Pressurized Water Reactor
B&W Technology
Crosstraining Course Manual

Chapter 14.0

Oconee Tube Leak

TABLE OF CONTENTS

APPENDIX

LIST OF FIGURES

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14.0 OCONEE-2 STEAM GENERATOR TUBE LEAKAGEError! Bookmark not defined.

Learning Objectives:

1. List the symptoms of a steam generator tube leak.

2. Describe the actions that should be taken if the tube leakage exceeds technical specification limits

3. List three actions that can be taken to minimize offsite releases during steam generator tube leakage events.

14.1 Initiation of the Leak

On September 18, 1981, Oconee Unit 2 was in the power escalation phase of a mid-cycle restart after a short-term outage. At 1010, the power increase was stopped at approximately 94 percent power to calibrate nuclear instrumentation. The RCS was at 2150 psig and 579°F (T_{avg})

At 0930, the plant staff noted that the reading on the condenser off-gas monitor, 2RIA-40, was increasing from the normal 3,000 cpm that had been indicated at 0800. By 1145, the condenser offgas monitor had increased to 40,000 cpm. The primary-to-secondary leak rate was calculated to be 0.03 gpm, based on grab samples from the condensate steam air ejector (CSAE). Shortly thereafter, the operators initiated corrective actions in accordance with procedure OP/O/A/1106/31, “Control of Secondary Contamination.” This procedure provides three functions when primary-to-secondary leakage is suspected: (I) it minimizes radioactive discharges from the secondary system to the turbine building sumps, (2) it controls any contaminated water that does accumulate in the turbine building by terminating all automatic discharges, and (3) it provides guidance for identifying the leaking steam generator and criteria for shutting down and isolating the plant.

At 1200, the turbine building and Powdex sump pumps were secured to avoid unplanned release of potentially contaminated water in the sumps. By 1420, potentially contaminated drains were rerouted from the turbine building sump to the hotwell pump sump in order to minimize the spread of contamination.

At 1300, radiation measurements on the “A” and “B” main steam lines showed no detectable difference. However, by 1350, measurements on the “B” line had increased to 0.02 mR/hr above background, while the “A” line remained at background.

At 1529, 2RIA-40 went off-scale high and 2RIA-17 (main steam line “B” radiation monitor) increased to about 5 mR/hr. This indicated that the leak had suddenly increased and that it was in the “B” steam generator. The leak was calculated to be about 25 gpm

based on a grab sample from the CSAE. An “Unusual Event” was declared, and appropriate NRC, corporate, and local civil authorities were notified.

14.2 Shutdown and Leak Isolation

Immediately following the sudden increase in leak rate, a rapid plant shutdown using normal procedures was initiated. The shutdown followed procedure OP/2/A/1102/10, “Controlling Procedure for Unit Shutdown.” The leak rate was calculated as 25 gpm, and the event was classified as a major tube leak rather than as a tube rupture. Consequently, procedure EP/O/A/1800/17, “Steam Generator Tube Rupture,” was not followed, although it was occasionally used for general guidance. Reactor power was reduced at a rate of approximately 3 percent/minute (compared to a normal shutdown rate of about 10 percent/hour.) The reactor was subcritical approximately one hour after the high leak rate commenced. The electrical generator was taken off line when the power level fell to 15 percent. Initially, the turbine bypass valves were opened to maintain steam pressure below the steam safety relief valve setpoints. Main feedwater pump “B” was manually tripped at 1622, and the “B” steam generator feedwater and turbine bypass valves were closed at 1632, when “B” main steam pressure was about 840 psig. Other valves were also closed so that by 1745 the “B” steam generator was essentially isolated except for minor leakage paths.

14.3 Plant Cooldown

With action having been taken to isolate the “B” steam generator, cooldown was continued using the “A” steam generator. At about this time (1627), an additional high pressure injection (HPI) pump was started to make up for cooldown “shrink” and continued leakage. The reactor was initially cooled down and depressurized from 1627 until about 2300 on September 18. Pressure in both OTSGs was decreased within normal shutdown limits from an initial value of about 890 psig to 40 psig at 2100. Following actions to isolate the “B” steam generator, its pressure was nearly the same as the saturation pressure corresponding to the primary temperature (T_c) after 1745, as shown in Figures 14-1 and 14-2.

