



Ranco Seco Loss of ICS Power

Chapter 15.0
B&W Cross-Training Course
R-326C

OBJECTIVES

1. Describe the symptoms of an overcooling transient.
2. Explain how the loss of power to the ICS control stations resulted in:
 - a. An overheating event and
 - b. A subsequent overcooling event.
3. Describe the effect of operating a multi-stage centrifugal pump without a suction source.

Appendix – Sequence of Events

Average temp 582°F. RCS pressure 2150 psig.

Reactor Power 76%. ICS in full automatic control.

Note: Rancho Seco does not have main steam isolation valves.

TRANSIENT INITIATOR - LOSS OF ICS DC POWER

04:13:47 Loss of ICS DC power (power supply monitor failed).

04:13:+ Main feedwater flow decreasing rapidly. MFPs to minimum speed. RCS pressure increase, spray valve opened manually.

04:14:01 AFW initiated on low MFP discharge pressure (<850 psig).

PLANT TRIP AND START OF COOLDOWN

04:14:03 Reactor trip on high RCS pressure. PZR spray closed.

04:14:04 RCS pressure peaks at 2298 psig. Six OTSG safety valves open and later reseal.

04:14:06 Second AFW pump starts on low MFP discharge pressure.

04:14:06 Peak hot leg temperature of 606.5°F reached.

04:14:+ Operators start to perform E.01 - reactor trip letdown isolated. Operators start E.02 - vital systems verification

04:14:11 AFW flow to both OTSGs via 50% AFW (ICS) valves.

04:14:25 PZR level decreasing. "A" HPI MOV opened to increase makeup flow to the RCS.

Appendix – Sequence of Events

- 04:14:30 Overcooling symptoms noted. Loss of ICS DC power has positioned the following valves to 50%:
1. Turbine Bypass Valves
 2. Atmospheric Dump Valves
 3. AFW Flow Control Valves
- 04:14:48 Makeup tank level decreases due to excessive RCS makeup. MU pump suction shifted to BWST.
- 04:15:04 “B” makeup (HPI) pump started for additional makeup.
- 04:16:02 AFW flow to OTSGs >1000 gpm. MFW flow indicating about 3 million pounds per hour. Actual MFW flow is zero because of MFP speed. In addition, the main feedwater stop valves were closed. However, a flowpath from the MFP to the OTSGs is available through the startup main feedwater valves.

Appendix – Sequence of Events

SFAS ACTUATION - COOLDOWN - DEPRESSURIZATION

- 04:16:57 RCS pressure decreased from 2298 psig to 1600 psig. SFAS actuated at the setpoint of 1600 psig. PZR level dropped from 220 inches to 15 inches. The SFAS actuation opened all 4 HPI MOVs to predetermined positions. The following equipment was also actuated by the SFAS signal:
1. MUT outlet valve closed - BWST supply to HPI opened.
 2. MU pump recirculation path isolated.
 3. AFW valves to the 100% position.
 4. LPI/DHR pumps start.
 5. Both EDGs start.
- 04:16:59 The "A" HPI pump started by SFAS. "B" HPI already running. Both HPI pumps and the MU pump supplying MU to RCS.
- 04:17:10 AFW (SFAS) flow control valves manually closed.
- 04:17:15 A & B emergency air conditioning units auto start. Significant increase in control room noise level.
- 04:17:27 Motor driven AFW pump auto sequenced back to the vital bus. Dual drive AFW running on steam source.
- 04:18:58 RCS temperature less than 500°F.

Appendix – Sequence of Events

- 04:19:00 Pressurizer emptied. Steam bubble in reactor vessel head.
- 04:19:15 Emergency air conditioning stopped to reduce noise level.
- 04:20:00 STA to turbine deck to determine lifting relief valves.
- 04:20:00 PZR level off scale low. Subcooling margin of 85 degrees and increasing.
- 04:20:+ Technician sent to check ICS power supplies. All four 24-vdc power supplies were de-energized. The automatic bus transfer (ABT) did not transfer. The power supply to the ICS would be inspected by three people during the next 20 minutes without discovering that switches S1 and S2 feeding the 24-vdc supplies were open.
- 04:20:20 OTSG pressures at 500 psig. Feedwater into the OTSGs from condensate pumps via open startup feedwater valves. An additional 1000 gpm feedwater flow to the steam generator.
- 04:21:25 Minimum RCS pressure of 1064 psig (RCS temperature of 464°F) is reached.
- 04:21:+ RCS cooldown continuing. However, flow from the HPI pumps starts to increase RCS pressure even though pressurizer level is off scale low.
- 04:22:00 B&W pressure and temperature limits for PTS are exceeded; however, technical specification NDT limits are not exceeded. Operator starts to throttle HPI flow.

