General Electric Advanced Technology Manual

Chapter 7.2

Oyster Creek Log Summary

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7.2 Oyster Creek Log Summary

Learning Objectives:

1. Explain why this event is only a problem for BWR/2 product lines.

2. List the two areas of the reactor vessel that are monitored to determine vessel water level.

7.2.1 Introduction

Oyster Creek is a BWR/2 plant rated at 1930 MWt and 670 MWe. At the time of the incident, May 2, 1979, the unit was operating at 98 percent power. At approximately 1350 hours an inadvertent reactor high pressure scram occurred during surveillance testing on the isolation condenser high pressure initiation switches.

The technician performing the test was in the process of verifying that the sensing line excess flow check valve was open when the scram occurred. The scram was attributed to a momentary simultaneous operation of pressure switches due to a hydraulic disturbance associated with valve manipulations required by procedure to verify the position of the excess flow check valve. The hydraulic disturbance also caused a momentary trip of the isolation condenser initiation switches. Two of the four reactor high pressure scram sensors share a common sensing line with the isolation condenser initiation switches being tested. These sensors were not closed long enough to initiate an automatic initiation of the isolation condensers since a time delay is involved in the initiation logic. However, these sensors are also used in the automatic recirculation pump trip logic which did operate (no time delay involved).

One of two startup transformers, SB, was out of service to perform an inspection of its associated 4160 volt cabling (permitted by Technical Specifications). Transformer SB supplies off site power to one half of the station electrical distribution system (Figure 7.2-1) when power is not available through the station auxiliary transformer. The 4160 volt busses which receive power from SB are 1B and 1D. Buss 1D supplies power to certain redundant safety systems and is designed to be powered from the number 2 diesel generator in the event power is not available from either the auxiliary or startup transformer. Buss 1B supplies 4160 volt power to non-safety related systems and hence, does not have a diesel backup power source.

One of the five recirculation loops, loop D, was not in service due to a faulty seal cooler cooling coil. The pump suction valve was open, discharge valve closed, and discharge valve bypass open. No other systems and/or components important to the event were out of service.

7.2.2 Event Description

A reactor scram occurred for the reasons described above, coupled with a simultaneous trip of the four operating recirculation pumps. The control room operator verified that all control rods inserted and proceeded to drive in the IRMs and SRMs. At this time, 4160 volt power was being supplied from the main turbine generator via the auxiliary transformer. Steam flow started decreasing due to loss of heat production. Feed flow remained at full flow rate.

The turbine generator subsequently tripped on reverse power as designed which initiated an automatic transfer of power to the startup transformers. Power to busses 1A and 1C successfully transferred from the auxiliary transformer to startup transformer SA. Since SB was out of service at this time, power was lost to busses 1B and 1D which caused an automatic start of the number 2 diesel generator.

Loss of power to bus 1B resulted in loss of condensate pumps and feedwater pumps B and C. Although power was available to the A condensate and feedwater pumps, the A feedwater pump tripped on low suction pressure. With mass inventory leaving the reactor vessel through the steam bypass valves with no make-up, reactor water level decreased.

In anticipation of low-low water level (level 2), automatic isolation of the reactor, the operator closed the MSIVs. To establish a heat sink to remove decay heat from the reactor, the B isolation condenser was placed into service (Figure 7.2-2). The operator closed the A and E recirculation loop discharge valves (stroke time is approximately 2 minutes). It was postulated that the remaining two loops were also closed by the operator. The conclusion that the five recirculation pump discharge valves were closed was based upon subsequent loop temperature changes observed later in the event.

The temperature of the E recirculation loop decreased due to the addition of cold water from the isolation condenser condensate return line. Loops A, B, and C temperatures increased slightly which was attributed to natural circulation forcing hot water (536°F) through the loops that were previously cooled by the addition of cold feedwater.

Water inventory shifted from the core area to the downcomer region due to the isolation condenser returning condensed steam from the core area to the downcomer. The water inventory shift continued as the discharge valves moved in the closed direction.

The cooldown of E recirculation loop stopped when the discharge valves reached their fully closed positions. Indicated reactor water level continued to increase due to the shift in water inventory. Reactor pressure continued to decrease as a result of isolation condenser operation. To reduce the rate of cooldown the B isolation condenser was removed from service. As a result, indicated water level decreased due to water returning to the core region from the downcomer region via the five 2 inch recirculation loop discharge valves bypass lines. The recirculation loops discharge temperatures reached equilibrium and then began a slow cooldown trend.

