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August 26, 1994
C311-94-2113

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Dear Sir:

Three Mile Island Nuclear Station, Unit 1 (TMI-1)
Operating Licensing No. DPR-50
Docket No. 50-289
LER 94-001-01

This letter transmits Licensee Event Report (LER) No 94-001-01 regarding the Pressurizer Spray Valve (RC-V1) which was found to have experienced boric acid degradation of the body-to-bonnet bolted fasteners due to failure of the evaluation process to consider the effects on fastener pre-load when motor operator torque settings were increased. This supplement provides the additional information regarding identification of the root cause and corrective actions which were not available for the original LER submittal. Public health and safety were not affected. The abstract provides a brief description of the event. For a complete understanding of the event, refer to the text of the report.

Sincerely,

T. G. Broughton
Vice President and Director, TMI

MRK

Attachment

cc: Region I Administrator
TMI-1 Senior Project Manager
TMI Senior Resident Inspector

IE22
1/1

NRC FORM 366 (5-92) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO. 3150-0104
EXPIRES 5/31/95

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
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TITLE (4)
BORIC ACID DEGRADATION OF PRESSURIZER SPRAY VALVE (RC-V1) FASTENERS

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
03	07	94	94	-- 001 --	01	08	18	94	FACILITY NAME	DOCKET NUMBER

OPERATING MODE (9)	N
POWER LEVEL (10)	75

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more) (11)

	20.402(b)		20.405(c)		50.73(a)(2)(iv)		73.71(b)
	20.405(a)(1)(i)		50.36(c)(1)		50.73(a)(2)(v)		73.71(c)
	20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)		OTHER
	20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)		(Specify in Abstract below and in Text, NRC Form 366A)
	20.405(a)(1)(iv)	X	50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)		
	20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
M. R. Knight, TMI-1 Licensing Engineer	(717) 948-8554

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
E	AB	V	V085	YES						

SUPPLEMENTAL REPORT EXPECTED (14)			EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE).	X	NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

BORIC ACID DEGRADATION OF PRESSURIZER SPRAY VALVE (RC-V1) FASTENERS DUE TO FAILURE TO CONSIDER PRE-LOAD WHEN INCREASING MOTOR OPERATOR TORQUE

On March 7, 1994, TMI-1 was operating at reduced power having located and isolated a body-to-bonnet leak from the pressurizer spray valve (RC-V1). RC-V1 was declared inoperable. Because of boric acid degradation exhibited by RC-V1 fasteners, this event was found to be reportable in accordance with 10CFR50.72(b)(1)(ii) and 10CFR50.73(a)(2)(ii). With RC-V1 isolated, operation was permitted while preparations were made to shut down and repair RC-V1. The plant was shut down on March 17, 1994 and the valve repaired. The root cause was failure to consider the effects on fastener pre-load when the motor operator torque settings were increased. There were nc safety consequences. RC-V1 was repaired and other bolted connections were inspected. Corrective actions include an evaluation of corrosion resistant fastener materials, programmatic improvements, and training.

BORIC ACID DEGRADATION OF PRESSURIZER SPRAY VALVE (RC-V1) FASTENERS DUE TO FAILURE TO CONSIDER PRE-LOAD WHEN INCREASING MOTOR OPERATOR TORQUE

I. Plant Operating Conditions before Event:

On March 7, 1994, TMI-1 was operating at reduced power (75%) as a result of having located and isolated a body-to-bonnet leak from the pressurizer spray valve (RC-V1). The condition of the valve was under investigation and attempts to stop the leak were being discussed.

II. Status of Structures, Components, or Systems that were Inoperable at the Start of the Event and that Contributed to the Event:

None.

III. Background:

A. Component Operation:

During normal plant operation, Reactor Coolant System (RCS) [AB/---][1] pressure is controlled by the pressurizer [AB/PZR] steam cushion in conjunction with pressurizer spray and pressurizer heaters. The pressurizer spray line originates at the discharge of the "A" reactor coolant pump. Pressurizer spray flow is controlled by a motor operated globe valve (RC-V1), the spray valve [AB/V], in response to pressure set points. Motor operated valve (MOV), RC-V3, in series with RC-V1, provides a backup means of securing spray flow in the event RC-V1 sticks open.