Appendix – Sequence of Events

- 04:22:50 OTSG pressures decrease to 435 psig. Steam line break logic actuated. Main and startup regulating valves are closed. Feedwater flow from the condensate pumps is terminated.
- 04:23:00 Atmospheric dump valves and turbine bypass valves were shut locally. (Manual handwheels used.)
- 04:23:10 "B" AFW (ICS) flow control valve partially closed. Operator thought valve was fully closed. Flow has decreased by 40%.
- 4:25:30 HPI recirculation valves to makeup tank opened. HPI pump suction being supplied by BWST.
- 4:26:22 "A" AFW flow control valve closed locally. Operator thinks that the valve is only 80% closed.
- 04:26:47 Pzr level back on scale. Subcooling margin is 170 degrees. Operators throttle HPI to slow the increase in RCS pressure.
- 04:28:00 Makeup tank level off scale high. Makeup tank relief valve lifts.
- 04:28:00 RCP "C" stopped at an RCS temperature of 418°F.
- 04:28:43 RCS letdown restored.
- 04:28:59 "A" HPI stopped.

Appendix – Sequence of Events

- 04:29:40 Operator damages “A” AFW flow control valve in an attempt to close valve >80% closed. Operator directed to close AFW manual isolation.
- 04:29:40 RCS pressure peaks at 1616 psig. RCS temperature is 418°F.
- 04:29:45 “C” and “D” HPI valves are closed in order to reduce the repressurization while temperature is decreasing.
- 04:30:00 An unusual event is declared.
- 04:30:30 Plant is depressurized using PZR spray in an attempt to restore PTS limits.
- 04:33:20 “B” AFW flow control valve closed by second operator. AFW flow to “B” OTSG is stopped.
- 04:33:20 “A” OTSG filled to top of steam shroud. Water begins to spill into the steam lines. Flow into the OTSG is in excess of 1300 gpm.
- 04:35:+ The “A” HPI suction valve from the BWST is closed in an effort to lower makeup tank level. However, the makeup tank outlet valve is still closed.
- 04:36:+ The manual AFW isolation valve cannot be closed by the operator.
- 04:39:00 RCS subcooling margin reached a peak of 201 degrees and began to decrease (RCS temp = 390°F, RCS press = 1430 psig). This is approximately 800 psig into the PTS region.