The operator placed both isolation condensers in service to gain control of the heatup. This caused an increase in indicated water level and a decrease in pressure. To slow the rate of cooldown, the B isolation condenser was removed from service. At that moment, indicated water level reached a maximum of approximately 14.4 feet above the top of active fuel. Shortly after B isolation condenser was removed from service, indicated water level decreased to 13 feet 8 inches above active fuel, and stabilized. Water level remained stable during that period because the head of water in the downcomer region was sufficient to establish equilibrium between the water entering the core region via the five 2 inch bypass lines and the condensed steam returning to the downcomer from the isolation condenser.

During performance of local alarm verification and indicator checks the low-low-low (level 1) water level indicators were found to be below their alarm setpoint (10 inches). A recheck performed locally showed that the pointers were active (moving) although they continued to read below their alarm point. Also the instruments were indicating at or slightly above their lower level of detection.

The A isolation condenser was removed from service, thus stopping the removal of inventory from the core region. Indicated water level decreased as the water in the downcomer region flowed into the core region.

The C recirculation pump was started to provide a better indication of the plant cooldown rate. After the pump started, indicated water level dropped approximately 3 feet in less than two minutes causing the operator to stop the pump and investigate the reason for the level drop. In response to the level problem, the operator attempted to start the A feedwater pump. The pump failed to start due to a tripped overload on the auxiliary oil pump which provides an interlock in the feedwater pump starting sequence. The auxiliary oil pump was started locally followed by starting the A Feedwater pump. Indicated water level increased to a level corresponding to 13 feet 8 inches above the top of the core. The operator now recognized that all five recirculation loop discharge valves were closed and indicated water level and actual water level may not have been the same.

The A recirculation pump was placed in service which removed the disparity between the water level instruments. Indicated water level dropped approximately three feet to 11 feet 4 inches above the top of the fuel. Recirculation loop A temperature increased from 375°F to 465°F after starting the pump. In addition, the low-low-low water level condition cleared at this time.

7.2.3 Areas of Concern

The need for better communication between the downcomer region and the core region was apparent. Therefore, a Technical Specification revision was issued which required that at least two recirculation loops will be lined up with their respective suction and discharge valves open during all modes of plant operation. The requirement was so important that it was placed in the Safety Limit section of Technical Specification.

7.2.4 Corrective Actions

A confirmatory order, dated March 14, 1983, was issued that required an interlock system for the recirculation pump loops. In lieu of the interlock, Oyster Creek received approval for the installation of an alarm system that would provide annunciation when the fourth loop was isolated. This modification was required to be completed by October 1986.

7.2.5 Related subsequent Safety Limit Violation

While performing maintenance on the Reactor Building Closed Cooling Water System (RBCCW) on September 11, 1987, at 2:30 a.m., an operator identified leakage within the system and proceeded to isolate one of the two recirculation loops which was in service at the time. This is a violation of Technical Specifications 2.1, Fuel Cladding Integrity, which requires two recirculation loops to have their suction and discharge valves in the full open position during all modes of operation. Within seconds the operator placed one of the three isolated loops into operation. The total elapsed time with less than two loops in service was approximately 2 ½ minutes. The plant was in shutdown and on shutdown cooling with reactor temperature about 140 °F prior to the event.

7.2.6 Summary

Unlike other BWRs the BWR/2 reactor vessels do not have direct communication from the annulus region to the core inlet plenum. Water must exit the reactor vessel via recirculation loops and then reenter the vessel bottom head.

