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

August 4, 1994

NRC INFORMATION NOTICE 94-55: PROBLEMS WITH COPES-VULCAN PRESSURIZER POWER-OPERATED RELIEF VALVES

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to problems involving cracking of plug material, severe wear of plugs and cages, and a problem with the misalignment and galling of a stem in Copes-Vulcan power-operated relief valves (PORVs). 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 April 7, 1994, at the Salem Generating Station, Unit 1, a reactor trip was followed by two automatic actuations of the safety injection (SI) system. The continued injection of water from the safety injection system filled the pressurizer steam space with subcooled water and, without the normal pressurizer steam space to dampen pressure excursions, resulted in repeated actuation of the plant PORVs to limit reactor coolant system pressure. Salem Unit 1 has two pressurizer PORVs, each of which is actuated through separate automatic controls. During the event, one PORV (1PR-2) cycled at least 200 times, and the other PORV (1PR-1) cycled at least 100 times. The fluid inlet conditions to the valves were liquid water at a temperature and pressure of approximately 290°C (550°F) and 16,000 kPa (2300 psia). The PORVs are 2-inch, air-operated valves manufactured by Copes-Vulcan that have a plug and cage-type internal trim design. (See Figure 1 for a detail of the valve trim.)

Discussion

The Copes-Vulcan PORV design used at Salem Unit 1 has a plug which is guided by a cage; close clearances exist between the outside diameter of the plug and the inside diameter of the cage. When the valve opens, fluid in the system flows from under the plug through several equally spaced ports in the cage,

and then to the valve outlet. When the valve closes, the plug seats against a machined surface of the cage. The cage is positioned on a gasket in a close-clearance counterbore in the valve body. The stem transmits the motive force from the air actuator to the plug and is threaded into the plug. A steep taper section on the stem just above the threaded section produces a wedging action at the relatively thin pinning boss. The valve stems are made of Type 316 austenitic stainless steel, and the plug and cage are both made of Type 420 hardened martensitic stainless steel.

Following the event of April 7, Public Service Electric and Gas Company (the licensee) removed both sets of PORV internal components from Unit 1 for inspection. The licensee inspected the internal components and discovered three deficiencies: (1) scoring in the plug and cage area (both valves), (2) axial cracking on the pinning boss through which the anti-rotation roll pin passes (both valves), and (3) galling on the stem where it passed through the bonnet (1PR-2 only). The scoring on the 1PR-2 plug and cage was more severe than on 1PR-1.

The licensee believes the scoring found on the plug and cage of 1PR-2 was the result of out-of-tolerance machining of the inside diameter of the cage and the increased thickness caused by deposition of material as the scoring occurred. In the area of the scoring, the inside diameter of the cage of this valve was between 0.038 to 0.046 mm (1.5 to 1.8 mils) less than that allowed by the tolerance provided by the manufacturer. The inside diameter of the cage of the 1PR-1 PORV was within the allowable tolerance. The fewer number of operational cycles together with the dimensional conformance of the 1PR-1 internal components may have caused less scoring in 1PR-1 than in 1PR-2.

The licensee determined that the cracks in the pinning boss were caused by intergranular stress corrosion cracking (IGSCC). The extent of cracking was similar for both 1PR-1 and 1PR-2, extending from the top of the pinning boss, above the anti-rotation pinhole, and continuing down to just below the top of the plug. Metallographic examinations of the cracked regions showed that the cracking followed intergranular morphology, and the results of fractographic examinations confirmed that cracks initiated at the top and bottom surfaces of the pinholes and progressed axially outward from the anti-rotation pinhole in the pinning boss. There was no evidence that fatigue contributed to the failure. Other factors that could promote IGSCC include the preload stresses applied when the valve stem and plug are assembled together by the manufacturer and stresses due to differential thermal expansion. The licensee found similar cracking, though less prominent than the cracking in 1PR-1 and 1PR-2, on internal components of valves maintained in the warehouse as new spare valves.

The licensee performed stress and fracture mechanics analyses to evaluate the stress condition in the valve plug and to assess the potential for additional crack growth. These analyses indicated that differential thermal expansion of

the stem and plug materials causes significant stresses in the pinning boss. In addition, because of the steep taper wedging action in the stem-to-plug assembly, high stress concentrations are found in the vicinity of the anti-rotation pin hole of the plug boss. The licensee determined that continued crack growth further into the much heavier plug itself is possible, if the plug is left in service.