Figure 14-2 also shows that the temperatures in both steam lines remained higher than the saturation temperature of the liquid in the steam generators throughout the cooldown. Since superheat above the reactor coolant temperature could not have existed, these temperature lags are evidently caused by the slower cooling of the metal in the steam lines where the steam temperature detectors were located.

Shortly after the reactor was shut down, both SG levels decreased to about 25 inches on the start-up range (about 29 inches above the lower tube sheet). The “A” steam generator remained at this level; at 1718, the last running main feedwater pump (2A) was manually tripped, and the condensate booster pumps were used to supply water to the “A” steam generator. At 1745, the “B” steam generator level began to rise at about 0.4 percent/minute. This corresponded to a net water addition rate of about 50 gpm and

included the tube leak and the effects of feedwater in-leakage and steam out- leakage. At 2200, as the level in the “B” steam generator approached 90 percent on the operating range, a reactor building entry was made and the bottom drains on the “B” steam generator were opened in order to drain the SG to the main condenser hotwell through the hot blowdown lines. This was done to prevent filling the main steam lines with water. As far as can be determined, this periodic draining of the steam generator did prevent overflow of water into the steam lines, although the level exceeded the upper limit of the operating range on the level instrumentation.

From about 1930 until 2230 on September 18, the RCS pressure was held steady at about 540 psig. The reason for holding pressure rather than continuing to lower it may have been related to certain activities that were taking place during that time, such as setting the valve line-up for the Low Range Reactor Coolant System Pressure indicator. By 2300, the RCS pressure had been lowered to 300 psig.

At approximately 0800 on September 19, the RCS reached the conditions specified in Oconee operating procedures (<250°F, <350 psig) for initiating decay heat removal via the LPI system .

At about 0900, an attempt was made to open the LPI suction valves from the reactor coolant system (2LP-l and 2LP-2). Valve 2LP-2 failed to open electrically both from the control panel and from the circuit breaker. Three reactor building entries were made from 1100 on September 19 through 0400 on September 20 in an attempt to open the valve manually. During those three entries, the valve operator was manually moved 3/4 turn, 3/4 turn, and 2 turns respectively. After each entry, the plant staff tried to open the valve electrically from the breaker. These efforts were unsuccessful because the valve stem had been deformed. At 0400 on September 20, the valve was opened by removing the operator and “jacking” the valve open using manual hoists (come-alongs).

By 0647 on September 20, the LPI system line-up was complete, and decay heat removal was initiated, having been delayed about 21 hours. Cooldown and depressurization of the RCS resumed, and at 0430 on September 21, the operators began pumping down the RCS loops. The tube leak was terminated at 0615 on September 21, 1981.

14.4 Turbine Building Flooding and Decontamination

As described earlier (Section 14.1), the turbine building sumps were isolated shortly after initial tube leak determination on September 19, 1981, in accordance with procedure OP/O/A/1106/31. Normal leakoff from both Units 2 and 3 was flowing to the sumps from such things as valves, flanges, and drains. Thus, a considerable amount of initially uncontaminated water flowed to the sumps. (Unit 1 was shut down and did not contribute to the water inventory in the sumps.) At about 1700 on September 18, the CST overflowed to the turbine building trenches. This occurred following system alignment for entering the feedwater cleanup mode.

At about 1200 on September 19, the circuit breakers for the feedwater pump (FDWP) seal injection sump pumps tripped due to a breaker malfunction. While these were being repaired, the sumps overflowed to the turbine building sumps. Since radioactive water from the “B” steam generator was being drained to the hotwell at this time, the FDWP seal injection water was contaminated and resulted in contamination of the water in the turbine building sumps. At 0930 on September 20 the CST overflowed to the turbine building sumps again. The cause of the overflow may have been related to restarting the FDWP seal injection sump pumps or to manual hotwell level control in preparation for breaking main condenser vacuum.

