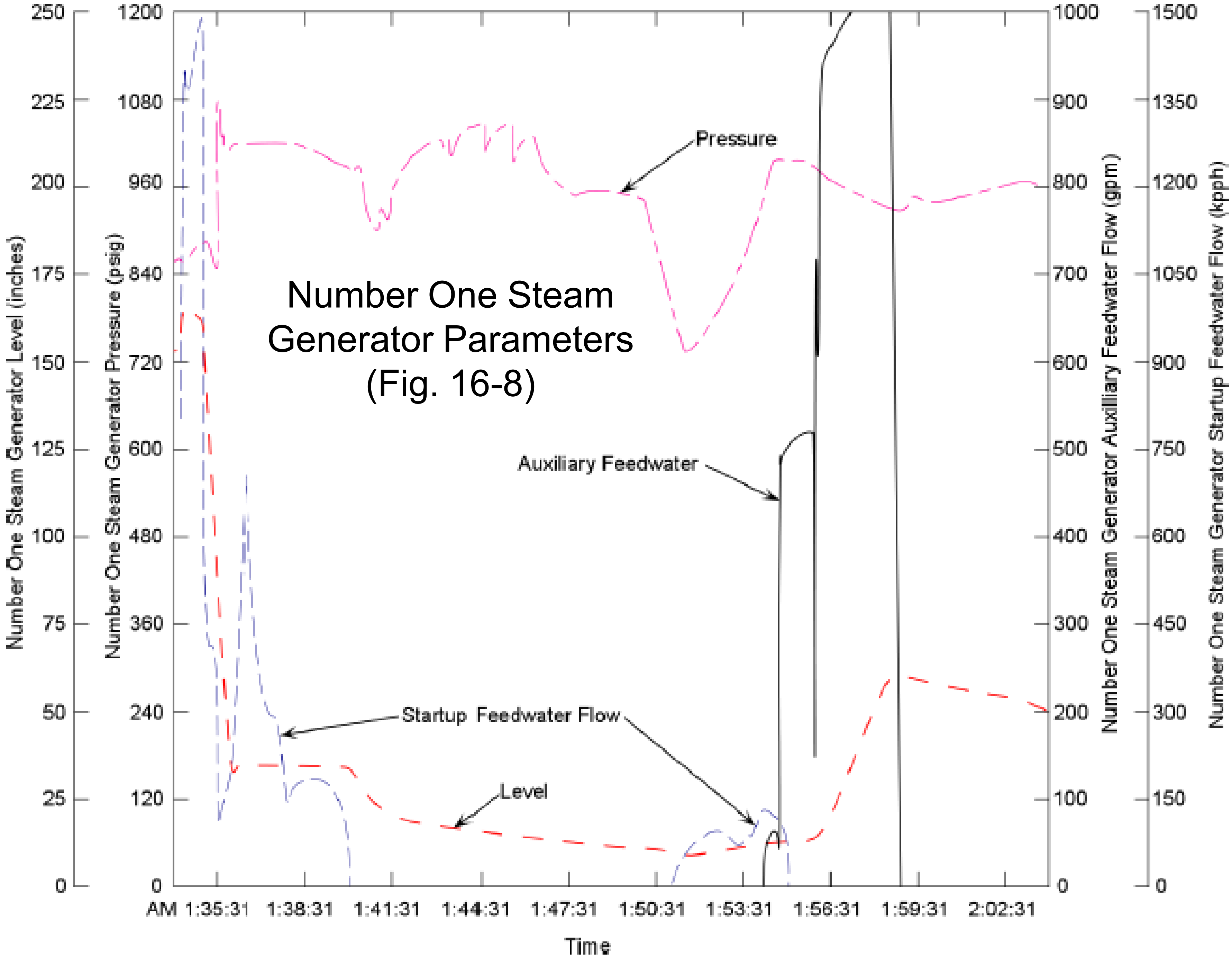


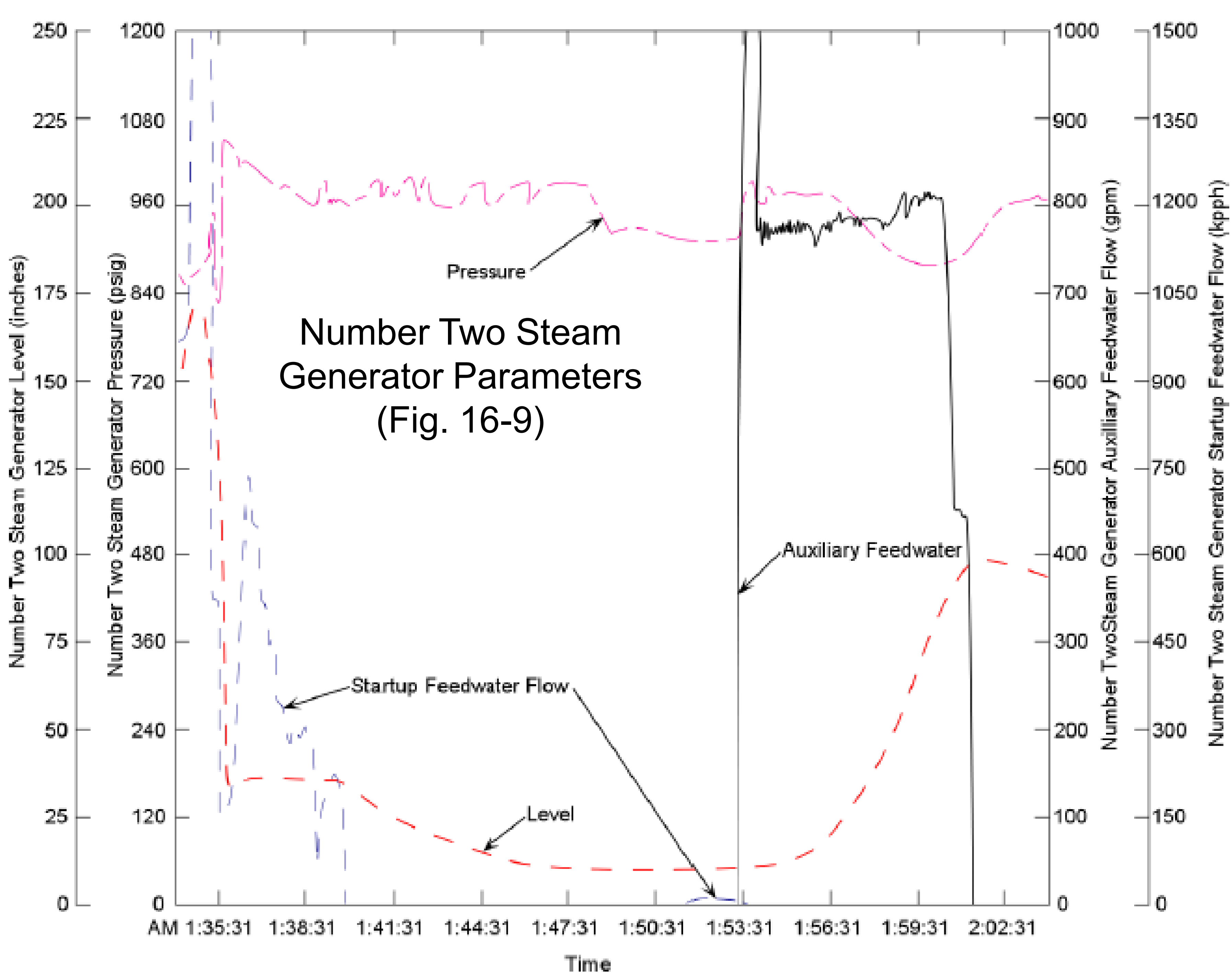


