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

December 20, 1990

NRC INFORMATION NOTICE NO. IN 90-79: FAILURES OF MAIN STEAM ISOLATION CHECK VALVES RESULTING IN DISC SEPARATION

Addressees:

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

Purpose:

This information notice is intended to alert addressees to potential problems involving the design and location of main steam isolation check valves (MSCVs) that could result in disc separation as a consequence of fatigue failure of the post (or stud). 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 do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

On October 8, 1990, the Tennessee Valley Authority (the licensee) noted that three of four MSCVs had failed at the Sequoyah Nuclear Power Plant, Unit 1. Each failure involved the disc separating from the swing arm. In 1982, the disc on one of the same Sequoyah MSCVs had become disconnected, and in 1983, the disc on a main steam isolation valve (MSIV) at the Joseph M. Farley Nuclear Plant, Unit 2 (effectively the same design as the Sequoyah MSCVs) became disconnected, too. (See "Discussion" below.)

In March 1990, before the recent MSCV failures, the licensee inspected an MSCV at Sequoyah Unit 1 in response to Electric Power Research Institute (EPRI) guidance (see below). The licensee found that this MSCV was severely worn where the surface of the swing arm collar met the surface of the disc. The valve post that connects the disc to the swing arm was worn at the unthreaded portion that meets the swing arm collar; and both washers, originally located where the threaded and unthreaded portions of the post meet, were missing. As a result of these findings, the licensee inspected the other three MSCVs and found that two of them had similar levels of degradation. To correct the problem, the licensee, in consultation with the valve manufacturer, modified the posts of all three affected MSCVs by machining down the unthreaded portion of the posts, adding weld buildup using high-hardness filler material, and remachining the posts to their original diameter. They also redistributed the stresses at the post-to-disc connections by reducing the thread torque preload on the post from 2800 to 2400 foot-pounds.

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In September and October 1990, personnel at Sequoyah Unit 1 heard loud noises coming from the steam piping. A radiograph revealed that an MSCV disc had separated from its swing arm. Further investigation revealed that the discs in two other MSCVs had also separated from their respective arms. The licensee found that the detached disc in one MSCV had lodged against its valve stop, and the detached discs from the other MSCVs had traveled several hundred feet through the piping and had lodged just upstream of the turbine throttle valves. All valve posts had broken at a machined fillet where the portion threaded into the disc joins the unthreaded portion that passes through the swing arm collar (see Figure 1). In addition, an inspection of the MSCVs in Unit 2 revealed cracks similar to those that led to the 1982 failure at Unit 1. The Unit 2 valves had not received the weld buildup modification noted above.

Discussion:

The MSCVs at Sequoyah Unit 1 were manufactured by Atwood & Morrill Co., Inc. These valves are 32-inch, articulated, swing check valves with a single-post design and are located just downstream of the main steam isolation valves (MSIVs). All of the MSCVs that experienced disc post failures are actually welded to their corresponding MSIVs; the MSCV with the disc still intact was located 2.5 pipe diameters downstream of its corresponding MSIV and was not severely worn. The NRC staff believes that although the valve location may have made the MSCVs susceptible to high-cycle, low-stress fatigue failure, the weld buildup modification in 1990 appears to have so accelerated the rate of fatigue wear that the posts failed within seven months.

EPRI studied the mechanisms that cause check valves to degrade and the methods to prevent this degradation. The results of this study are documented in EPRI NP-5479, "Application Guidelines for Check Valves in Nuclear Power Plants," January 1988. The EPRI study indicates that placing check valves just downstream of a source of turbulence could cause failure and is "deserving of priority attention." Flow disturbances just upstream of a check valve can cause discs to flutter and subject valve internals to cyclic loads and premature failure.