To prevent further problems with the internal components made of Type 420 stainless steel, the licensee has installed plugs made of Type 316 stainless steel overlaid with Stellite and cages made of 17-4 PH stainless steel in the Unit 1 PORVs. The design of the replacement plug eliminates the pinning boss used for the Type 420 stainless steel plug, thus eliminating the tendency for crack formation in the thin boss section. The stem is now pinned to a thick section of the plug rather than through the relatively thin boss, and the plug height has been increased (to account for the elimination of the boss) to provide the same stroke length as before. The licensee determined that the Unit 2 PORVs did not require modification because their plugs and cages are made of 17-4 PH stainless steel.

The manufacturer has determined that Salem is the only nuclear power facility that installed the Type 420 stainless steel internal components in Copes-Vulcan pressurizer PORVs. However, the manufacturer believes there may be other Copes-Vulcan valves in nuclear service utilizing Type 420 material for the internal components and these components could experience similar problems.

The licensee determined that the galling of the Type 316 stainless steel stem in 1PR-2 was caused by the tight clearance between the stem and the bonnet stem guide, together with a misalignment of valve internals that occurred during field assembly. If the galling had continued, the stem could have become bound to the bonnet, preventing the valve from responding to the air operator.

The licensee has revised the installation procedures for the internal components and the bonnet to reduce the possibility of misalignment. The revised procedures require periodically stroking the valve by hand during the assembly process to ensure smooth movement and to improve stem and plug assembly centering. Because the clearances between the plug and cage and between the stem and bonnet are very small, the manufacturer recommends manually stroking the stem and plug before and after bonnet torquing and after installing packing regardless of the material used in the valve internal components.

In summary, this information notice raises questions with respect to: (1) the use of Type 420 stainless steel in this or similar valve applications, (2) valve component misalignment during field assembly, (3) out-of-tolerance machining on Copes-Vulcan PORVs, and (4) high stress concentrations because of the design of the internal components of Copes-Vulcan PORVs.

Related Generic Communications

The NRC issued Bulletin 89-02, "Stress Corrosion Cracking of High-Hardness Type 410 Stainless Steel Internal Preloaded Bolting in Anchor Darling Model S350W Swing Check Valves or Valves of Similar Design," on July 19, 1989, following the discovery of IGSCC of Type 410 martensitic stainless steel, a material similar to Type 420 martensitic stainless steel.

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.

Brian K. Grimes, Director
Division of Operating Reactor Support
Office of Nuclear Reactor Regulation

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Attachments:
1. Figure 1, Copes-Vulcan Power-Operated Relief Valve Trim Detail
2. List of Recently Issued NRC Information Notices

