

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

December 15, 1998

NRC INFORMATION NOTICE 98-45: CAVITATION EROSION OF LETDOWN LINE
ORIFICES RESULTING IN FATIGUE CRACKING OF
PIPE WELDS

Addressees

All holders of operating licenses for nuclear power reactors, except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to potential problems caused by cavitation erosion of letdown line orifices in the chemical and volume control system (CVCS). Such erosion has contributed to failures in pipe welds downstream of the letdown line orifices. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On September 11, 1996, Surry Power Station, Unit 2, experienced its fourth socket weld failure in 12 months. The failed welds were located on the low-pressure portion of the CVCS letdown line, just downstream of the pressure-reducing orifice isolation valves. The licensee determined that the most likely cause of the weld failure was flow-induced vibration. The licensee performed a microscopic examination of the Unit 2 letdown line orifices and concluded that two of the orifices exhibited cone-shaped patterns, wider at the discharge of the orifice and tapering toward the inlet of the orifice. In addition, the orifice exhibited very rough and irregular surface profiles. The damage to the letdown line orifices is indicative of cavitation erosion and is believed to have contributed to flow-induced vibration of the letdown line and to the socket weld failures.

On March 15, 1997, the licensee performed radiographic examinations on the Surry Unit 1 letdown line orifices to check for an erosion condition similar to that previously seen in the Unit 2 letdown line orifices. The licensee concluded that erosion was present in all three orifices and that the most extensive deterioration was present in the 45-gpm orifice. The licensee's microscopic examination of this orifice indicated that its nominal diameter of 0.212 inch had eroded to approximately 1 inch. This erosion occurred over the last 5 inches of the orifice

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length. One of the 60-gpm orifices exhibited minor erosion, but the second 60-gpm orifice exhibited deterioration of its 0.242-inch-nominal diameter to approximately 0.5 inch. This erosion occurred over the last 1.5 inches of the orifice length.

Socket welds have also failed at Diablo Canyon Nuclear Power Plant, Unit 2. From June 1989 through December 1990, four socket welds failed on two of three reactor coolant system (RCS) pressure letdown lines in the CVCS. All four failed welds were located on the piping downstream of the RCS letdown orifice isolation valves. On March 19, 1991, Diablo Canyon Unit 2 experienced the fifth letdown leak since June 1989. During the repair effort, the licensee determined that the cause of the failures was flow-induced vibration due to a damaged letdown orifice upstream of the weld failure. The licensee inspected the orifice and found that the discharge end of the orifice was severely pitted, resulting in a 0.75-inch opening, reducing to the nominal 0.25-inch diameter at a depth of 1.25 inches.

Discussion

The CVCS letdown orifices control the amount of coolant that is let down (removed) from the RCS and provide the initial pressure reduction of this high-pressure fluid. The letdown fluid undergoes purification and filtration to maintain the RCS within its design activity limits.

The letdown orifice is typically a stainless steel cylinder with a 0.25-inch-diameter aperture through the center. The RCS pressure of 2235 psig is reduced to approximately 350 psig through the orifice. On the basis of the licensees' examination of the damaged orifices, deterioration was found to have resulted from cavitation erosion.

In the case of Surry's degraded orifices, the licensee's review determined that age and operating conditions accounted for the varying degrees of degradation among the orifices from Units 1 and 2. In addition to flow-induced vibrations associated with cavitation erosion of the letdown orifices, inadequate piping/support configuration, low-cycle operational events, and weld flaws may also have contributed to the socket weld failures.

The review by the Diablo Canyon licensee concluded that the cavitation erosion was the result of (1) an out-of-calibration pressure transmitter that reduced the downstream pressure below that required to prevent cavitation; (2) an incorrectly adjusted blowdown setting of the pressure relief valve on the downstream line; and (3) once the orifice was damaged, self-induced cavitation further damaged the orifice. The licensee's root cause determination indicated that the damaged orifice was causing flow-induced vibrations. The vibrations, in turn, caused socket welds to fail and also caused some damage to pipe supports.

In summary, cavitation erosion of the letdown orifices can lead to vibration of the letdown line and, thus, to fatigue failures of letdown line socket welds.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.


for Jack W. Roe, Acting Director
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Information Notice No.	Subject	Date of Issuance	Issued to
98-44	Ten-year Inservice Inspection (ISI) Program Update for Licensees that Intend to Implement Risk-Informed ISI of Piping	12/10/98	All holder of operating licenses for nuclear power reactors, except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor
98-43	Leaks in the Emergency Diesel Generator Lubricating Oil and Jacket Cooling Water Piping	12/04/98	All holder of operating licenses for nuclear power reactors, except those licensees that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel
98-42	Implementation of 10 CFR 50.55a (g) Inservice Inspection Requirements	12/01/98	All holders of operating licenses for nuclear power reactors
98-41	Spurious Shutdown of Emergency Diesel Generators from Design Oversight	11/20/98	All holders of operating licenses for nuclear power reactors, except for those who have ceased operations and have certified that fuel has been permanently removed from the reactor vessel
98-40	Design Deficiencies Can Lead Reduced ECCS Pump Net Positive Suction Head During Design-Basis Accidents	10/26/98	All holders of operating licenses for nuclear power reactors, except those licensees who have permanently ceased operations and have certified that fuel has been permanently removed from the vessel

OL = Operating License
CP = Construction Permit

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