The backstop design may be another possible contributor to the MSCV failures at Sequoyah Unit 1. The configuration is such that a single backstop makes contact with the disc edge. The swing arm is beveled where it contacts the disc, permitting oscillation of the disc that is further exaggerated by a 40-mil clearance between the post and swing arm collar. This arrangement allows a maximum resultant disc oscillation of up to approximately 0.25 inch at the rim of the disc. In the case of Sequoyah Unit 1, the effects of this design were magnified by having the post built up with filler material; this modification concentrated the stresses on the post where it meets the disc and accelerated the failure of the post. Atwood & Morrill recommended, as corrective action, modifying Sequoyah's single-backstop MSCV design to a three-point backstop design that may help limit lateral disc oscillation. The NRC staff has identified that other Atwood & Morrill and Schutte & Koerting swing check valves with single posts may be of this design and may, therefore, be susceptible to this mode of failure. Other valves with a similar design may also be affected.

In previous instances, MSCV discs have separated from their respective swing arms when the post(s) failed before approaching its design fatigue life. For instance, the previous Sequoyah Unit 1 failure occurred in 1982 when the post came unscrewed from its disc when a tack weld connecting the post to the disc failed. At Farley Unit 2, in 1983, an Atwood & Morrill, 32-inch MSIV disc separated when the posts failed. Although neither of these failures involved the 1990 weld buildup modification performed at Sequoyah Unit 1, both cases involved the articulated check valve design that helps ensure proper disc-to-seat alignment, but also allows flexure of the disc during flow conditions while the valve is on the open backstop. This flexure, caused by flow disturbances, exposed the posts of both the Sequoyah Unit 1 and Farley Unit 2 valves to cyclic loads and, in the case of Farley Unit 2, resulted in excessive wear and eventual fatigue failure of the posts.

It appears that any check valve with disc flexure is susceptible to cyclic fatigue failure of the posts. Such features as single-post design, backstop contact with the disc edge instead of the disc nut, and valve location near a source of turbulence, increase the susceptibility of a check valve to cyclic fatigue failure. The result may be that the post unscrews from the disc, unscrews from the nut, or simply fails; and the disc separates. An example of such a failure is a main feedwater regulator check valve (manufactured by Pacific Valve Company) disc separation at the San Onofre Nuclear Generating Station, Unit 1, in 1985, when the post failed because of high flow velocity and valve installation near a source of turbulence. (Other recent examples of failures of check valve internals are discussed in Information Notice 90-03, "Malfunction of Borg-Warner Bolted Bonnet Check Valves Caused by Failure of the Swing Arm", dated January 23, 1990, Information Notice 89-62, "Malfunction of Borg-Warner Pressure Seal Bonnet Check Valves Caused by Vertical Misalignment of Disk", dated August 31, 1989, NRC Bulletin No. 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", dated July 19, 1989, and Information Notice 83-54, "Common Mode Failure of Main Steam Isolation Nonreturn Check Valves", dated August 11, 1983.)

Among the corrective actions taken by the industry in response to these check valve failures are: tack welding the post to the disc, better disc nut locking devices, interference threads for the post, multiple-backstop designs, and multiple-post designs. Despite these actions, check valves continue to fail prematurely. Most recently, a potential problem was found at Sequoyah Unit 2 during their 1990 refueling outage, where an MSCV had cracks in its post and disc near the post-to-disc weld similar to those that led to the 1982 post-to-disc weld failure at Unit 1. These cracks occurred despite the corrective actions--i.e., reweld of the disc and increased torque preload on the post--taken by the licensee in response to the 1982 post failure.

Check valves are used widely in the nuclear industry and can play a key role in the safe operation of the plant. EPRI has taken steps to improve the longevity of these valves by providing guidance for improving check valve reliability. The NRC staff also has developed an action plan (NUREG-1352) aimed at improving check valve reliability. An underlying concern with check valve reliability appears to

be that certain features, such as valve installation location and backstop design, may increase the susceptibility of check valve internals to premature cyclic fatigue failure.