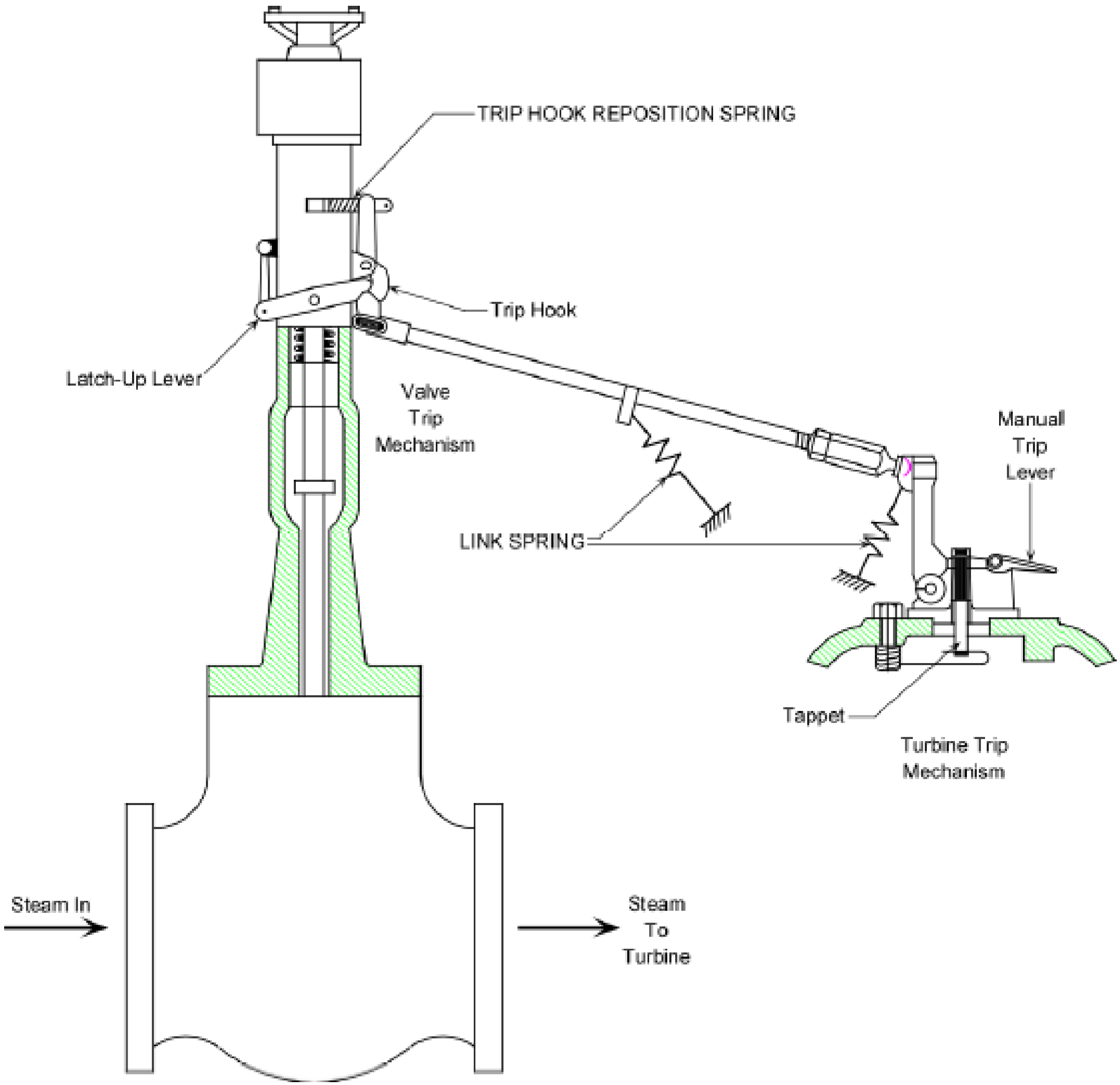
Steam and Feed Rupture Control System Logic (Fig. 16-6)

Reactor Coolant System and Pressure Response (Fig. 16-7)

