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IN 86-01

UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
OFFICE OF INSPECTION AND ENFORCEMENT  
WASHINGTON, DC 20555

January 6, 1986

IE INFORMATION NOTICE NO. 86-01: FAILURE OF MAIN FEEDWATER CHECK VALVES CAUSES  
LOSS OF FEEDWATER SYSTEM INTEGRITY AND  
WATER-HAMMER DAMAGE

Addressees:

All nuclear power reactor facilities holding an operating license (OL) or a construction permit (CP).

Purpose:

This notice is provided to inform recipients of a recent event caused by five main feedwater (MFW) check valve failures at a pressurized-water-reactor (PWR) plant. These failures resulted in a loss of MFW system integrity and significant water-hammer damage. Recipients are expected to review the information for applicability to their facilities and consider actions, if appropriate, to preclude similar problems occurring at their facilities. However, suggestions contained in this information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

On November 21, 1985, San Onofre Unit 1 was operating at 60% power when an auxiliary transformer failed, resulting in a loss of power to a vital bus and to the bus feeding the east (electric) MFW pump. (A schematic of the MFW system is enclosed as Figure 1.) The west (electric) MFW pump remained energized from the unit main generator due to an abnormal electrical lineup. When the east MFW pump tripped, its discharge-check valve (FWS-438) failed to seat properly. As a result of the failure of the east MFW pump discharge-check valve, the west MFW pump supplied feedwater backwards through this discharge-check valve and overpressurized the east feedwater heater-condensate train. Several tubes apparently ruptured in the east feedwater train fifth stage (low pressure) feedwater heater as a result of the overpressurization, causing the shell side of this feedwater heater to rupture also. In addition, several main turbine rupture discs failed. Following the above events, the operators tripped the reactor and turbine by procedure because of the loss of power to a vital bus. This also caused the west MFW pump to trip. Both 12-inch MFW pump discharge-check valves (FWS-438 and 439) were later found cocked open, supported by their disc antirotation lugs that had rotated under the check valve hinge arm.

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When the west MFW pump tripped, all three steam generator (SG) MFW regulating valve discharge-check valves (FWS-345, 346 and 398) also failed to seat. Two of these 10-inch check valves were later found to have their flappers loose in the bottom of the valve body with their nuts missing. The third 10-inch check valve was later found to have failed in the same mode as FWS-438 and 439. These check valve failures in the MFW system resulted in leak paths from the SGs backward through the MFW regulating valves and the east MFW pump to the ruptured east train FW heater. In addition, the west MFW train may have been pressurized from the SGs. The net effect of this is that the inventory in all three SGs began to blow steam and hot water back through the east MFW train.

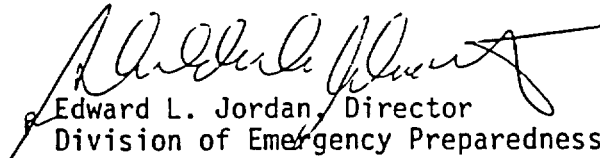
The above reactor trip also caused level shrink in the SGs, causing SG level to drop below the actuation level for the auxiliary feedwater (AFW) pumps. The electric driven AFW pump received an actuation signal, but no longer had electric power available. The steam-driven AFW pump, after a 3-minute automatic warmup period, began to deliver relatively cold feedwater to the SGs at a point in each of the MFW lines between the MFW regulating valve discharge-check valve and the SG. This AFW to the SG feedwater lines initially flowed backward through the failed check valves and forward through long horizontal runs of feedwater pipe in the primary containment. Although the operators were unaware that the check valves had failed, they then closed all MFW regulating valves, FCV-456, 457 and 458 and their associated isolation valves, MOV-21, 20 and 22 in accordance with procedures. (The effect of the closure of these MFW valves has yet to be determined.) Contact between steam in the feedwater lines and the cool AFW in the horizontal pipe resulted in a water-hammer. The water-hammer caused damage to the feedwater line pipe supports and stretched the bonnet bolts on the "B" feedwater regulating valve bypass-line check valve (FWS-378), causing the metal valve gasket to extrude. The flapper on this 4-inch check valve was later found to have been damaged by the water-hammer impact. The extrusion of the valve gasket resulted in a substantial steam-water leak from the "B" SG to the feedwater mezzanine area and the atmosphere that was not isolatable for some time because of the proximity of the associated isolation valve to the leak. As a result, the "B" SG boiled dry since all "B" AFW flow was carried out through the leak. Plant personnel were finally able to close valves FWS-342 and FWS-376 to isolate the leak and continue the plant cooldown about six hours after the event started.

#### Discussion:

The NRC sent a five-member incident investigation team (IIT) to the San Onofre, Unit 1 site shortly after the above incident. The licensee agreed to hold in abeyance any work in progress or planned (as allowed by plant safety considerations) until the licensee and the NRC had an opportunity to evaluate the event. The licensee also has agreed to maintain Unit 1 shutdown until concurrence is received from the NRC to return to power. The IIT has completed a preliminary investigation of this event and expects to issue a report in January 1986.

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No specific action or written response is required by this information notice. If you have questions about this matter, please contact the Regional Administrator of the appropriate NRC regional office or this office.