Cleanup of contaminated water required temporary large-scale water processing. Demineralizers, pumps, hoses, and fittings were acquired. By the afternoon of September 19, 1981, normal leakoff from all three units was being processed by portable demineralizers. The processed water was routed along with Unit 3’s turbine building sump to the upper settling basin. Between September 19 and September 24, a temporary discharge line was installed between the CST pumps and the normal plant discharge line, which included RIAs 33 and 34. The Unit 2 and Unit 1 CSTs were used as holding tanks where processed, demineralized water was stored for sampling prior to release to Keowee tailrace. This method was generally used until the Units 1 and 2 turbine building sump was put back on batch release. Including water used for decontamination purposes, an estimated 2.5 million gallons of contaminated water was processed. The entire cleanup process required about six weeks.

APPENDIX - SEQUENCE OF EVENTS

9/17/81

0000 Plant condition 2150 psig and 535°F
Deboration in progress

0543 Reactor critical
increasing power

1600 - Reactor power - 60%

9/18/81

0800 Reactor power 87.5%, increasing
Condenser off-gas monitor 2RIA-40 reads 3000 cpm (normal)

0930 - 2RIA-40: increasing

1030 - 2RIA-40: 10,000 cpm

1145 - 2RIA-40: 40,000 cpm
Condensate steam air ejector (CSAE) grab sample indicates primary-to-secondary leak of 0.03 gpm

1200 - Initiated "Control of Secondary Contamination" procedure, OP/O/A/1106/31.
- Stopped turbine and powdex sump pumps

1300 - Radiation measurements of "A" and "B" main steam lines show no detectable difference

1319 2RIA-40 grab sample: $4.25xl0^{-4}$ mCi/ml gaseous activity

1350 - Radiation measurements of main steam lines "A" are background: "B" lines are 0.02 mR/hr above background

1420 - Completed rerouting potentially radioactive drains from the turbine building sump to the hotwell pump sump

1529 - 2RIA-40: off-scale high
- Main steam line "B" radiation monitor 2RIA-17 indicates 5 mR/hr
- Leak determined to be in "B" steam generator
- Commenced reactor shutdown

1543 - Declared "Unusual Event" since tube leak calculated to be approximately 25 gpm
- Notified authorities

1558 - Generator off line

1622 - Main feedwater pump "B" manually tripped

1627 - Reactor subcritical
Cooling down RCS
Started additional HPI pump to keep up with "shrink" and leak

1632 - Closed SG "2B" feedwater and turbine bypass valves

1640 - RCPs 2A2 and 2B2 shutdown

1655 - All CRDs inserted

SEQUENCE OF EVENTS (continued)

1700 - Condensate storage tank overflows to turbine building trenches
1718 - Main feedwater pump “A” manually tripped
1750 - 2B OTSG level increasing; 2A OTSG level at 25"
1800 - 2B OTSG level is increasing
1900 - 2B OTSG level is 40% (operating range)
2100 - Made reactor building (RB) entry to line up pressurizer auxiliary spray
2200 - Opened bottom drains on 2B OTSG and started drain back to hotwell through blowdown lines

9/19/81

0000 - RCS at 286°F, 300 psig
SG “B” pressure is 35 psig
0900 - 2LP-2 (LPI suction from RCS) would not open electrically
1100 - Made three RB entries to try to open 2LP-2 manually
1300 - Reactor building purge on
2045 - RCS gross activity $6.4xl0^{-1}$ mCi/ml

9/20/81

0400 - 2LP-2 opened manually by maintenance personnel
0647 - Started LPI pump 2A (Decay Heat Removal)
0714 - Secured 2Al RCP
0930 - CST overflowed to trenches
1000 - Broke vacuum on main condenser

