General Electric Advanced Technology Manual

Chapter 7.3

Dresden Log Summary

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7.3 Dresden Log Summary

Learning Objectives:

1. Explain the need for a maximum combined flow limiter in the Electro Hydraulic Control System.

2. Explain the term half isolation.

3. Explain why isolation valve control switches must be in the closed position prior to resetting the isolation signal.

4. Explain the need to reset a reactor scram when the condition has cleared.

7.3.1 Introduction

Dresden Unit 3 is a BWR/3 plant rated at 2527 MWt and 809 MWe. At the time of the incident, September 19, 1985, the unit was operating at 83 percent reactor power. At approximately 1339 hours, Dresden Unit 3 tripped from an average power range monitor (APRM) high-high flux scram. The trip resulted from a pressure transient that was caused by closure of the turbine control valves. During the scram recovery, difficulty was encountered in resetting reactor protection system (RPS) channel B. Also during the recovery, the scram discharge volume (SDV) vent and drain valves opened while the control rod drive scram inlet and outlet valves on every CRD hydraulic control unit were open. This resulted in the release of reactor vessel water inventory to the reactor building.

Several days before the Unit 3 scram had occurred, the Instrument Maintenance (IM) department had installed a multi-point recorder to various points in the Electro Hydraulic Control (EHC) circuitry. Unit 3 had been experiencing problems with the Economic Generation Control (EGC) portion of the EHC system and to identify the cause of the problems the multipoint recorder was installed to monitor certain parameters. The IM department was successful in identifying the EGC problem and decided to remove the recorder from the EHC sample points. While removing the recorder leads from the EHC control circuit, an IM mechanic accidentally moved a circuit card, momentarily disrupting the maximum combined flow portion of the EHC circuit. This caused a zero maximum combined flow output voltage signal resulting in closure of all the turbine control valves and bypass valves. The closure of the control valves caused a reactor pressure spike, resulting in a high neutron flux and a subsequent APRM high-high flux scram.

7.3.2 Failure of Scram Reset

When the scram occurred, the Unit 3 reactor operator followed scram procedure DGP 2-3. When moving the reactor mode switch to the "refuel" position, it was left partially between the "shutdown" and "refuel" position. This generated a reactor mode switch scram signal on the “B” RPS channel which could not be reset. The last time the operator attempted to reset the scram (approximately ten minutes after the scram) he was only able to reset the “A” RPS channel. Approximately one hour and sixteen minutes after the scram, the Unit 3 operating engineer noticed the mode switch in the midposition. When the mode switch was fully placed in the "refuel" position, the reactor operator was able to fully reset the reactor scram signal.

7.3.3 Scram Discharge Volume Air Header Failure

The scram air header is designed to supply control air to the SDV air operated vent and drain valves and all 177 CRD scram inlet and outlet valves. During a reactor scram, the air supply to the SDV header is isolated by the SDV backup scram valves. The air within the isolated portion of the header is vented to the Reactor Building atmosphere by each control rod drive hydraulic control unit scram pilot valves and the scram dump valves, Figure 7.3-1. The backup scram valves also depressurize the header through exhaust ports. The system is designed such that, even during a half scram condition, full system pressure is supplied to the header.

During the event, only partial system pressure was restored after the reactor operator reset the "A" RPS channel. While the degraded condition existed, maximum air header pressure was only 38 psig. This pressure was sufficient to automatically open the vent and drain valves, but was not sufficient to close the scram inlet and outlet valves. This provided a direct path for primary system coolant from the reactor vessel to enter the Reactor Building. The SDV vent lines are routed to the reactor water cleanup pump and shutdown cooling heat exchanger area atmosphere. The SDV drain valves are routed to the Reactor Building equipment drain sump. The SDV remained in an unisolated condition for approximately 33 minutes, resulting in the release of contaminated water and steam into the second and third floors of the Reactor Building. The shutdown cooling pump room area passed steam through a ventilation duct into the X area, where the outboard MSIVs are located. This resulted in an increase in X area temperature and a resultant isolation signal to close the MSIVs. The air header pressure returned to normal when the reactor operator reset channel “B”. No contamination was released outside the reactor Building.

After the SDV system was isolated and the unit was placed in cold shutdown, several functional tests were performed on the SDV system. The cause of the air header system failure remains unknown.