Table 7.2-1 Oyster Creek Reactor Vessel Levels

	Vessel Elevation	Distance Above TAF	Yarway	GEMAC	Barton
Flange	660"				
Steam Line	591"				
Top of Steam Separators & Indication	539"	15'6"	100"		130"
Turbine Trip	529"		90"		
Normal Level	519"	13'10"	80"	6'4"	
Low Level Scram	490"	11'5"		51"	
Bottom of Steam Separators	485"				
Bottom of Dryer Skirt	477"				
FWCS Inst. "0"	443"			0"	
Low-Low Level	439"	7'2"	0"		
Feed Line Nozzle	422"				
Low-Low-Low Level	418"				0"
Core Spray Nozzle	408"				
TAF	353"				
Vessel "0"	0"				

Table 7.2-2 Oyster Creek Plant Information

MWt	1930
MWe	670
Steam Flow/Feed Flow	7.33 x 10^6 lb/hr
Core Flow	73.6 x 10^6 lb/hr
RFPs	3 motor driven pumps (33% each)
BPV capacity	45%
Isolation Condensers	2 (3% steam flow each)
Containment	Mark I
SRVs (ADS)	4
Safety Valves	15
Recirculation System	5 loops, 1 variable speed pump each, NO Jet Pumps
Decay Heat Removal	Shutdown Cooling System
Low Pressure ECCSs	2 - 100% Core Spray Systems
High Reactor Pressure	1050 psig
ATWS-RPT	1060 psig
IC Auto Initiation	1060 psig or low-low level

Table 7.2-3 Sequence of Events

1350 hrs	Oyster Creek (BWR/2) was operating at base load conditions of 1895 MWT (98% of rated) using 4 of the 5 recirculation loops. Equipment out of service included the D recirculation loop (suction valve open, discharge valve closed, and discharge bypass valve open) and one startup transformer (for inspection of its cabling). An instrument technician was performing surveillance testing of the isolation condenser pressure switches.
1351(0s)	High pressure reactor scram and simultaneous trip of all operating recirculation pumps.
1351 (13)	Turbine generator trip on low load. Diesel generator #2 started. The B and C condensate pumps and the B and C RFPs tripped on undervoltage and the A RFP tripped on low suction pressure.
1351 (13.6)	Reactor water level at low level scram setpoint.
1351 (31)	Diesel generator #2 closed into the 1D switchgear. A second CRD pump was started.
1351 (43)	Reactor water inventory continuing to decrease. Operator closed MSIVs.
1351 (59.6)	Reactor mode switch was transferred from run to refuel.
1352 (16)	The B isolation condenser was placed in service. The operator closed the A and E recirculation loop discharge valves. [It is postulated that the B and C recirculation loop discharge valves were also closed at this time.]
1352 (30)	Reactor low water level alarm cleared.
1352 (36)	The B isolation condenser return valve was fully open.
1353 (52)	Low low low reactor water level instrument trip.
1354 (6)	All recirculation loop discharge valves were fully closed.
1355 (10)	The B isolation condenser was removed from service.
1355 (30)	Reactor pressure increasing.
1358 (30)	A & B isolation condensers placed in service.
1359 (48)	The B isolation condenser was removed from service. Indicated water level dropped from 14.4 ft. above TAF to 13’8" above TAF.
1400	The four low low low level indicators were verified locally to be below their trip point
1404 (30)	The low low low level indicators continue to read below their trip point.
1411 (12)	The A isolation condenser was removed from service.
1415 (48)	The A isolation condenser was used several more times to control reactor pressure.
1422 (54)	The C recirculation pump was started.
1424 (33)	The C recirculation pump was shutdown after indicated water level dropped about 3 feet in less than 2 minutes. The C recirculation pump was isolated. Started the A RFP.
1427 (48)	The A recirculation pump was placed in service at a flow rate of 1.9×10^4 GPM. Indicated water level dropped about 3 feet to 11’4" above the top of active fuel. The low low low water level condition was cleared at this time.
1431	Steps were initiated to bring the reactor to a cold shutdown condition.
1451	The B startup transformer was returned to service and the B switchgear was re-energized.
2228	Cold shutdown condition was achieved.

Table 7.2-4 Oyster Creek Reactor Level Problems

Events Chronology

May 2, 1979	Added new SAFETY LIMIT to T.S. requiring that a minimum of 2-loops remain open, e.g., suction & discharge valves fully open, during all Operational Conditions*
1979-1980	Refueling Outage: Installed a Fuel Zone LI & Recorder in the control room. This provides accurate <u>core</u> water level indication when all RR pumps are stopped.
1980	NUREG-0737: Required plants w/o jet pumps (except Humboldt Bay) to install interlocks that would assure that a minimum of 2-recirc loops valves would remain open during *all operational conditions* other than cold shutdown. However, an agreement was reached between the NRC and OC to incorporate an alarm system instead of an interlock system.
March 14, 1983	Confirmatory Order: NRC decreed that the licensee meet 0737 requirements as stated above.
April 23, 1986	The NRC published a proposed T.S. revision in the Federal Register that would permit the installation of an alarm unit, in lieu of interlocks, that would activate when the 4th consecutive RR loop became isolated.
Sept. 11, 1987	A control room operator closed one of the two remaining open recirc pump discharge valves. The operator immediately went to OPEN on a discharge valve in another loop (valves cannot be throttled but will go to the position selected by the operator before he can reverse its direction). An alarm was received in the control room when the 4th loop discharge valve became isolated. **