During a down power transient, steam demand decreases causing the primary coolant temperature leaving the Once Through Steam Generators (OTSGs) to increase. The increase in RCS temperature causes water to insurge into the pressurizer. As the pressurizer steam space is compressed, some of the steam

[1] The Energy Industry Identification System (EIIS), System Identification (SI) and Component Function Identification (CFI) Codes are included in brackets, "[SI/CFI]," where applicable, as required by 10 CFR 50.73(b)(2)(ii)(F).

TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

will condense to limit the pressure increase. If the transient is large enough, RC-V1 will automatically open to spray cooler water from the RCS cold leg into the pressurizer steam space to condense the steam and reduce RCS pressure.

Pressurizer spray flow is provided by the driving force created through the pressure differential between the reactor coolant pump (RC-P1A) discharge and the pressurizer. RC-V1 is capable of automatic or manual operation. When operated in manual control, a jog circuit is provided to control flow to control the rate of RCS depressurization. In the automatic control mode, RC-V1 will open at a high pressure setpoint and remain open until pressure decreases to the lower predetermined setting.

None of the conclusions regarding design basis transients or accidents identified in TMI-1 FSAR Chapter 14 rely upon operation of pressurizer spray. Pressurizer spray was assumed to function during loss of electric load events; however, the spray had no significant impact on the event. RC-V1 is not required to shut down the plant, to maintain the plant in a safe shutdown condition, or to mitigate the consequences of any design basis accident. The only safety related function of RC-V1 is to serve as part of the reactor coolant pressure boundary (RCPB) unless it is isolated by closure of a manual valve (RC-V31) and a MOV (RC-V3).

B. RC-V1 Maintenance History:

1. Valve Packing History:

Prior to 1989, frequent packing repairs and adjustments of RC-V1 had been required. In 1989 the valve was modified to eliminate the lower packing and leak-off provision and to live-load the valve packing. These changes significantly improved the performance of the packing and no packing work was performed until the Cycle 10 Refueling Outage (10R) in 1993.

The 10R packing replacement was strictly preventive and was not dictated by packing performance. Post maintenance testing and inspections of the valve were satisfactory. However, the 10R packing work was not

performed correctly; only 4 of the specified 5 rings of packing were installed and the valve had to be re-packed during the 10U1[2] Outage.

Repairs to the packing during the 10U1 Outage included replacement of a cracked carbon bushing, installation of five rings of packing, and correcting an error found in the installation of Belleville spring washers on the packing bolts; spring washers had been stacked in wrong orientation. The installation error of the Belleville washers was minor and would have had no adverse affects on the packing.

It is possible that the cracked bushing may have existed or occurred during the 10R repacking of RC-V1, thereby preventing the installation of all five packing rings and contributing to packing leakage. At HSD conditions during the startup following the 10U1 packing repair, the packing was inspected and no leakage was identified.

2. Body-to-Bonnet Joint Maintenance:

The body-to-bonnet gasket on RC-V1 was last replaced in 1980. Machinery history shows no other body-to-bonnet gasket problems, repairs or indications of leakage.

3. Valve Motor Operator Maintenance:

In 1990 the valve motor operator control scheme was changed to close the valve on torque instead of the limit switch. The purpose of this change was to provide a more leak tight method of closing RC-V1. Seat leakage through the valve reoccurred and in 1992 the torque switch setting was increased.

During the 10R Outage in 1993 the Limitorque motor operator was refurbished, and the torque switch settings were further increased because leakage through the valve continued to be a problem in 1991 during Cycle 9

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[2] The first unscheduled outage during operating cycle 10 (10U1) began on November 14, 1993 and ended on November 19, 1993.

operation. Changes to the torque switch settings increased the closing thrust. The valve was stroked and inspected for leakage under HSD conditions as part of the packing replacement post maintenance testing with satisfactory results.

A calculation was performed to evaluate the increased torque settings against the operator and valve limits. A maximum thrust limit was determined. Although the closing force applies a load opposite the bonnet stud loading force, the potential effects of torque switch changes on the bonnet bolting or gasket were not evaluated at that time.

4. RC-V1 and Spray Line Insulation Replacement:

During the 10R Outage temporary blanket material, installed during a previous outage, and mirror insulation around RC-V1 was replaced with permanent blanket type insulation. Per interviews with the Maintenance craft and the foreman who removed the mirror insulation and installed the blanket insulation, no significant boron deposits were found around RC-V1. Decontamination activities near RC-V1 were routine and minor; there was no evidence of significant leakage from the RC-V1 body-to-bonnet joint during the 10R Outage.