7.3.4 Areas of Concern

Investigation of plant records revealed a similar event had occurred on Unit 2 on April 29, 1972. The unit was in cold shutdown at the time of the event and no primary containment inventory had been lost. Following the event a study was performed by the General Electric Company on the scram solenoid valves behavior with low air pressure. Figure 7.3-2 shows the two pilot valves in series with channel “A” RPS reset and “B” tripped. Tests performed indicated that at low air supply pressure, approximately 5 psi air pressure would pass through the pressure diaphragm of the “A” RPS valve and leak past exhaust diaphragms of the “B” RPS valves.

According to the valve manufacture, Asco, a minimum of 10 psi across the valve is required to seat an exhaust diaphragm. However, actual tests showed that for the “A” valve 6 psid was required and only 4 psid was required to close the “B” valve when it was energized as indicated in Figure 7.3-3.

7.3.5 Corrective Actions

The Dresden Station Unit 2/3 scram procedure DGP 2-3 was revised as follows:

- The reactor operator was directed to place the mode switch to the shutdown position after any scram occurs. This will help prevent any future mid-positions of the mode switch. If the mode switch is replaced in the future with a more reliable type, this instruction will be removed.

- The reactor operator was directed to close the SDV vent and drain valves using the individual control switches before resetting the scram. This will prevent any possible steam releases in the future if the scram air header pressure were to become degraded.

- A caution statement was added to the procedure. If the SDV vent and drain valves will not close during any half scram condition, following a full reactor scram reset, the reactor operator is instructed to manually scram the reset channel.

- The reactor mode switch contacts were visually inspected for any impairment.

7.3.6 PRA Insight

In addition to providing power to the reactor protection system, the RPS buses provide power to the primary containment isolation control system (PCIS). This system operates valves as required to isolate the reactor vessel and/or primary containment to conserve coolant inventory and prevent the release of radioactive materials. Loss of power to RPS bus “B” de-energizes all “B” train logic in the isolation control system and results in the isolation of among other things the Reactor Water Cleanup System and the shutdown cooling mode of the Residual Heat Removal (RHR) System.

On February 3, 1990 an event occurred at Susquehanna Unit 1 that conveys the important interrelationship between the RPS and the PCIS. Unit 1 was shutdown on February 1, 1990 for maintenance. Two days later a test of the alternate power supply to RPS bus “B” was conducted. When normal power was secured, the alternate supply failed to close in on the bus. The loss of power resulted in isolation of certain valves controlled by this system including a RHR shutdown cooling suction supply valve. With normal shutdown cooling lost, the reactor water temperature began to increase. Operators stopped the coolant temperature rise at 252°F by opening three Safety Relief Valves (SRVs). Makeup water was provided by the control rod drive pump.

An event tree model of sequences to core damage was developed considering the potential unavailability of mitigating features described in Susquehanna's procedures. This event tree (Figure 7.3-4), addresses RPV makeup via the control rod drive, condensate, core spray, or low pressure coolant injection systems. If the SRVs are used, then suppression pool cooling is also assumed to be required.

Figure 7.3-4 includes the following core damage sequences:

- Successful use of the SRVs and SP cooling for heat removal, but failure to provide RPV makeup via the CRD, condensate, core spray and LPCI systems.
- Failure of SP cooling following successful opening of the SRVs. RWCU is successful but makeup via the condensate system fails.
- Failure of SP cooling following successful opening of the SRVs. RWCU fails to provide letdown/heat removal.
- Similar to sequence 2 except the SRVs fail to open.
- Similar to sequence 3 except the SRVs fail to open.

The conditional probability of subsequent core damage associated with the event (LER 387/PNO-I-90-8) is conservatively estimated to be 4.1 x 10-5. The relative significance of this event compared to the postulated events at Susquehanna is indicated below:

7.3.7 Summary

In the Dresden event, the output of the Maximum Combined Flow (MCF) limiter of the EHC logic failed to zero. This closed all turbine valves and BPVs. The purpose of the MCF is to limit the maximum amount of steam the turbine and BPVs can remove from the vessel if the pressure regulator should fail high. In addition, the RPS was not capable of being fully reset. Should a leak occur in the scram discharge volume during a scram condition there are no current means available to detect this leak other than visual. Therefore, if a reactor scram occurs, it is very important for the RPS to be reset if the scram signal is cleared.