Enclosure
Filed in Jacket

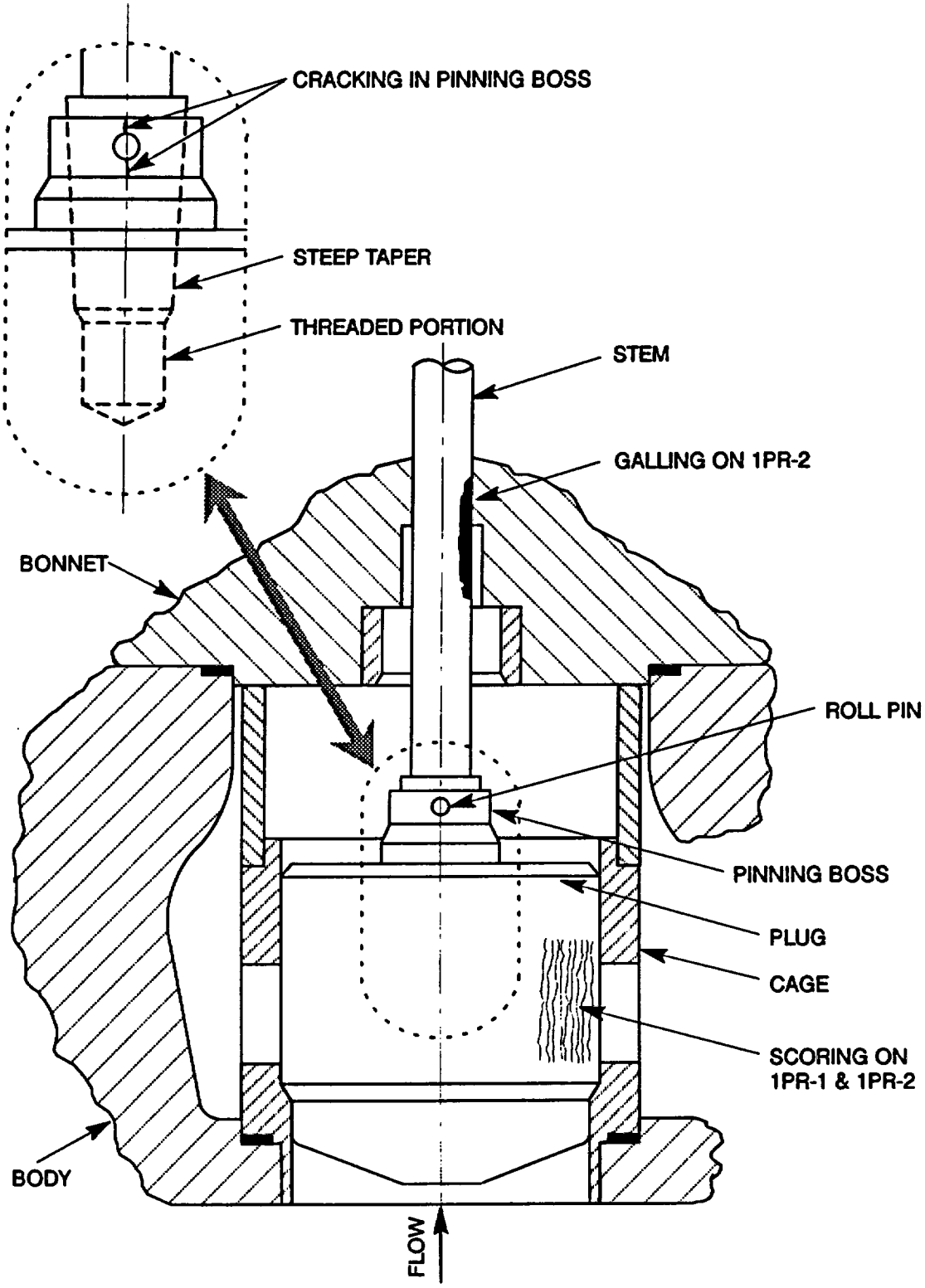

Figure 1 Copes-Vulcan Power-Operated Relief Valve Trim Detail

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
91-79, Supp. 1	Deficiencies Found in Thermo-Lag Fire Barrier Installation	08/04/94	All holders of OLs or CPs for nuclear power reactors.
94-54	Failures of General Electric Magne-Blast Circuit Breakers to Latch Closed	08/01/94	All holders of OLs or CPs for nuclear power reactors.
91-45, Supp. 1	Possible Malfunction of Westinghouse ARD, BFD, and NBFD Relays, and A200 DC and DPC 250 Magnetic Contactors	07/29/94	All holders of OLs or CPs for nuclear power reactors.
94-42, Supp. 1	Cracking in the Lower Region of the Core Shroud in Boiling-Water Reactors	07/19/94	All holders of OLs or CPs for boiling water reactors (BWRs).
94-53	Hydrogen Gas Burn Inside Pressurizer During Welding	07/18/94	All holders of OLs or CPs for nuclear power reactors.
94-52	Inadvertent Containment Spray and Reactor Vessel Draindown at Millstone Unit 1	07/15/94	All holders of OLs or CPs for nuclear power reactors.
94-51	Inappropriate Greasing of Double Shielded Motor Bearings	07/15/94	All holders of OLs or CPs for nuclear power reactors.
94-50	Failure of General Electric Contactors to Pull in at the Required Voltage	07/14/94	All holders of OLs or CPs for nuclear power reactors.
94-49	Failure of Torque Switch Roll Pins	07/06/94	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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NAME	TechEd	AJKugler	JADavis	CBeardslee
DATE	06/24/94	06/27/94	06/27/94	06/30/94
OFFICE	EB:RI*	C/RPB4:RI*	EMEB:DE*	C/EMCB:DE*
NAME	HIGregg	ARBlough	CGHammer	JRStrosnider
DATE	07/07/94	07/07/94	07/11/94	07/08/94
OFFICE	C/EMEB:DE*	D/DE*	AC/OGCB:DORS*	D/DORS
NAME	RHWessman	BWSheron	ELDoolittle	BKGrimes
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FILE NAME: 94-55.IN

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