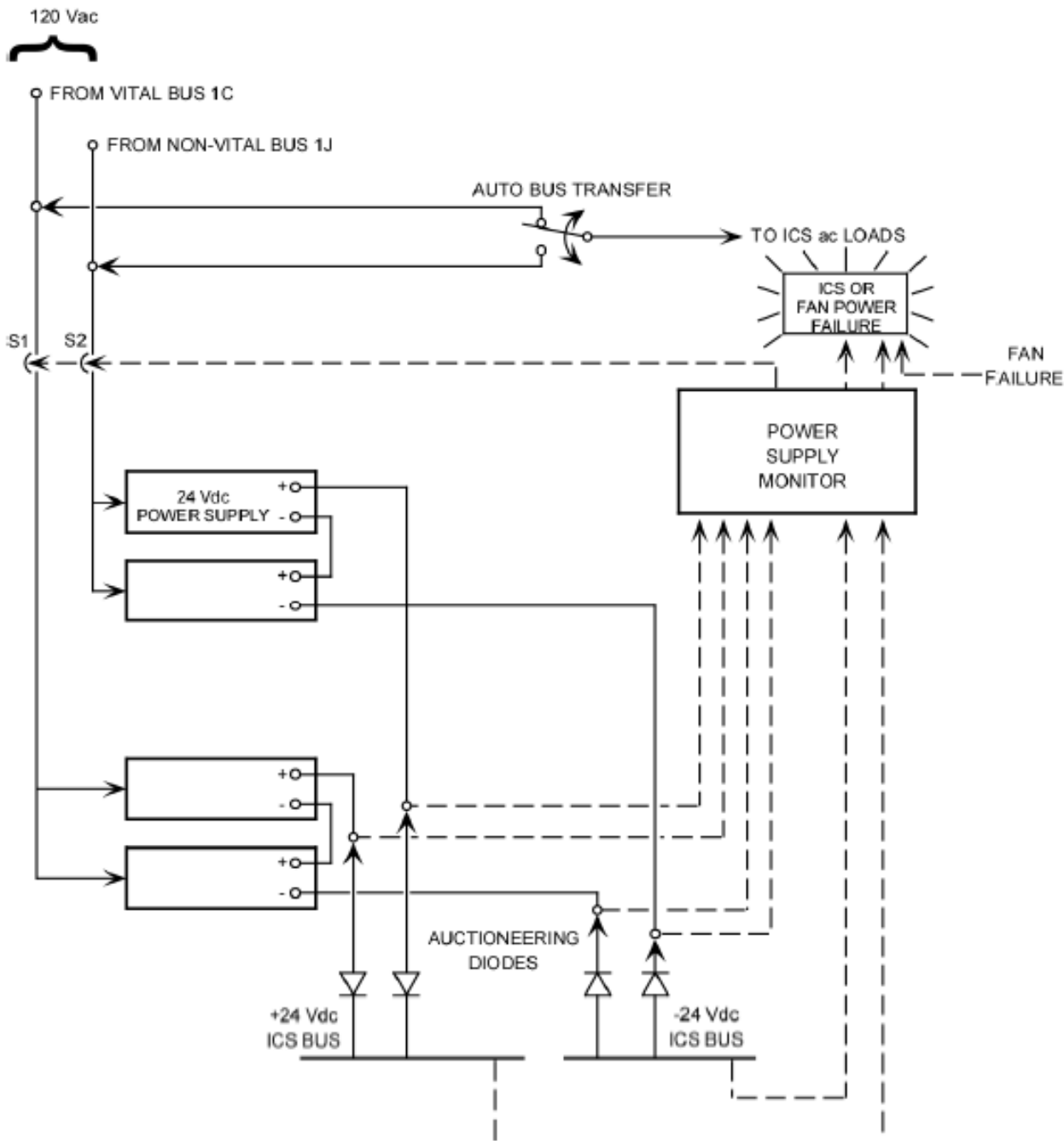
Appendix – Sequence of Events

ICS POWER RESTORATION AND PLANT STABILIZATION

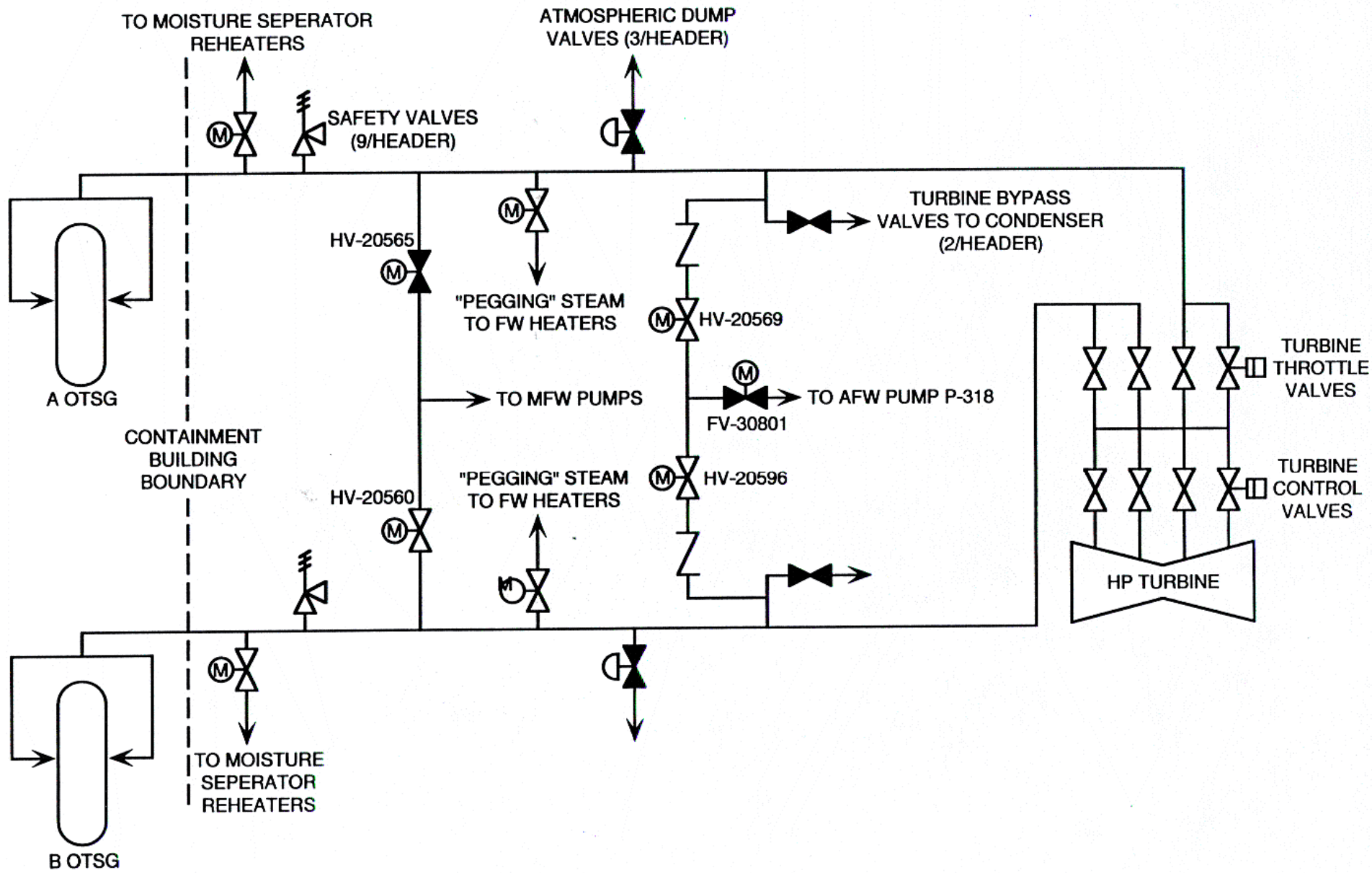
- 04:40:00 The “Backup” shift supervisor finds switches S1 and S2 in the OFF position. The switches were closed. The valve stations reverted to the HAND position. All valves with the exception of the AFW flow control valves had been isolated. The control room operators closed the AFW (ICS) flow control valves.
- 04:40:+ With AFW flow isolated, the RCS starts to heat up. The lowest RCS temperature was 386°F. The RCS had cooled down 180 degrees in 26 minutes.
- 04:41:00 Operators report that the “A” AFW manual isolation valve is stuck open. Operators are directed to disengage the handwheel for the “B” AFW flow control valve and to return the ADVs and TBVs to service.
- 04:41:10 “A” OTSG level below the steam shroud.
- 04:42:42 “B” HPI pump stopped. The makeup pump remains in service.
- 04:42:56 Operators closed the “A” and “B” HPI MOVs.
- 04:43:50 RCP seal injection low flow.
- 04:43:54 “B” HPI pump restarted to reestablish RCP seal injection flow.
- 04:40:+ Steam leakage from the damaged makeup pump causes an auxiliary building stack radiation monitor alarm. Makeup pump damaged due to a lack of suction. Radioactive release is within Tech. Spec. limits.