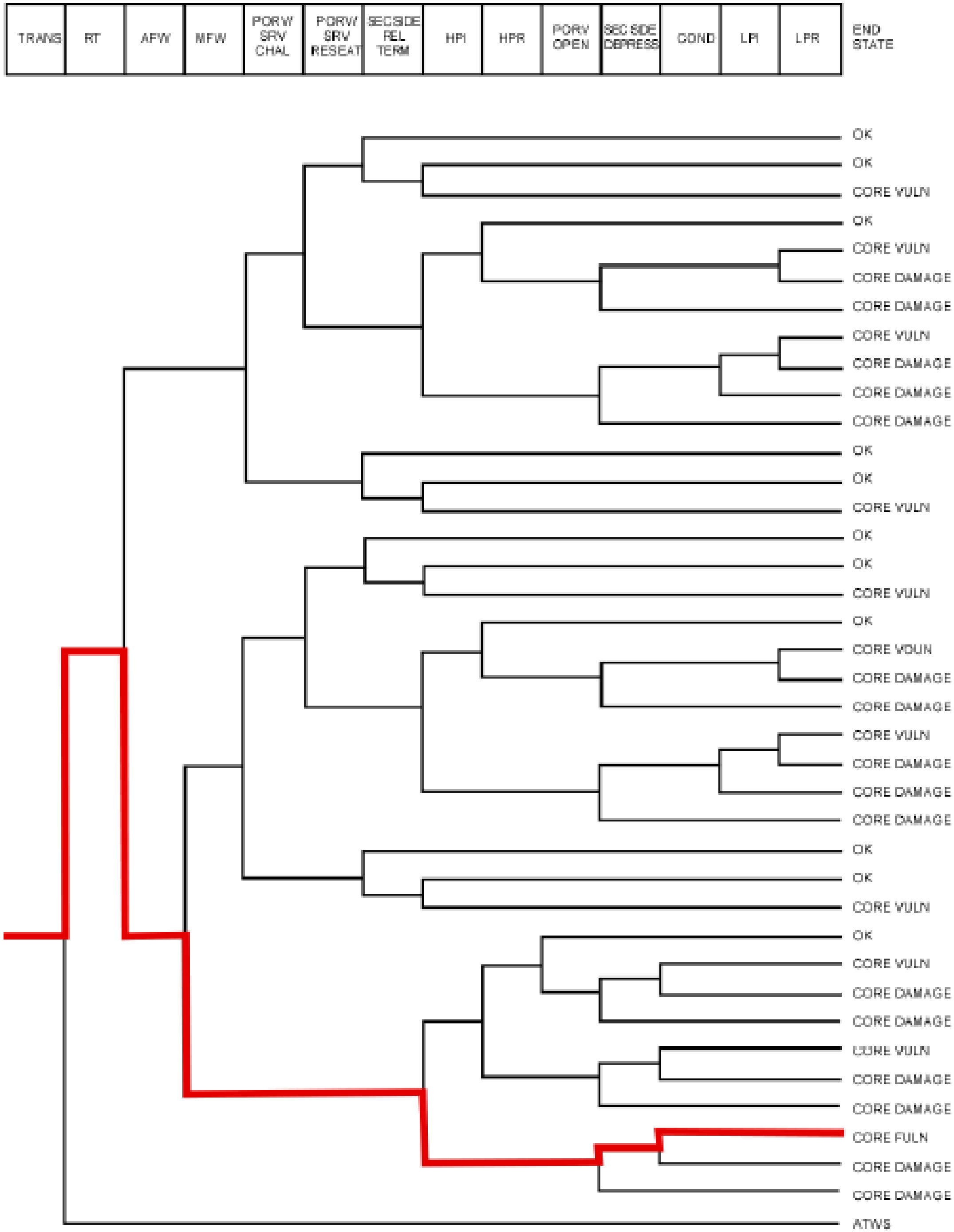



Number One Steam Generator Parameters (Fig. 16-8)
Pressure
Auxiliary Feedwater
Startup Feedwater Flow
Level
Number One Steam Generator Level (inches)
Number One Steam Generator Pressure (psig)
Number One Steam Generator Auxiliary Feedwater Flow (gpm)
Number One Steam Generator Startup Feedwater Flow (kpph)
Time
AM 1:35:31
1:38:31
1:41:31
1:44:31
1:47:31
1:50:31
1:53:31
1:56:31
1:59:31
2:02:31
250
225
200
175
150
125
100
75
50
25
0
1200
1080
960
840
720
600
480
360
240
120
0
1000
900
800
700
600
500
400
300
200
100
0
1500
1350
1200
1050
900
750
600
450
300
150
0


Number Two Steam
Generator Parameters
(Fig. 16-9)
Pressure
Auxiliary Feedwater
Startup Feedwater Flow
Level
Number Two Steam Generator Level (inches)
Number Two Steam Generator Pressure (psig)
Number TwoSteam Generator Auxiliary Feedwater Flow (gpm)
Number Two Steam Generator Startup Feedwater Flow (kpph)
Time
AM 1:35:31
1:38:31
1:41:31
1:44:31
1:47:31
1:50:31
1:53:31
1:56:31
1:59:31
2:02:31