The RPS provides power to other systems in addition to the RPS logic. One of those systems is the Nuclear Steam Supply Shutoff System (NSSSS). The NSSSS is divided into two divisions, division 1 and division 2. Each division controls power to either an inboard or an outboard isolation valve logic. If the divisional logic is de-energized, the valve (s) will close. If only one RPS bus looses power, then either the inboard or outboard isolation valve for a particular system will close providing what is termed a half isolation.

Table 7.3-1 Sequence of Events

1330	Unit 3 at 83 percent power - Normal operation.
1339	APRM high flux scram occurs.
(+1s)	Maximum combined flow alarm received.
(+5s)	Approximately 20 control rods found at position 02. Received Group II and III containment isolation.
(+6s)	The reactor operator manually scrams the unit per the scram procedure and takes scram procedure actions.
1340	The reactor operator resets Group II and III isolation.
1344	The Reactor Water Cleanup System restarted and establishes blowdown to the main condenser.
1349	The control room operator attempted to reset the reactor scram but only the ‘A’ channel would reset.
1351	The control room operator notes that the scram inlet and outlet valves did not close in addition to a low SDV air header alarm.
1355	The Unit 3 Shift Foreman investigated the air header problem and reported a pressure of only 38 psig (Normal pressure 83 psig).
1412	Received a steam tunnel high temperature alarm (channel D) accompanied with a group I half isolation.
(+15s)	High temperature in steam tunnel verified at 160^{o}F.
1415	The reactor operator received a RWCU heat exchanger relief valve leakage alarm and isolated the RWCU system. The Unit 3 Shift Foreman was dispatched to investigate the leakage alarm.
1439	The Shift Foreman notified the control room operator that steam is present in the RWCU pump room, shutdown cooling pump room, and the torus basement.
1440	The control room operator was notified that steam was coming from the SDV vent and drain valves. The control room operator noticed that the vent and drain valves open, then manually closed them from the control room.
1441	The steam tunnel high temperature alarm and isolation were cleared and reset.
1455	While trying to identify the cause of the reactor half scram reset problem, the Unit 3 Operating Engineer discovered the reactor mode switch in a mid-position between the shutdown and refuel modes. The mode switch was placed in the refuel position and the ‘B’ RPS channel reset