Appendix – Sequence of Events

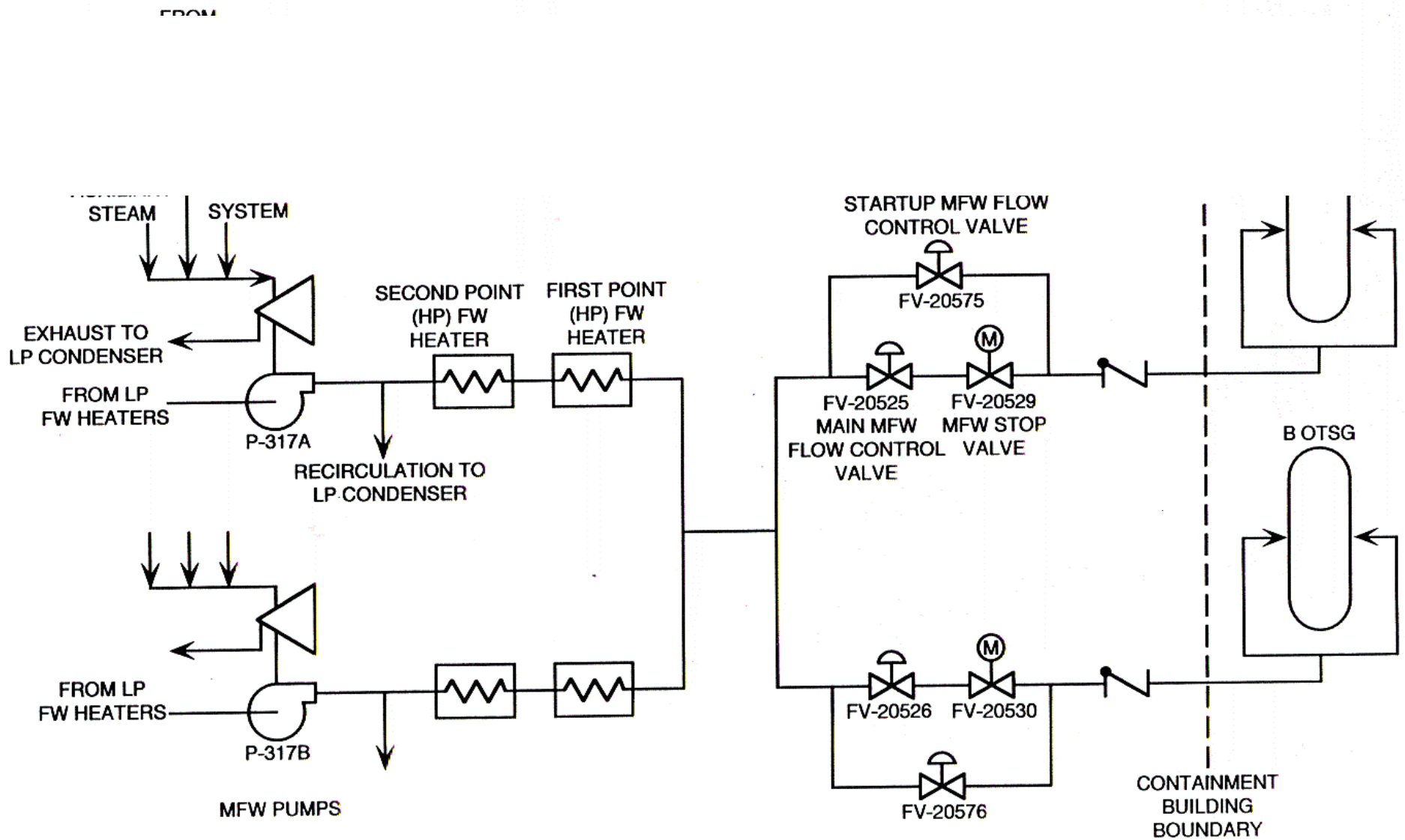
- 04:50:19 “B” HPI pump stopped.
- 04:50:30 “B” HPI pump restarted in response to a low RCP seal flow alarm. The operators have not realized that the makeup pump has been damaged.
- 04:52:+ “Backup” shift supervisor collapsed in control room. This operator had assisted in closing the ADV and TBV manual isolations.
- 05:00:+ Control room operators hear a loud noise. They observe that the makeup pump ammeter is reading low and realize that the pump has been damaged.
- 05:00:10 Makeup pump is tripped. Makeup tank outlet valve is opened allowing 450 gallons of water to spill out of the damaged pump. Makeup tank outlet valve is reclosed.
- 05:05:+ RCS pressure decreased out of the PTS region. A 3 hour soak is initiated. (RCS temp = 428°F, RCS press = 870 psig).
- 05:05:+ Ambulance called for “backup shift supervisor”.
- 05:27:+ Two auxiliary operators are contaminated while isolating the damaged makeup pump. Operators did not follow proper radiological safety procedures.
- 05:29:+ Operators are unable to open makeup isolation to the RCS. It was later found that the SFAS signal had not been cleared from the valve.
- 05:29:04 Second reactor coolant pump stopped.
- 06:06:00 Operators bypass SFAS.
- 07:15:+ Plant superintendent relieves shift supervisor as emergency coordinator.
- 08:41:+ The unusual event is terminated.