* Safety Limit Requirement – Fuel Cladding Integrity: At least 2-recirculation loops will be lined up as described. This will ensure that an adequate flow path exists from the annulus between the pressure vessel wall and core shroud, to the core. This provides good communication between these areas thus assuring that measured reactor water level is truly indicative of actual water level in the <u>core</u>.

** Subsequent to an investigation of this event:

1. Portions of Sequence of Alarms tapes were thrown into a commode, i.e., that portion referring to the RR pump's discharge valves closed alarms.

2. Two supervisors and three control room operators were suspended from duty pending outcome of the investigation.

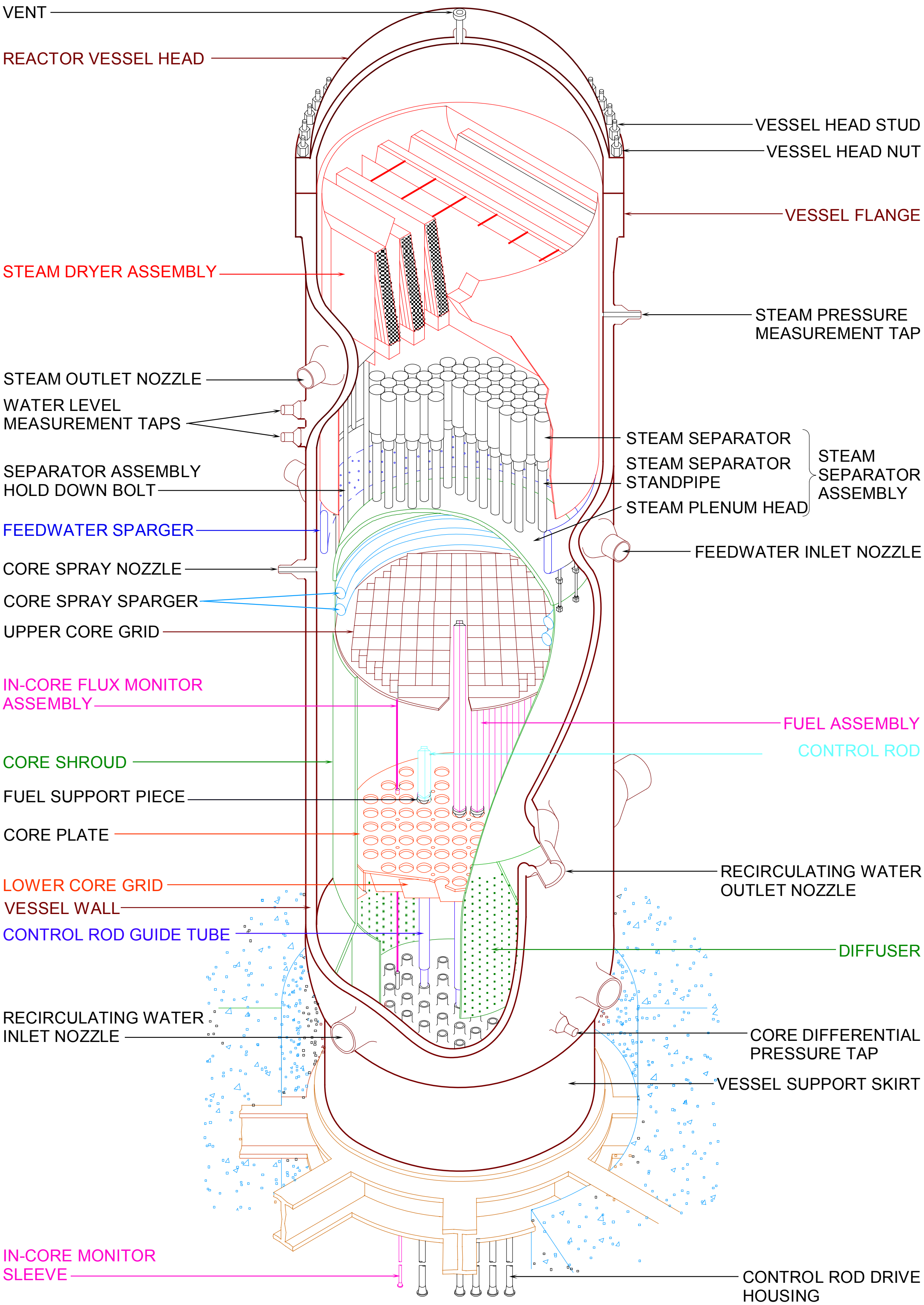

Figure 7.2-1 BWR/2 Reactor Vessel

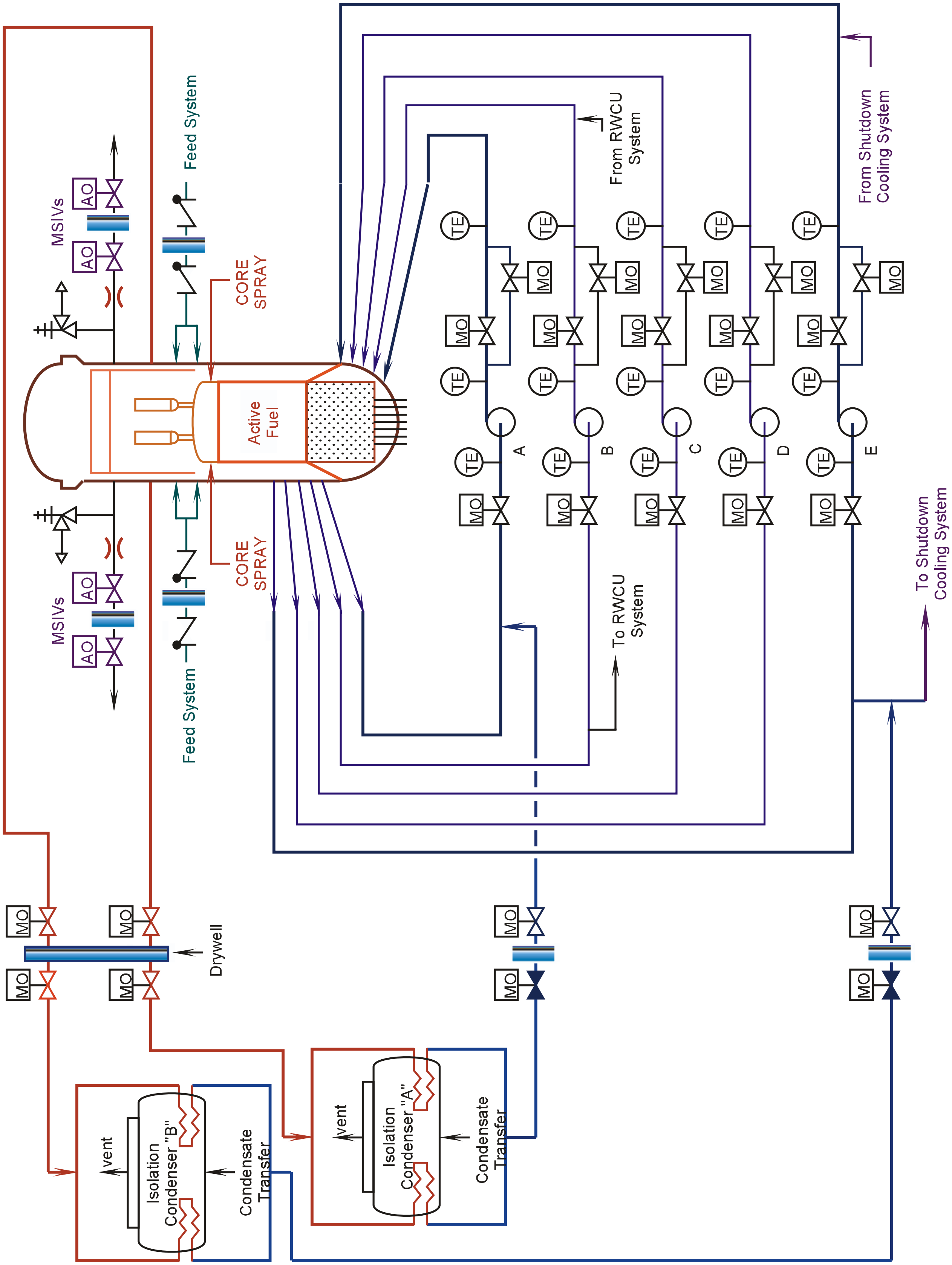