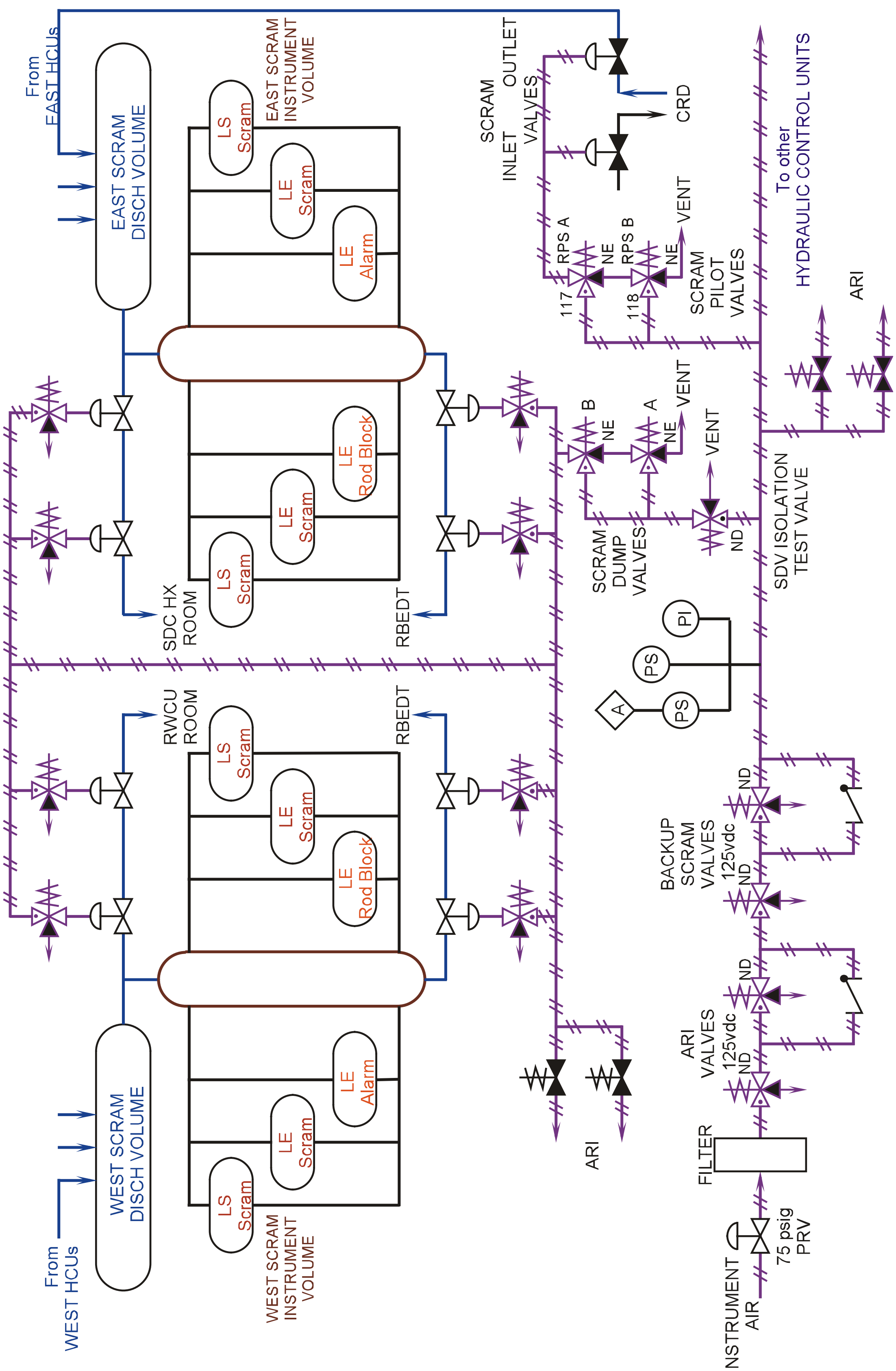

Figure 7.3-1 Dresden Scram Discharge Volume (SDV)

