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Document #: 70108698-0100

TITLE: Maximum Pressure in Underground Auxiliary Feedwater Piping

REASON FOR EVALUATION / SCOPE:

Degradation was found in the underground Auxiliary Feedwater (AFW) piping prior to entering the Outer Penetration Area per Notification 20456999. This is the supply piping to 12 & 14 Steam Generators (SGs), downstream of the AFW pumps. This Technical Evaluation determines the maximum potential pressure in this piping for input into a subsequent evaluation on minimum wall.

NOTE: This Technical Evaluation revises and supersedes Technical Evaluation 70108698-0050. It adds an additional scenario for evaluation of AFW pressure.

DETAILED EVALUATION:

Auxiliary Feedwater Operation:

The AFW System provides flow to the SGs during plant cooldown and startup conditions for decay heat removal when the Main Feedwater (MFW) System is out of service. The AFW System also provides flow to the SGs during transient conditions such as Steam Line Break (SLB), Feedwater Line Break (FLB), Small Break Loss of Coolant Accident (SBLOCA), Loss of Normal Feedwater (LONF), Loss of Offsite Power (LOOP) and Station blackout (SBO). The system consists of two Motor Driven AFW Pumps (MDAFPs), each of which feeds two SGs, and one Turbine Driven AFW Pump (TDAFP), which feeds all four SGs. During plant cooldown and startup, operators manually control AFW flow via the AF21 control valves for the MDAFPs and via the AF11 control valves for the TDAFP. During transient conditions, the AF21 control valves are in automatic and control to maintain MDAFP discharge pressure; the AF11 control valves are full open.

The maximum potential pressure in the system would be with all the AFW pumps deadheaded. However, this is an unrealistic condition. The actual maximum system pressure is a function of the maximum potential SG pressure. Per Reference 3, the maximum SG pressure is assumed to be the lowest Main Steam (MS) safety valve setting (1070 psig - Reference 2) plus 3% accumulation, or 1102 psig (1117 psia).

The maximum system pressure would occur with all three pumps

running on their design performance curves. Reference 3 provides a hydraulic analysis for the system transient conditions, using the AFW System hydraulic model. The SLB Inside Containment transient is analyzed with this pump alignment for two conditions - no failures and MDAFP runout protection failure, which is a failure of one of the AF21 valves to the full open position. The actual maximum pressure in a particular SG supply line would occur for a failure of an AF21 valve to the full closed position, which maximizes pressure in the SG supply line that remains aligned to the associated MDAFP. This condition was not analyzed in Reference 3 as the parameter of concern was maximum total SG flow. As such, additional cases were run with 11AF21 closed, to maximize pressure in the 12 SG supply piping (Case A), and with 13AF21 closed, to maximize pressure in the 14 SG supply piping (Case B). For conservatism and simplicity, it was assumed that the remaining AF21 valves are full open. In reality they would be throttled to maintain MDAFP discharge pressure; however, determining their position is an iterative and cumbersome process. Case 4 from Reference 3 Proto-Flo database S-C-AF-MDC-0445-R3.DBD was modified accordingly. The pressure in the underground piping is assumed to be that from the nearest upstream node in the model, which are the tie-ins between the MDAFP and TDAFP discharges in the Auxiliary Building. The resulting pressures at these nodes are 1259 psia (1244 psig) for 12 SG supply (Case A) and 1270 psia (1255 psig) for 14 SG supply (Case B). The Proto-Flo output reports are included as Attachments 1 and 2, respectively.

During normal plant cooldown and startup, it is unlikely all three AFW pumps would be running. Furthermore, the AF21s and/or AF11s are manually throttled to control cooldown rate and/or maintain SG level, which reduces the downstream pressure and thus the pressure in the buried piping. Therefore, this condition is bounded by the SLB transient condition with respect to pressure in the buried piping.

Auxiliary Feedwater System Testing:

MDAFP and TDAFP full flow testing to the SGs is performed per References 7 & 8 during each Refueling Outage. The highest pump discharge pressure occurs for the TDAFP test. The TDAFP discharge pressure was originally base lined at 1250 psig in 1998 (WO #960829007). Since then the TDAFP discharge pressure has varied been between 1235 and 1248 psig. These pressures are bounded by the limiting SLB Case from above (Case B, 13AF21 fails closed). Furthermore, similar to normal plant cooldown and startup, the AF21s and AF11s are manually throttled during testing to set the required flow, and so the pressure in the buried piping to 12 and 14 SGs would be even less. Therefore, full flow testing is bounded by the SLB transient condition. During quarterly surveillance testing (References 4-6), the AF21s and AF11s are closed, with flow going through the respective pump recirculation line, and thus is not applicable to this evaluation.