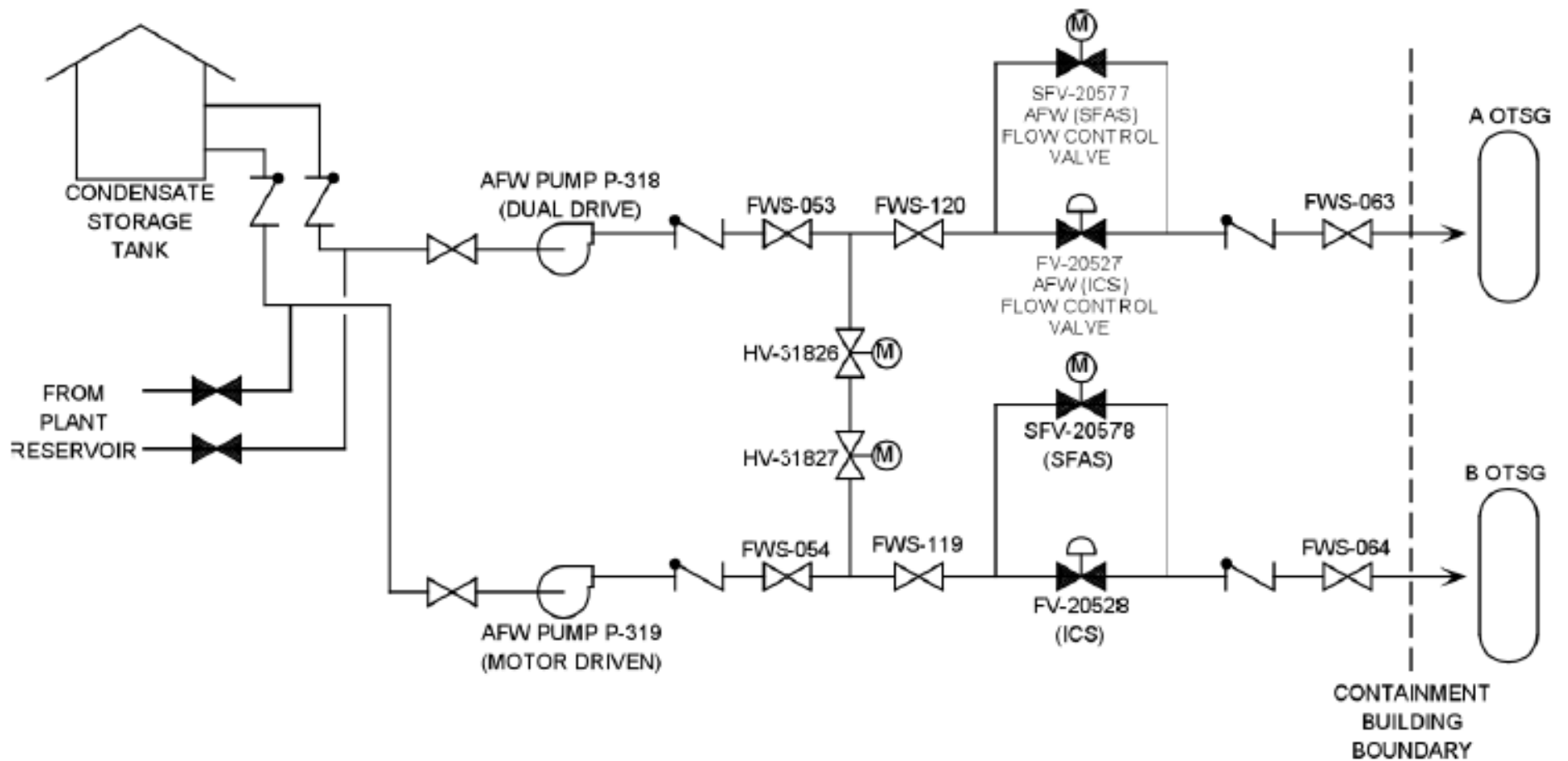
ICS Power Supplies
Fig. 15-1



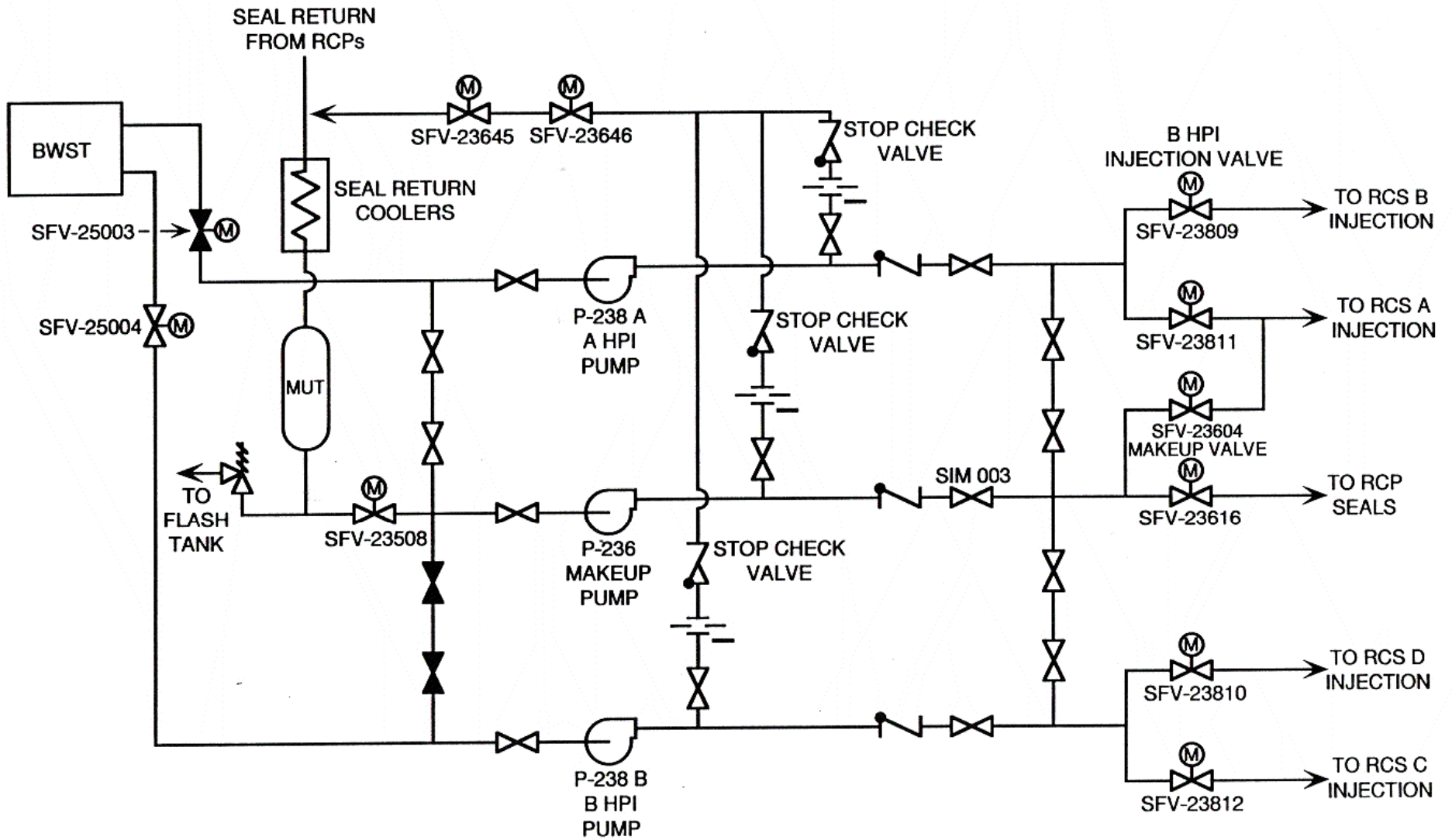
Main Steam System (Fig. 15-2)