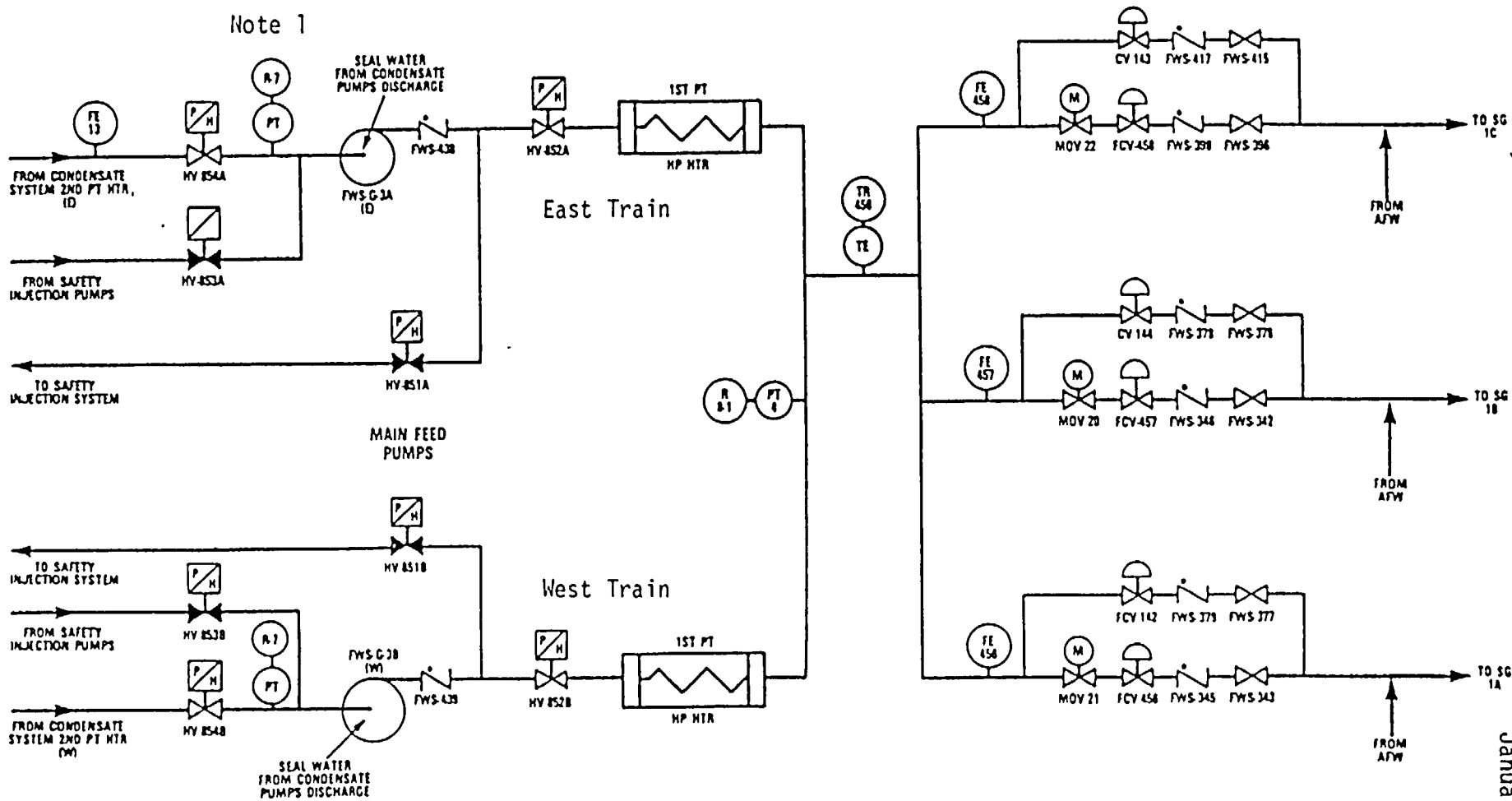
  
Edward L. Jordan, Director  
Division of Emergency Preparedness  
and Engineering Response  
Office of Inspection and Enforcement

Technical Contact: Henry Bailey, IE  
(301) 492-9006

Attachments:

1. Figure 1, San Onofre Unit 1 Main Feedwater System Schematic Diagram
2. List of Recently Issued IE Information Notices

Figure 1, San Onofre Unit, Main Feedwater System Schematic Diagram



Note: The ruptured fifth stage feedwater heater (not shown) is the lowest pressure heater in this east train.

Attachment 1  
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LIST OF RECENTLY ISSUED  
IE INFORMATION NOTICES

Information Notice No.	Subject	Date of Issue	Issued to
85-101	Applicability of 10 CFR 21 To Consulting Firms Providing Training	12/31/85	All power reactor facilities holding an OL or CP
85-100	Rosemount Differential Pressure Transmitter Zero Point Shift	12/31/85	All power reactor facilities holding an OL or CP
85-99	Cracking In Boiling-Water-Reactor Mark I And Mark II Containments Caused By Failure Of The Inerting System	12/31/85	All BWR facilities having a Mark I or Mark II containment
85-98	Missing Jumpers From Westinghouse Reactor Protection System Cards For The Over-Power Delta Temperature Trip Function	12/26/85	All Westinghouse designed PWR facilities holding an OL or CP
85-97	Jail Term For Former Contractor Employee Who Intentionally Falsified Welding Inspection Records	12/26/85	All power reactor facilities holding an OL or CP
85-96	Temporary Strainers Left Installed In Pump Suction Piping	12/23/85	All power reactor facilities holding an OL or CP
85-95	Leak Of Reactor Water To Reactor Building Caused By Scram Solenoid Valve Problem	12/23/85	All BWR facilities holding an OL or CP
85-94	Potential For Loss Of Minimum Flow Paths Leading To ECCS Pump Damage During A LOCA	12/13/85	All power reactor facilities holding an OL or CP
85-93	Westinghouse Type DS Circuit Breakers, Potential Failure Of Electric Closing Feature Because Of Broken Spring Release Latch Lever	12/6/85	All power reactor facilities holding an OL or CP

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OL = Operating License  
CP = Construction Permit