Figure 7.2-2 BWR/2 Isolation Condenser and Recirculation Systems

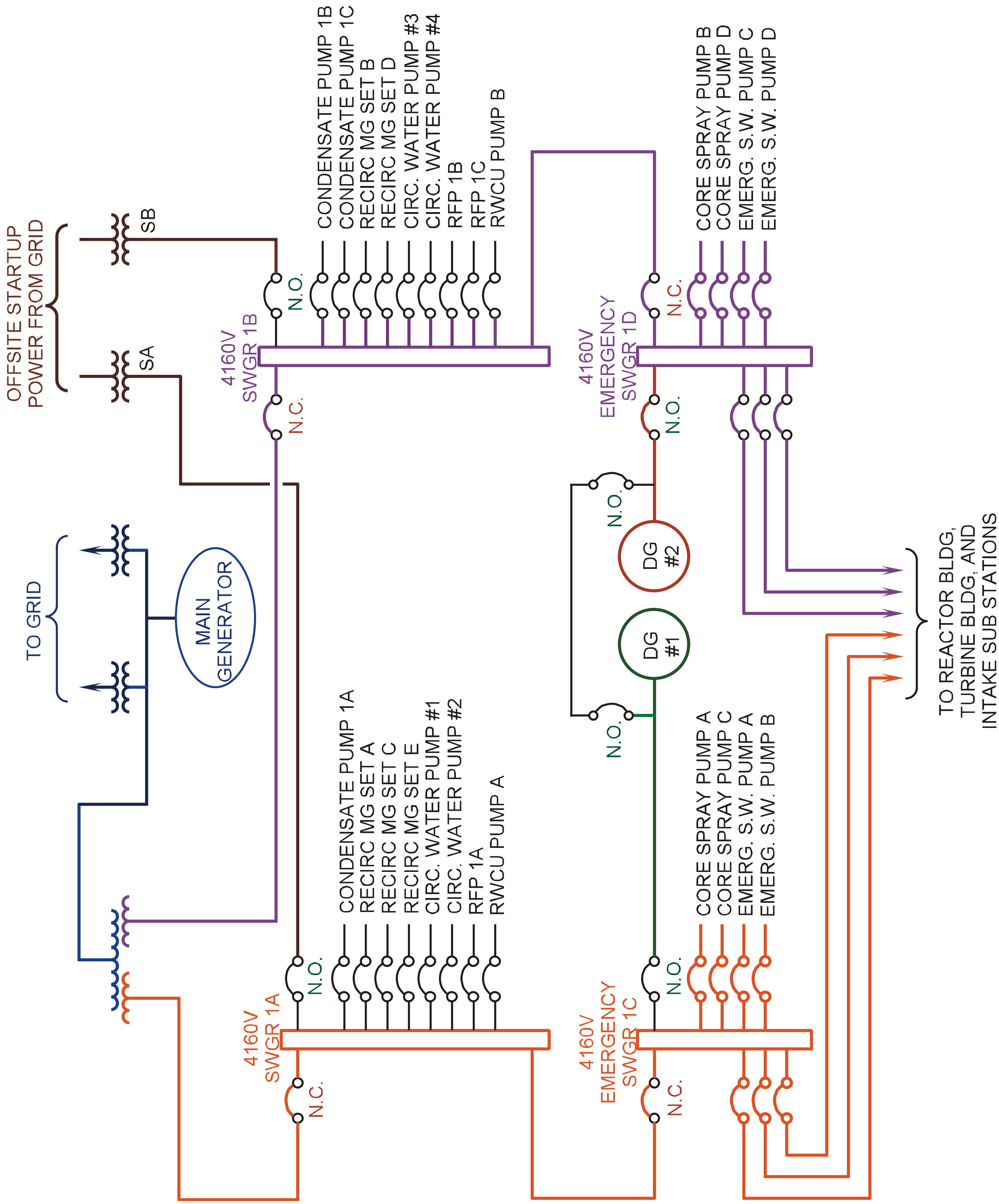

Figure 7.2-3 Oyster Creek Electrical Distribution

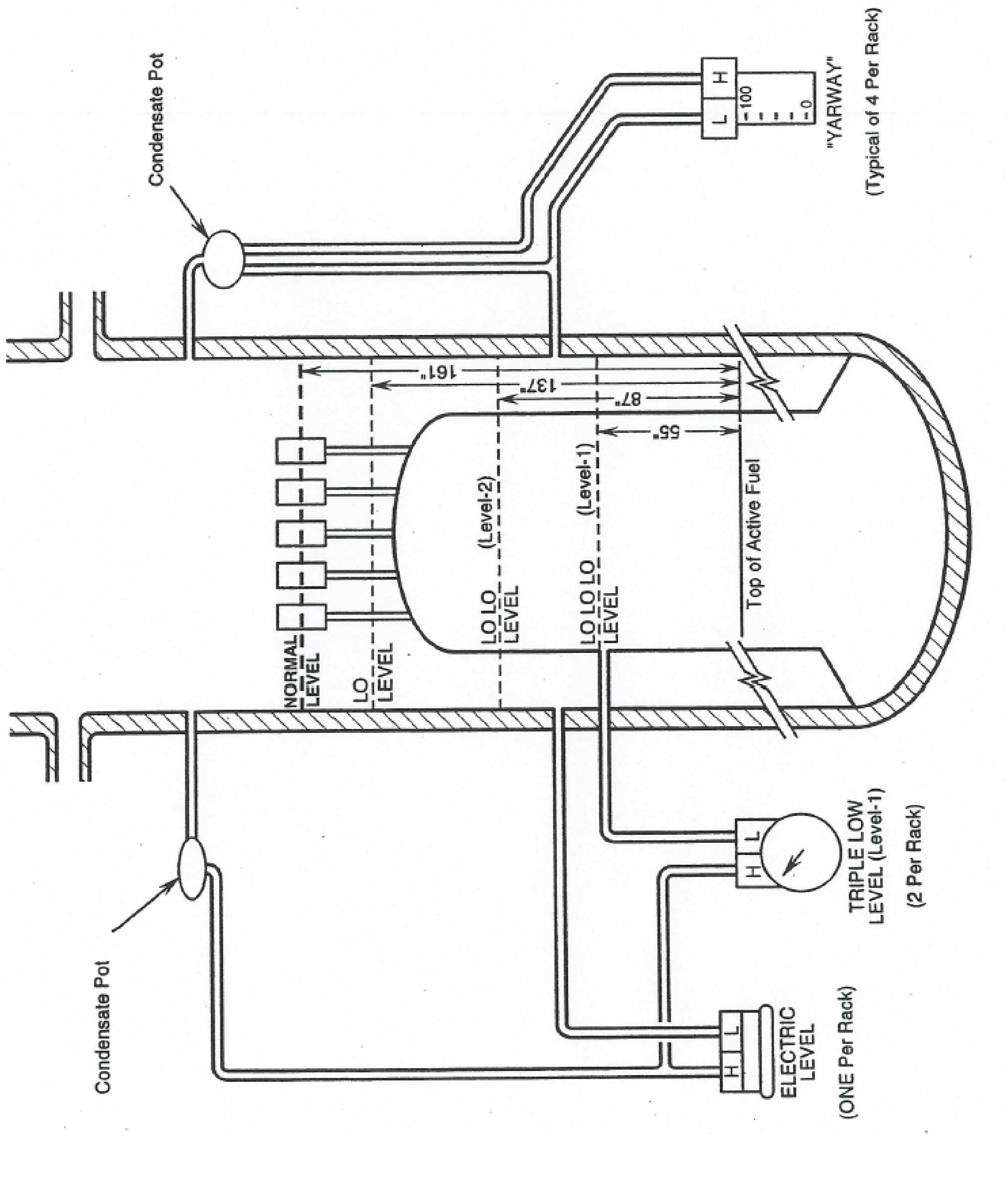

Figure 7.2-4 Oyster Creek Vessel Level Instrumentation