During the 10U2 shutdown (RC-V1 outage), the blanket material which had been installed during 10R was found saturated with boron and significantly damaged from the leak. The blanket type insulation covered the body-to-bonnet joint interface, but not the top of the bonnet studs or nuts. The configuration of the blanket insulation could have contributed to the high corrosion rates by fostering a moist environment which would have prevented the boron from drying.

IV. Event Description:

A. Summary of the Event:

On March 5, 1994 while at 100% power during the 1500-2300 shift, an increase of approximately 0.05 gpm RCS leakage was

identified using the mass balance calculation after receiving a Reactor Building (RB) particulate radiation monitor (RMA-2) alarm. A second RCS leakrate calculation subsequently validated the increase in leakage noted earlier. At 0730 on March 6, 1994 a control room operator observed steam in the vicinity of the pressurizer during a shift tour using the RB closed circuit video camera system. Plans were immediately initiated for an RB entry to investigate and assess the significance of the leak in accordance with Technical Specification (TS) 3.1.6.6. Total RCS leakage rate (leakage plus losses) was steady at approximately 0.21 gpm at that time.

At 1246 hours on March 6, 1994 GPUN personnel entered the RB to assess the leak. The leak was identified as an RC-V1 body-to-bonnet leak. The insulation was removed from RC-V1 and a steady wisp of steam was observed to emanate from the body-to-bonnet joint in the vicinity of the (capped) packing leak-off line. The steam plume produced insignificant impingement force and was not directed toward any equipment that could be damaged by the plume. The accessible studs appeared to be in acceptable condition. Only half of the bolting was clearly visible due to the limited access around the valve, the direction of the leak, and the configuration of the insulation on the valve.

At 1340 hours on March 6, 1994 the Plant Review Group (PRG) met to assess the safety significance of the leak. It was noted that the increase in total RCS leakage rate contributed by RC-V1 was approximately 0.06 to 0.10 gpm, well within the TS 3.1.6.1 limit of 10 gpm for identified leakage. Also, leakage was from a gasket in a bolted connection and not from a failure through a non-isolable fault in an RCS strength boundary (such as the reactor vessel, piping, valve body, etc.) The leak was isolable by closing RC-V3 and RC-V31. The PRG concluded that TS 3.1.6.6 was met, and that the leak did not require a plant shutdown at that time. It was decided to continue monitoring the RCS leakrate each shift and monitoring the leak twice each shift using the RB video camera system.

Radiological Controls determined that the leak did not pose a problem for RB entry. There was no RB purge in progress,

therefore there was no effect on offsite dose. It was also noted that initiation of RB purge would have had no significant effect on the offsite dose.

On March 7, 1994, personnel entered the RB to attempt tightening the valve body-to-bonnet joint. The stud nuts were to be torqued to 120 ft-lbs as recommended by Plant Engineering. The vendor-recommended minimum torque was 95 ft-lbs. Torquing the nut nearest the leak resulted in no movement of the nut. A second nut (approximately 180 degrees opposite the first nut torqued) was turned about one flat and the valve leakage suddenly increased. The Maintenance personnel later stated that movement of the fastener "felt soft." Although the torque wrench was placed on a third nut, Maintenance decided to stop work and exit the area due to increased leakage and the nut was not turned. Total RCS leakrate was calculated at approximately 3 gpm after this attempt to torque the bonnet stud nuts.

In subsequent planning for a second attempt to retorque the bonnet stud nuts, it was determined that the valve had been in the closed position when the first torquing attempt was made. With the valve closed it was felt that the valve bonnet flange joint could have moved and caused the leakage to increase. A revised torquing plan was developed for the second attempt.

After further planning it was decided to reduce reactor power to approximately 75% and isolate RC-V1 by closing the downstream valve, RC-V3, (motor operated from the Control Room) and the upstream valve, RC-V31 (local manual valve). This power level was chosen to reduce the rate of pressurizer insurge or outsurge associated with small load changes and hence offer greater stability to the plant with RC-V1 out of service. The valve was confirmed to be isolated by Operations personnel. RC-V1 was then cracked off its seat in preparation for retorquing the bonnet stud nuts.