9/21/81

0430 - Started pumping down RCS loops
0615 - Leak stopped

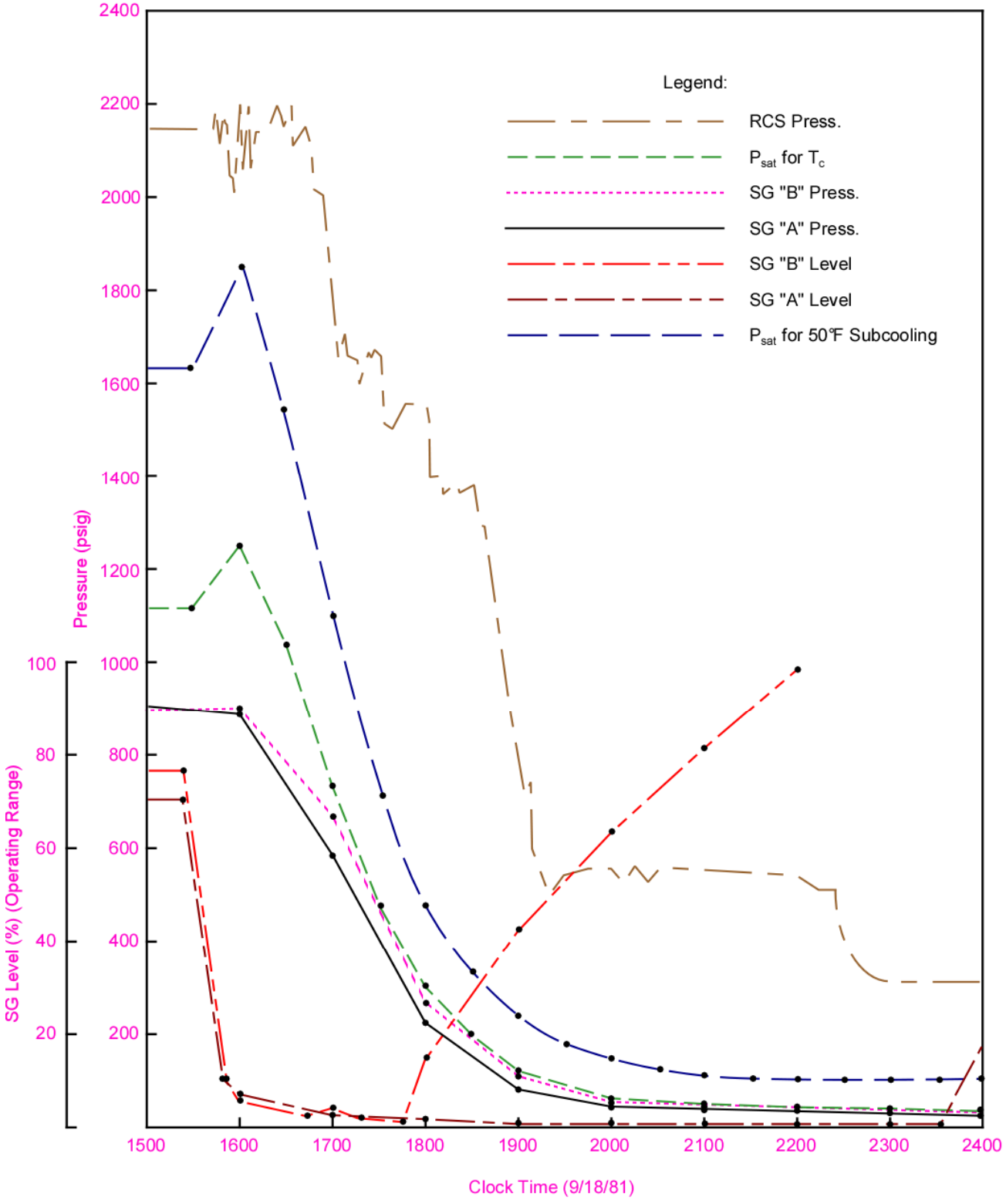