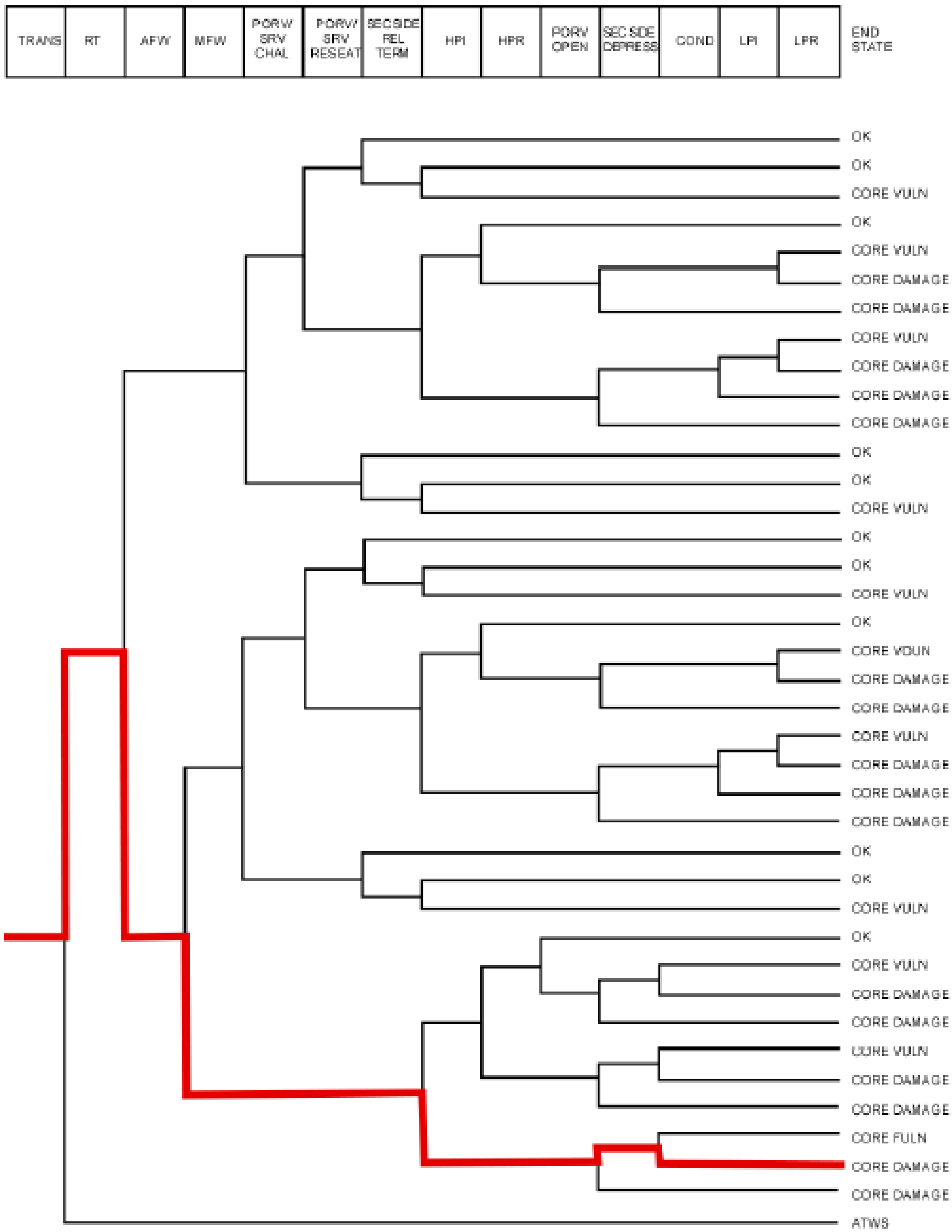


Trip Throttle Valve
Fig. 16-10



Dominant Core Vulnerability Sequence Event Tree

Fig. 16-11



Dominant Core Damage Sequence Event Tree
Fig. 16-12