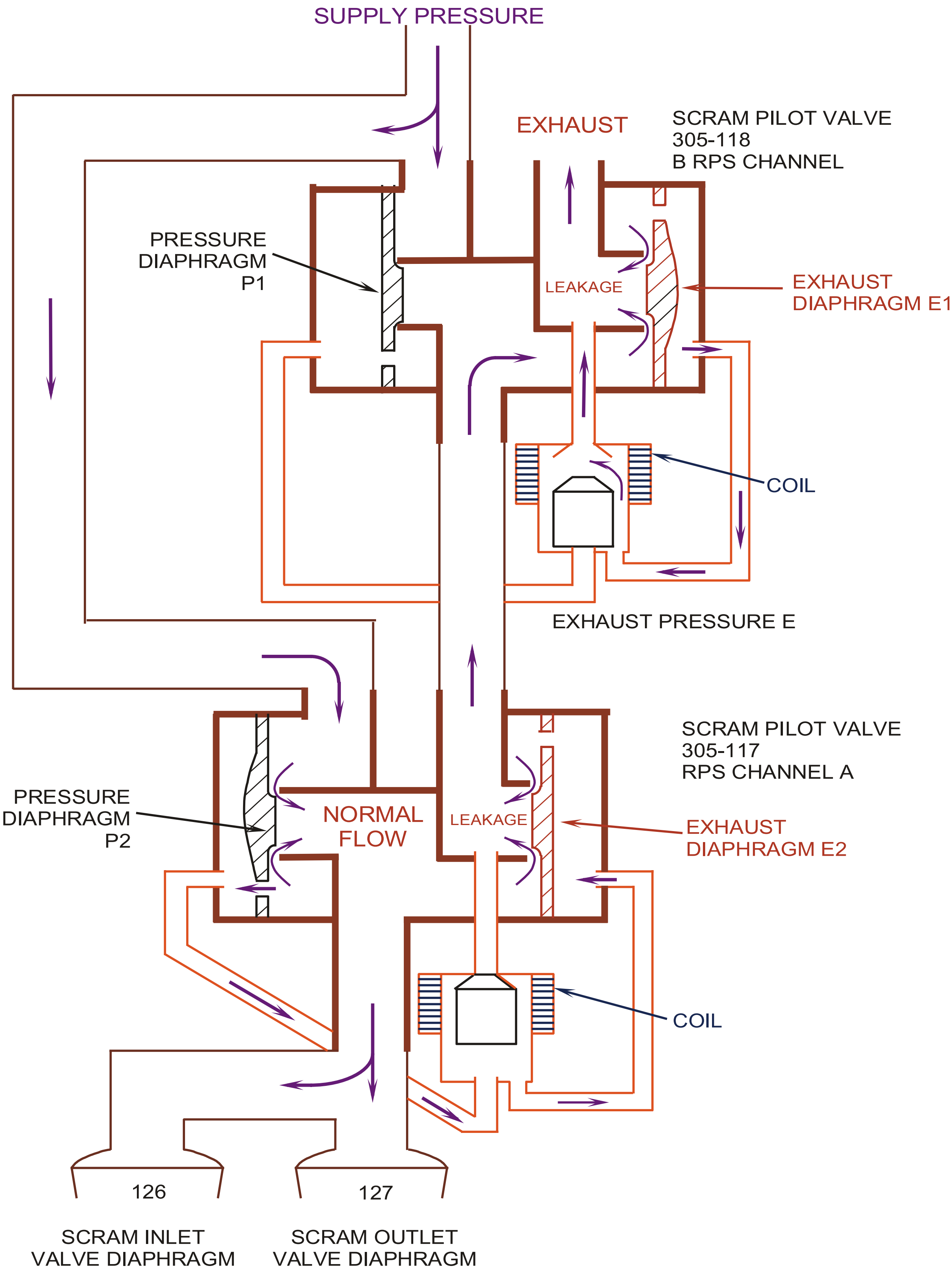

Figure 7.3-2 Scram Pilot Valve Configuration with “A” RPS reset and “B” Tripped