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

Charles E. Rossi

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Angie P. Young, NRR
(301) 492-1167

Yun-Seng Huang, NRR
(301) 492-1417

Edward Girard, RII
(404) 841-4186

Attachments:
1. Figure 1. Articulated, Swing Check Valve with Single Backstop
2. List of Recently Issued NRC Information Notices

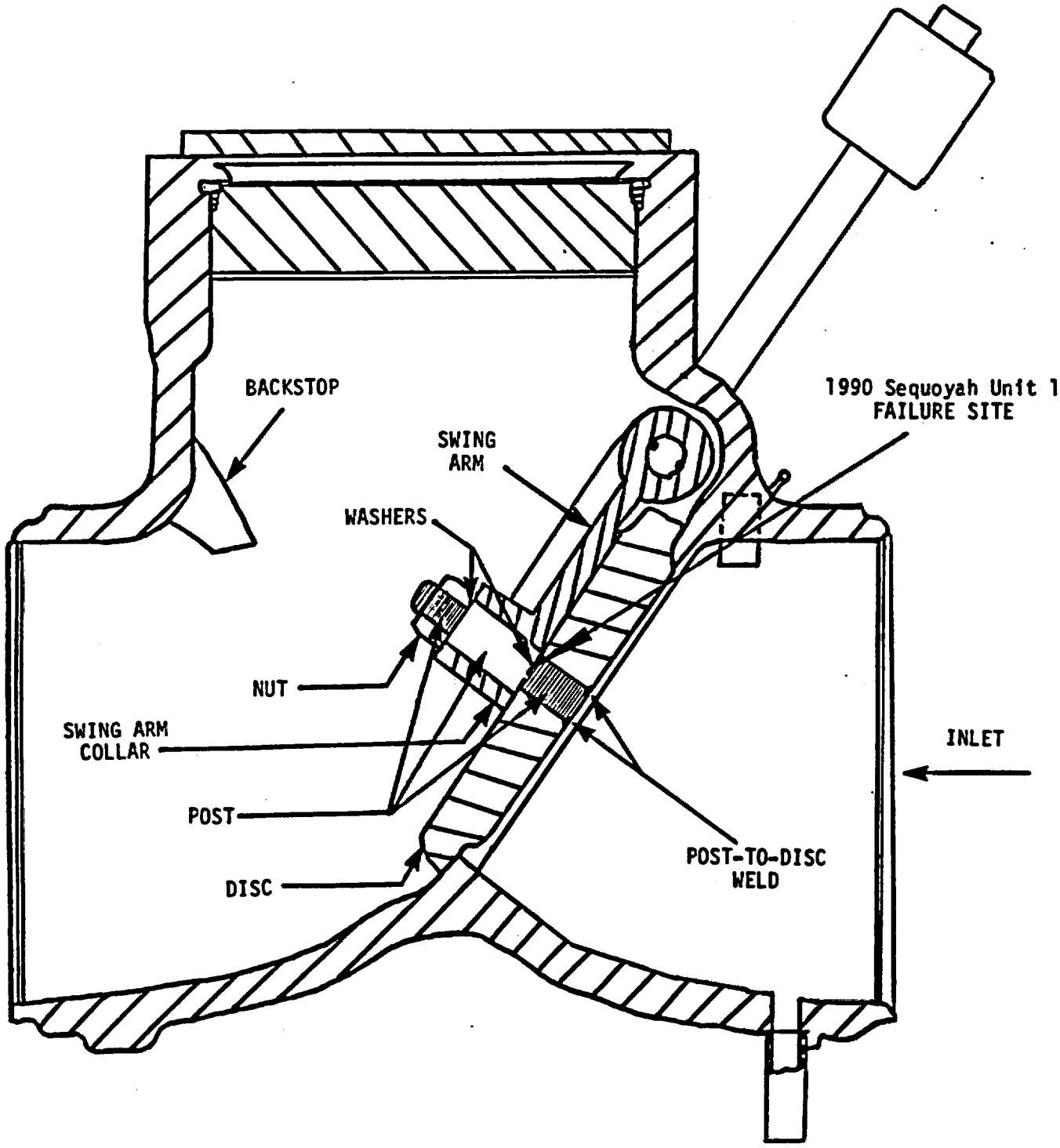

Figure 1. Articulated, Swing Check Valve with Single Backstop

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
90-78	Previously Unidentified Release Path from Boiling Water Reactor Control Rod Hydraulic Units	12/18/90	All holders of OLs or CPs for boiling water reactors (BWRs).
90-77	Inadvertent Removal of Fuel Assemblies from the Reactor Core	12/12/90	All holders of OLs or CPs for pressurized-water reactors (PWRS).
88-23, Supp. 3	Potential for Gas Binding of High-Pressure Safety Injection Pumps During A Loss-Of-Coolant Accident	12/10/90	All holders of OLs or CPs for pressurized-water reactors (PWRs).
90-76	Failure Of Turbine Overspeed Trip Mechanism Because Of Inadequate Spring Tension	12/7/90	All holders of OLs or CPs for nuclear power reactors.
90-75	Denial Of Access To Current Low-Level Radioactive Waste Disposal Facilities	12/5/90	All Michigan holders of NRC licenses.
90-74	Information on Precursors To Severe Accidents	12/4/90	All holders of OLs or CPs for nuclear power reactors.
90-73	Corrosion Of Valve-To-Torque Tube Keys In Spray Pond Cross Connect Valves	11/29/90	All holders of OLs or CPs for nuclear power reactors.
90-72	Testing of Parallel Disc Gate Valves In Europe	11/28/90	All holders of OLs or CPs for nuclear power reactors.
90-71	Effective Use of Radiation Safety Committees to Exercise Control Over Medical Use Programs	11/6/90	All NRC licensees authorized to use by-product material for medical purposes.
90-70	Pump Explosions Involving Ammonium Nitrate	11/6/90	All uranium fuel fabrication and conversion facilities.

OL = Operating License
CP = Construction Permit

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Original Signed by
Charles E. Rossi

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Attachments:
1. Figure 1. Articulated, Swing Check Valve with Single Backstop