Figure 14-1 Pressures and OTSG Levels

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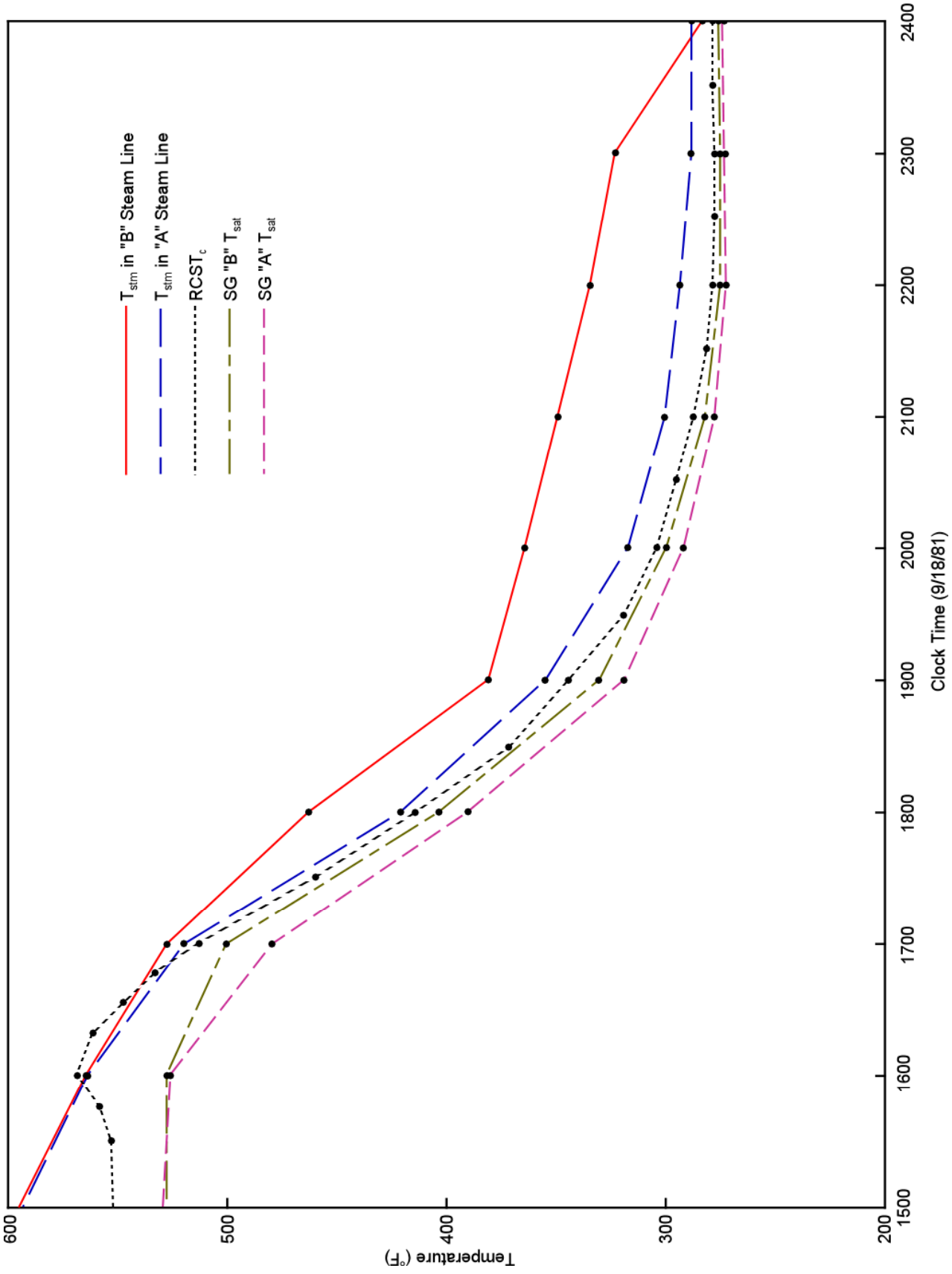