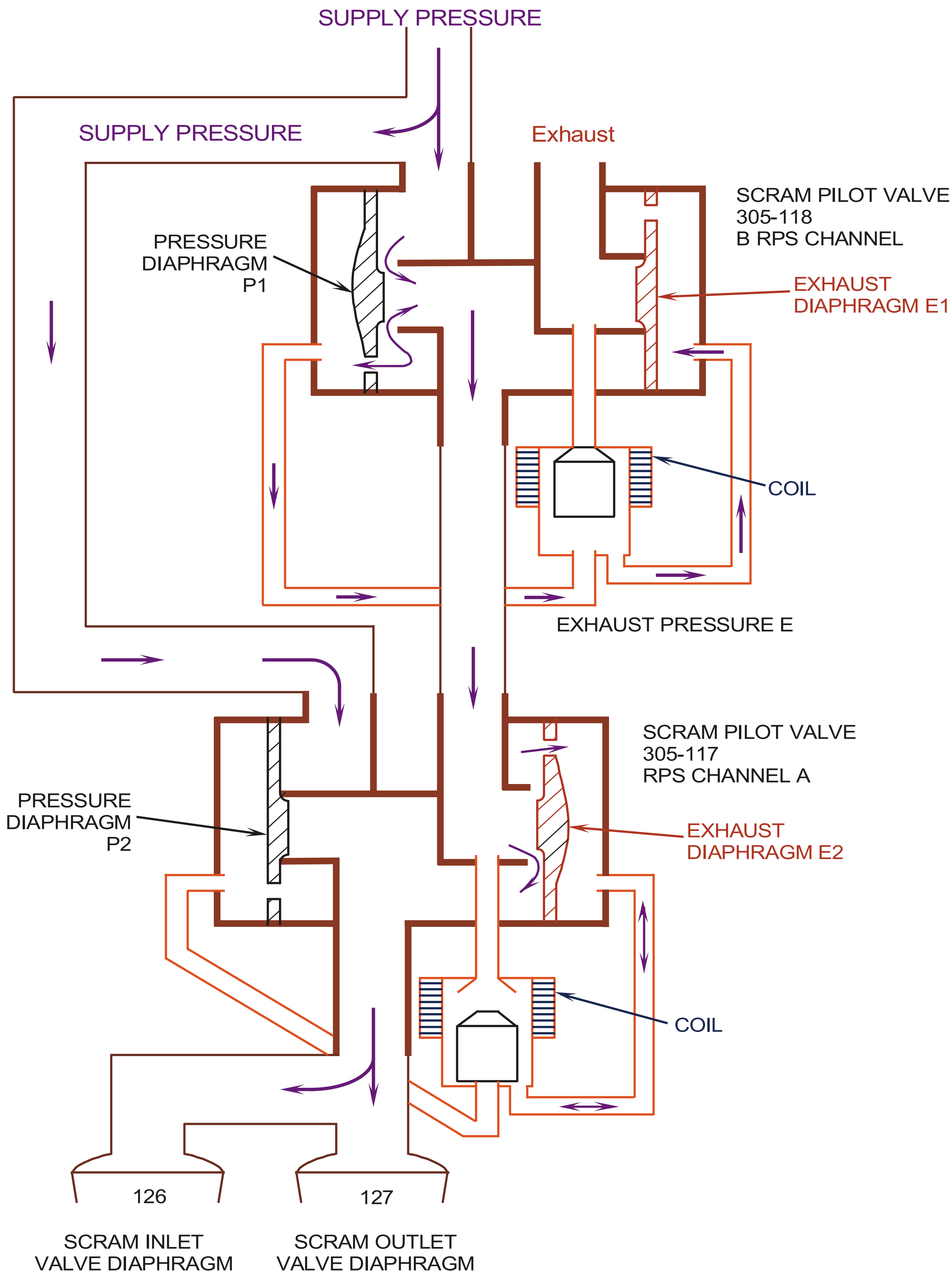

Figure 7.3-3 Scram Pilot Valve Configuration with “B” RPS reset and “A” RPS Tripped