At approximately 1835 on March 7, 1994 Maintenance and Engineering personnel attempted to tighten the valve joint by retorquing the studs. No movement was achieved when torquing of the first nut was attempted, which was about 90 degrees counter-clockwise from the leak area. Upon attempting to

position the torque wrench on a second nut, adjacent to the area of the leak, the stud/nut came out in the individual's hand. Closer inspection showed that three (3) studs immediately adjacent to the failed stud were significantly degraded. As noted above, this area had previously been difficult to examine closely because the leak was in an area where visibility was not good. The work area was secured and personnel exited the RB.

Because of the degraded condition exhibited by the RC-V1 studs, this event was found to be reportable on March 8, 1994 at 1405 hours in accordance with 10 CFR 50.72(b)(1)(ii) and 10 CFR 50.73(a)(2)(ii) and the NRC was notified at 1427 hours. With RC-V1 isolated, the plant was evaluated to be in a safe condition and operation could continue as preparations were made to shut down the plant and make the necessary repair to RC-V1. It was decided that the plant would be maintained at reduced power to lessen the pressure effects of transients. Also, loss of a feedwater pump from this reduced power would be less likely to result in a reactor trip.

On March 17, 1994 the plant was taken to Hot Shutdown (HSD) conditions to repair RC-V1. This outage is referred to as the second unscheduled outage during operating cycle 10 (10U2).

B. RC-V1 Leakage Examinations During the Cycle 10 Refueling (10R) and 10U1 Outages:

Technical Specification 4.2.1 and 10 CFR 50.55a(g) requires Inservice Inspection (ISI) compliance with the ASME Code Section XI, 1986 Edition. ASME Section XI, IWB-5210 requires a VT-2 Visual Examination of the RCS prior to startup following each refueling outage. Technical Specification 4.3 requires a VT-2 Visual Examination at 2285 psig prior startup after any RCS components are opened. Both requirements are met using Surveillance Procedure (SP) 1303-8.1, "Reactor Coolant System."

On October 14, 1993, during the heatup following the 10R Outage, a visual examination (VT-2) of RC-V1 for leakage was performed at HSD conditions in accordance with SP 1303-8.1. The packing was also inspected during HSD conditions as part

of post maintenance testing following the packing replacement. No indication of leakage at RC-V1 was noted during either inspection.

On November 14, 1993, while shutting down to replace a leaking Pressurizer Code Safety Valve in 10U1, Operations personnel noted a body-to-bonnet leak of RC-V1 during HSD conditions, documented the condition in the Shift Foreman's Logbook and initiated a Maintenance Work Request for repair. A Plant Engineer that was present also believed that the leakage was from the body-to bonnet area. However, Plant Maintenance performed an inspection during HSD conditions and determined from their observations that RC-V1 leakage was from the valve packing and not the body-to-bonnet joint. Therefore, the work request for repair of body-to-bonnet leakage was canceled and a Maintenance Job Order was issued to repair packing leakage.

When Maintenance performed their inspections during 10U1, the valve insulation around the bolted bonnet joint was removed from only one side, the south side, of RC-V1; whereas the leakage was directed northwest. Additionally, the location and height of the valve is such that inspection of the north side is very difficult. During the visual inspection which resulted in canceling the work request for repair of a body-to-bonnet leak, Plant Maintenance recalls noting no degraded studs or significant boric acid deposits. The initial inspection performed by Maintenance was at HSD conditions. Maintenance personnel observed steam originating from the packing area along with boron on the underside of the valve operator.

A followup inspection by a second Maintenance individual was performed with the RCS at low pressure and temperature. No active leak at the valve was observed. The individual concluded from his observations that the leak was from the valve packing based on the spray pattern of the boron deposits on the underside of the valve operator and yoke. These observations along with the fact that only 4 of the required 5 rings of packing had been installed during the 10R outage, lent further credibility to the belief that the packing was leaking and not the body-to-bonnet joint.

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Visual examination (VT-2) in accordance with SP 1303-8.1 was not required during the startup following the 10U1 Outage because this was not a refueling outage and RC-V1 had not been opened. Although packing repairs are exempted from ASME Section XI exams, the packing was inspected as part of the post maintenance testing.

In addition to the packing repairs, Plant Maintenance had obtained torque values and approval from Plant Engineering to check the torque on the flange bolting. As a precautionary measure while repacking the valve during the 10U1 Outage, the maximum torque (120 ft-lb) recommended by Plant Engineering was applied and no movement was noted. Since the nuts did not move and the studs/nuts were not lubricated or loosened prior to torquing, the applied torque could have been masked by friction forces, i.e., the torque applied to the studs was not necessarily as high as 120 ft-lbs.