Figure 14-2System Temperatures

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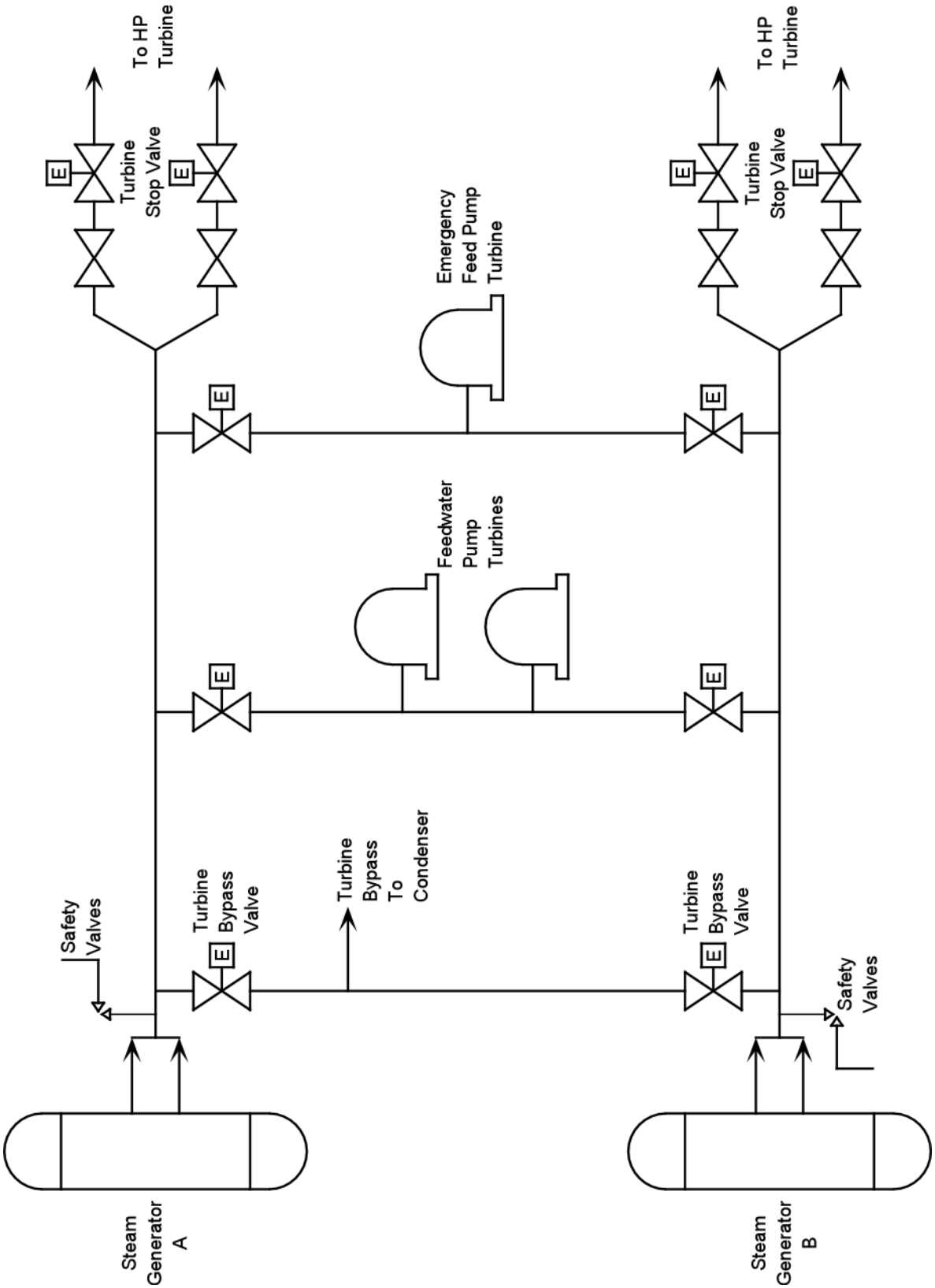