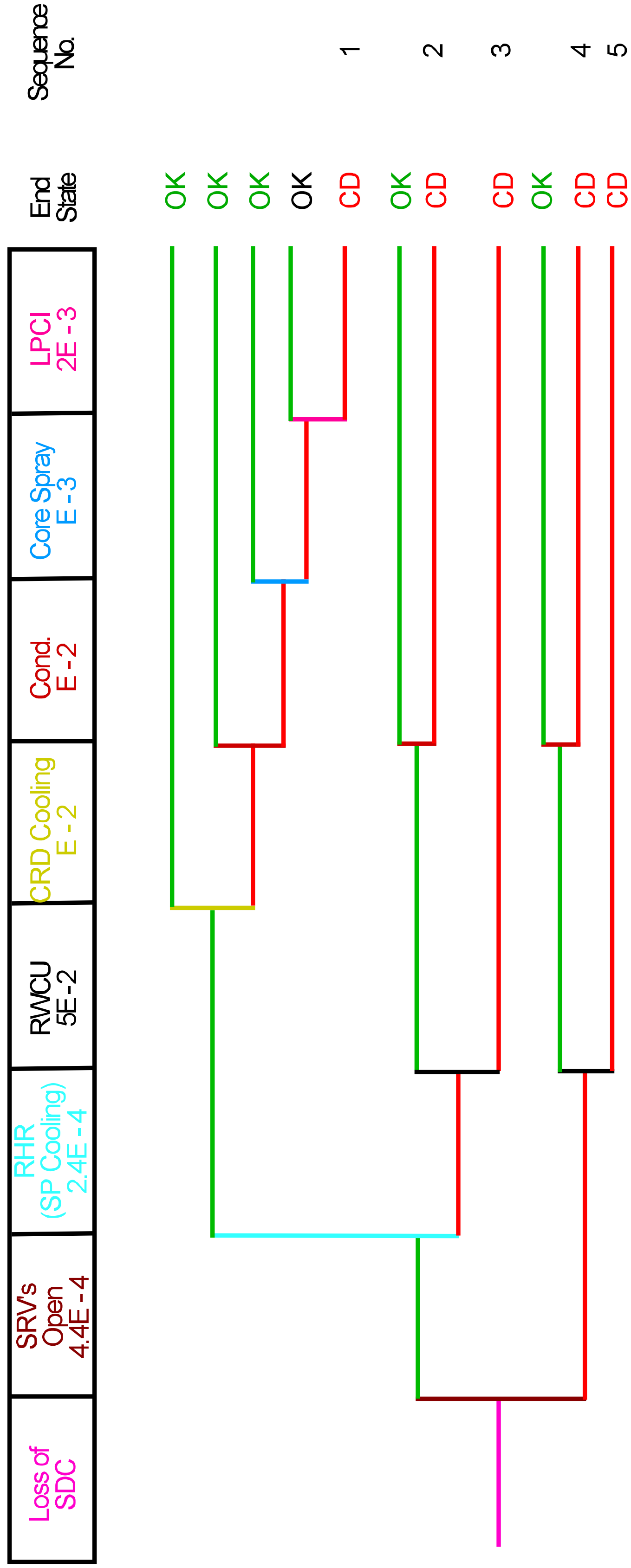

Figure 7.3-4 Event Tree for Loss of Shutdown Cooling at Susquehanna 1

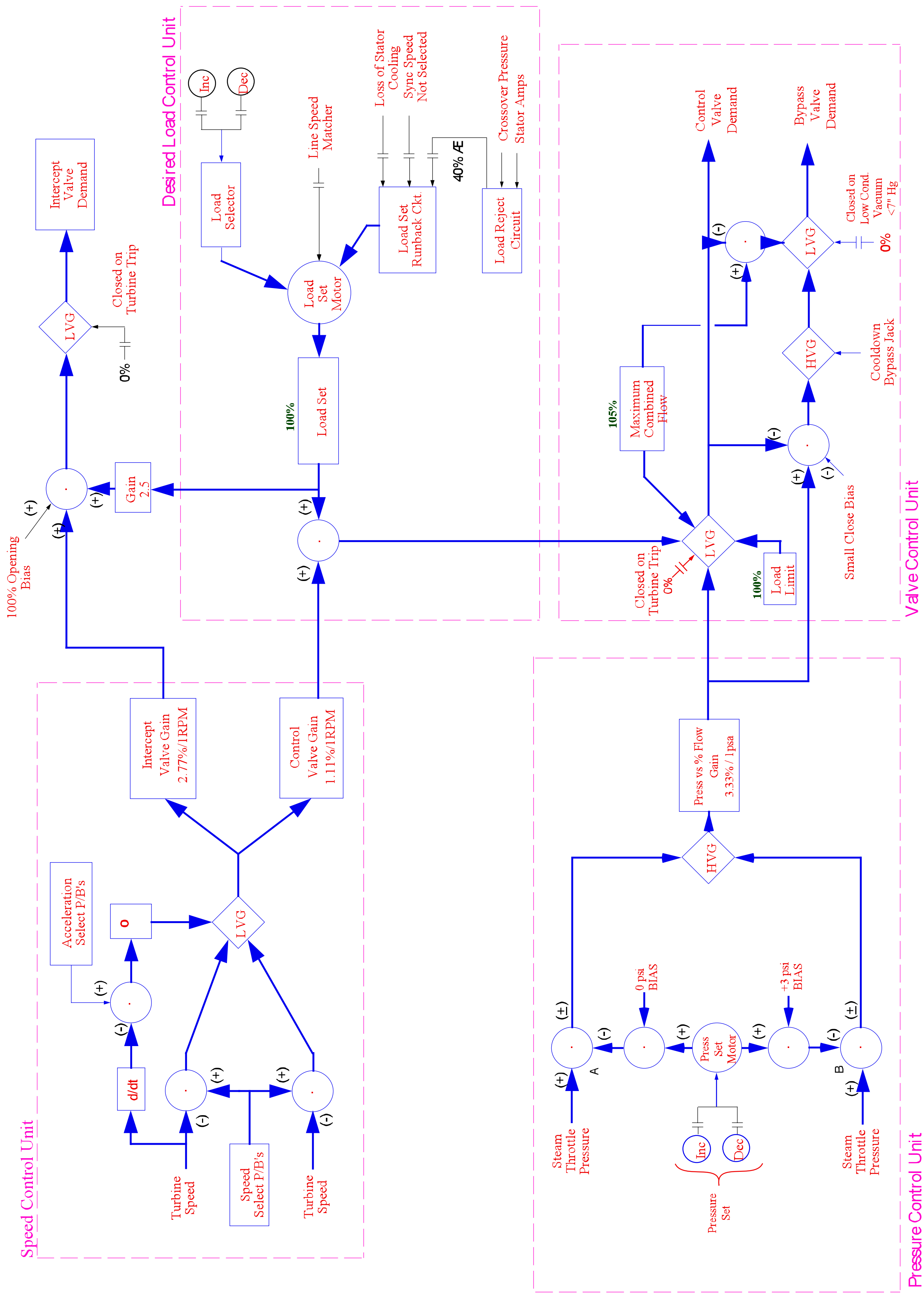