Main Feedwater System (Fig. 15-3)

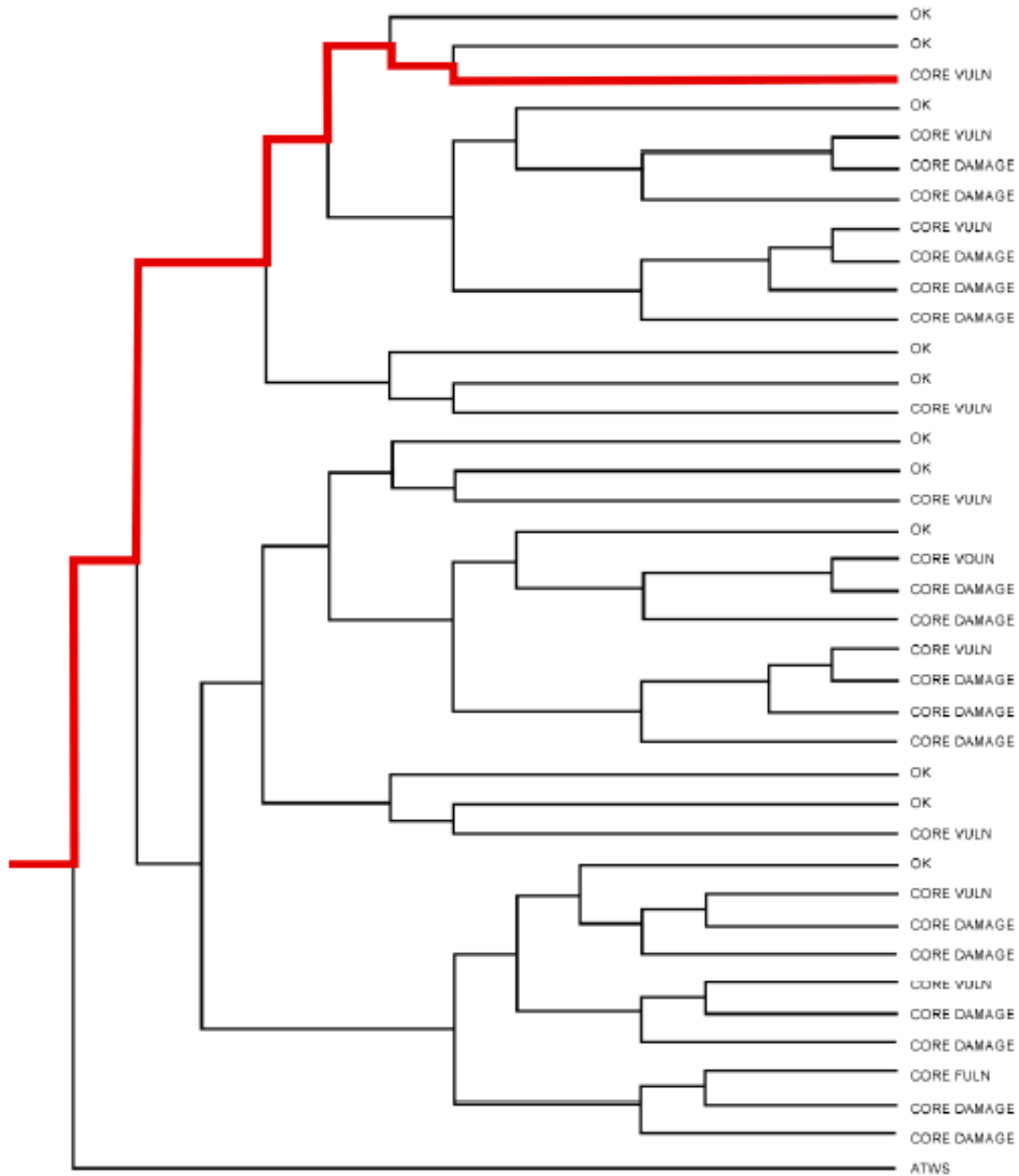


Auxiliary Feedwater System (Fig. 15-4)