2. List of Recently Issued NRC Information Notices

OFC	:OEAB:DOEA	:EMEB:DET	:OEAB:DOEA	:RII	:RPB:ADM	:C:OEAB:DOEA	:
NAME	:APYOUNG*	:YSHUANG*	:DFISCHER*	:EGIRARD*	:TECH ED*	:ACHAFFEE*	:
DATE	:11/02/90	:11/08/90	:11/14/90	:11/14/90	:12/07/90	: 11/16/90	:

OFC	:D:DET	:C:OGCB:DOEA	:D:DOEA	:	:	:	:
NAME	:JERICHARDSON*	:CHBERLINGER*	:CEROSSI	:	:	:	: :
DATE	:11/21/90	:12/11/90	:12/14/90	:	:	:	:

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*See previous concurrence

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Division of Operational Events Assessment
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Yun-Seng Huang, NRR
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Edward Girard, RII
(404) 841-4186

Attachments: (1) Diagram of Articulated, Swing Check Valve with Single Backstop
(2) List of Recently Issued NRC Information Notices

*See previous concurrence

OFC	:OEAB:DOEA	:EMEB:DET	:OEAB:DOEA	:RII	:RPB:ADM	:C:OEAB:DOEA	:
NAME	:APYOUNG*	:YSHUANG	:DFISCHER	:EGIRARD	:TECH ED*	:ACHAFFEE	:
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The previous Sequoyah Unit 1 failure occurred in 1982 and involved separation of the disc from the post due to the failure of the post-to-disc weld. At Farley in 1983, the disc separated when the bolts that attach the disc to the swing arm failed in an MSCV of similar size and design as those at Sequoyah. Neither of these failures involved the 1990 weld buildup modification performed at Sequoyah 1.

During the current refueling outage, a Sequoyah Unit 2 MSCV was found to have cracks in the its post and disc near the post-to-disc weld. This appears to be the same potential failure mechanism which caused the MSCV failure at Sequoyah Unit 1 in 1982.

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(301) 492-1417

Edward Girard, RII
(404) 841-4186

Attachments: (1) Diagram of Atwood and Morrill Co.,Inc. Check Valve
(2) List of Recently Issued NRC Information Notices

OFC	:OEAB:DOEA	:EMEB:DET	:OEAB:DOEA	:RII	:RPB:ADM	:C:OEAB:DOEA	:
NAME	:APYOUNG	:YSHUANG	:DFISCHER	:EGIRARD	:TECH ED	:ACHAFFEE	:
DATE	: 11/2/90	: /90	: /90	: /90	: 11/5/90	: /90	:

OFC	:D:DET	:C:OGCB:DOEA	:D:DOEA	:	:	:	:
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