Figure 7.3-5 Electro Hydraulic Control System Logic

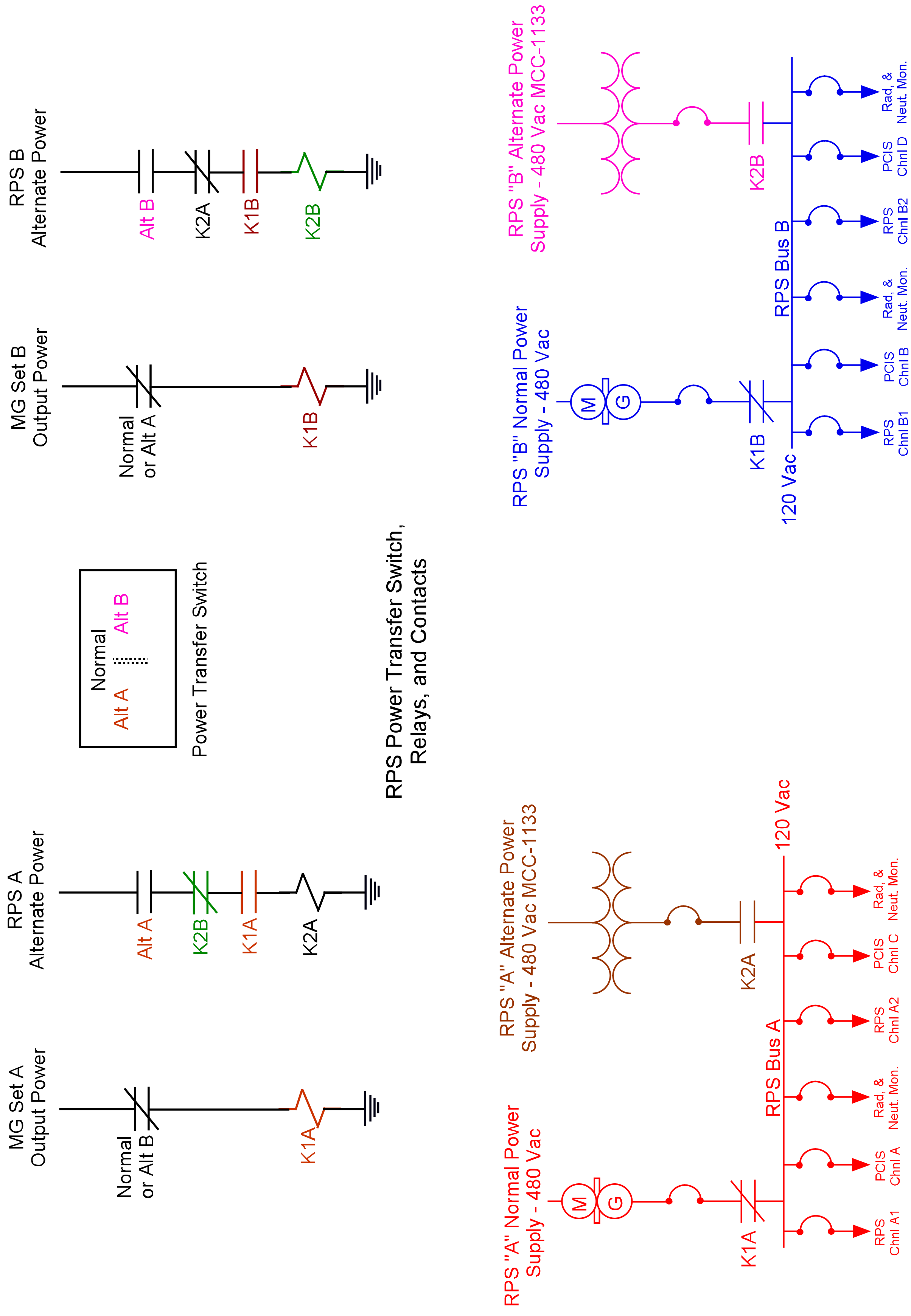

Figure 7.3-6 RPS Power Supply