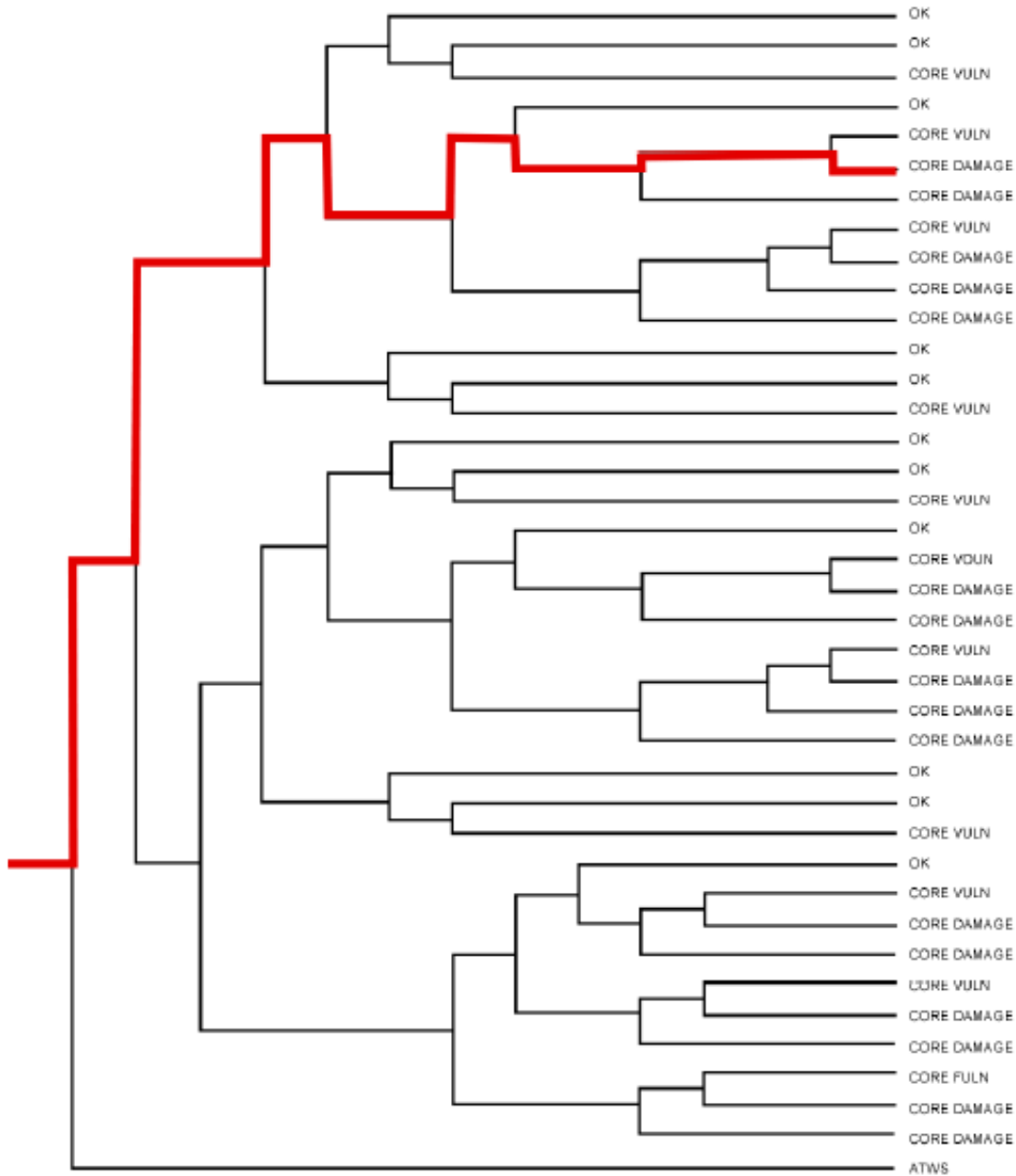
High Pressure Injection System (Fig. 15-5)

TRANS	RT	AFW	MFW	PORV SRV CHAL	PORV/ SRV RESEAT	SEC SIDE REL TERM	HPI	HPR	PORV OPEN	SEC SIDE DBPRESS	COND	LFI	LPR	END STATE
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Dominant Core
Vulnerability
Sequence Event
Tree
Fig. 15-6

TRANS	RT	AFW	MFW	PORV SRV CHAL	PORV/ SRV RESEAT	SEC/SIDE REL TERM	HPI	HPR	PORV OPEN	SEC/SIDE DBPRESS	COND	LPI	LPR	END STATE
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Dominant Core
Damage Sequence
Event Tree
Fig. 15-7