Main Feedwater Operation:

During normal plant operation, the MFW System provides flow to the SGs, and the AFW System is isolated from the SGs. During this condition, there is a potential for back leakage through the AF23 stop check valves, which are located just upstream of the AFW tie-ins to the MFW System. A leak check of these valves is performed quarterly per Reference 9. Trending of past test results finds no indication of significant leakage past these check valves. Test results found AFW line pressures typically around 25-30 psig with a MFW pressure of around 835-845 psig. A couple exceptions were for the test on 8/30/09, where the 12AF23 upstream pressure was 150 psig, and for the test on 3/1/10, where the 11AF23 and 12AF23 upstream pressures were about 115 psig. If these couple results were an indication of actual leakage, the AFW line pressure was still significantly below the MFW line pressure. Thus, even if the MFW System flow was low, with corresponding higher system pressure, the resulting AFW line pressure with any leakage past 12AF23 would still be very low compared to that with the AFW System in service.

Special LONF Scenario

Another plant transient scenario that potentially could challenge the above case is a LONF to one SG. In this condition the level in that SG would drop rapidly. The possibility that operators could initially align the associated motor-driven pump and the turbine-driven pump to this one SG to regain level as quick as possible is considered, which would result in a higher pressure in the buried piping than that determined for a SLB inside containment with a single failure of an AF21 valve to the closed position.

A LONF event would result in a reactor trip on low-low level in at least one SG. The motor-driven pumps automatically start on low-low level in any one SG and the turbine-driven pump automatically starts on low-low level in any two SGs. Initially the control valves are in automatic. In this mode, the AF11s are full open, and the AF21s throttle as a function of motor-driven pump discharge pressure.

The operators enter Emergency Operating Procedure 1-EOP-TRIP-1 (Reference 11) upon a reactor trip. Step 5 of 1-EOP-TRIP-1 sends the operator into 1-EOP-TRIP-2 (Reference 12) by noting that Safety Injection is not actuated and is not required. Upon entering 1-EOP-TRIP-2, the operators ensure or establish at least 22E4 lbm/hr total AFW flow (approximately 440 gpm) by placing the control valves in manual, and adjusting position as necessary. The turbine-driven pump speed is then lowered until either the total flow drops to 22E4 lbm/hr or the minimum speed is reached. The operators maintain AFW flow until at least one SG level is greater than 9%, then maintain the level between 9% and 33%.

Per Operations, AFW flow is adjusted by simultaneously adjusting the positions of all the control valves from the Control Console. The immediate concern is to have at least one SG in the required level range, and not necessarily the one that experienced a LONF. At some point, pending the need for other

priority actions, level will be attempted to be restored in any remaining SGs not within the required range. Also note that establishment of SG level is done after the turbine-driven pump speed is lowered. Therefore, the postulated LONF scenario is not credible, and the SLB inside containment with a single failure of an AF21 valve to the closed position remains the bounding condition.

CONCLUSIONS/FINDINGS:

The maximum potential pressure in the buried AFW piping during an accident is 1259 psia (1244 psig) for 12 SG supply and 1270 psia (1255 psig) for 14 SG supply. This occurs for a SLB Inside Containment transient with a single failure of an AF21 valve to the closed position, at the maximum potential SG pressure. For conservatism, the maximum operating line pressure in the buried AFW piping is set at 1275 psi.

REFERENCES:

1. P&ID 205236, Revision 54, Unit 1 Auxiliary Feedwater

2. P&ID 205203, Sheet 1, Revision 77, Unit 1 Main, Reheat & Turbine By-Pass Steam

3. S-C-AF-MDC-0445, Revision 3, Auxiliary Feedwater System Hydraulic Analysis

4. S1.OP-ST.AF-0001, Revision 15, Inservice Testing - 11 Auxiliary Feedwater Pump

5. S1.OP-ST.AF-0002, Revision 16, Inservice Testing - 12 Auxiliary Feedwater Pump

6. S1.OP-ST.AF-0003, Revision 38, Inservice Testing - 13 Auxiliary Feedwater Pump

7. S1.OP-ST.AF-0005, Revision 11, Inservice Testing Auxiliary Feedwater Valves Mode 4-6

8. S1.OP-ST.AF-0007, Revision 19, Inservice Testing Auxiliary Feedwater Valves Mode 3

9. S1.OP-ST.AF-0006, Revision 10, Inservice Testing Auxiliary Feedwater Valves

10. UFSAR Section 10.4.7.2, Auxiliary Feedwater System; Section 15, Accident Analysis

11. 1-EOP-TRIP-1 F, Revision 26, Reactor Trip or Safety Injection

12. 1-EOP-TRIP-2 F, Revision 24, Reactor Trip Response

13. UFSAR Section 15.2.8, Loss of Normal Feedwater

ATTACHMENTS

1. Case A Proto-Flo Ouput Reports: SLB Inside Containment with 11AF21 Failing Close
2. Case B Proto-Flo Ouput Reports: SLB Inside Containment with 13AF21 Failing Close

NOTE: The complete Technical Evaluation, including attachments, has been submitted to Records Management, Document Number 70108698-0100.

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