Figure 14-3 Oconee 2 Main Steam System

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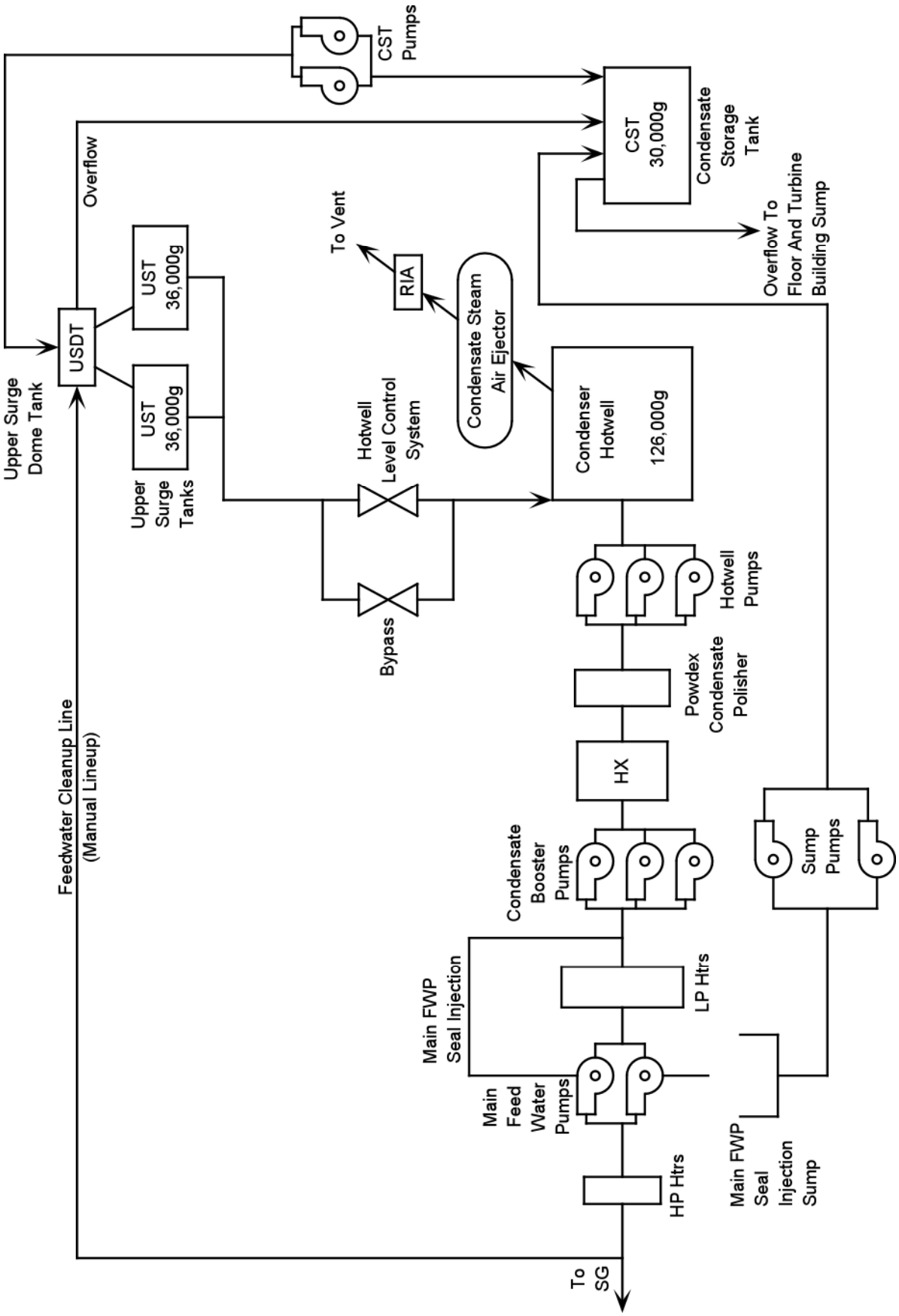

Figure 14-4 Oconee 2 Condensate and Feed System

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