Maintenance personnel who repacked and torqued RC-V1 noticed no significant boron buildup around the top of the bonnet. However, since insulation partially covered the bonnet joint at that time, buildup in the joint area would have not been clearly visible.

C. Observations during 10U2 Inspections of RC-V1:

1. Description of Valve As-found Condition:

On March 17, 1993 following the unsuccessful attempt to retorque the bonnet bolting and the identification of failed/degraded studs, the plant was taken to Hot Shutdown (HSD) condition to repair RC-V1. Upon achieving HSD, an entry was made to examine RC-V1 and collect information on the as-found conditions for the root-cause investigation. General area and close-up photographs of the valve were taken. Boron samples were taken from the floor and the valve insulation.

The origin of the leak was the body-to-bonnet interface in the vicinity of the packing leak off line. The inside surface of the valve insulation was covered with boron and boron had accumulated on the grating below the valve. On the top of the bonnet and bonnet studs/nuts, only

minor boron buildup was found with no signs of corrosion or boric acid degradation.

Four studs were severely corroded with one completely failed. The location of the most severe stud degradation was where the studs pass through the bonnet. The underside of the motor operator was covered with boron spray. There was no indication of a packing leak. The studs which were not severely corroded exhibited only minor amounts of boron deposit with minimum, if any, degradation. Some of the boron appeared discolored, indicating it may have been present for some time.

During removal of the bonnet nuts/studs, two studs were broken. Removal of the studs was relatively easy; drilling out of studs and re-tapping of body stud holes was not required. Upon removal of the bonnet, the valve body and bonnet were inspected including the gasket seating surfaces and threaded stud holes. The surfaces were found in good condition requiring only cleaning of the faces. The threaded stud holes were in good condition with no thread damage. The gasket and gasket seating surfaces gave no indication of the cause of the leak.

2. Description of the Gasket As-found Condition:

Inspections and measurements of the gasket removed during the 10U2 repair showed no signs of anomalies with the gasket material or the gasket installation. The asbestos filler was "washed out" in an area about 1/4 of the circumference of the gasket. However, the gasket stainless steel windings showed no signs of unusual distortion, cuts across the spirals, corrosion/pitting or of over-compression.

V. Component Data:

Pressurizer Spray Valve RC-V1 is a 2-1/2", 1500 Class Motor Operated globe valve (Figure B9-374B-13MS) manufactured by Velan and provided with a Limitorque motor operator. The valve has a bolted bonnet design with eight (8), 5/8" ASTM A193, Grade B7 studs and ASTM A194 Grade 2H nuts. The valve was designed in

accordance with ASME Section III (Summer 1969 Addenda and March 1970 Draft Addenda) and ANSI B16.5. The body and bonnet materials are ASME SA-182, Grade F316 stainless steel. The valve design pressure and temperature are 2500 psig and 670 degrees F respectively. Normal operating pressure and temperature of the spray line are approximately 2205 psig and 555 degrees F respectively.

The RC-V1 closure studs are threaded into the valve body and the bonnet-to-body joint is sealed with a spiral wound gasket. The gasket rests in a machined counterbore in the body and is compressed by the flat flange surface of the bonnet. The gasket area is designed to limit the maximum gasket compression so that excessive stud load would not be transferred to the gasket.

VI. Analysis of the Event:

A. Evaluation of Motor Operator Closing Force Changes on Gasket Seating Load:

The RC-V1 body-to-bonnet joint is sealed with a fiber filled, spiral wound gasket. The gasket is compressed by eight (8) 5/8" diameter A-193, B7 studs with A-194, 2H nuts. The original vendor recommended stud torque was 95 ft-lbs. Although RC-V1 was torqued to 120 ft-lbs during the 10U1 Outage, it was noted that the studs did not move. Therefore, it is assumed that only the original 95 ft-lbs torque was ever applied to the studs.

Prior to the event, changes were made to the RC-V1 motor operator torque switch which increased the closing inertial thrust. Because the motor operator closing force opposes the bonnet stud gasket loading force, increasing the closing thrust reduces the stud pre-load. It can be shown that the significant increases made to RC-V1 closing torque settings during the 10R Outage, would have reduced the estimated stud pre-load by over 50%.

Considering additional factors that can reduce the fastener pre-load, GPUN has determined that the excess pre-load, the force above that required to maintain proper gasket seating stress, could have been totally eliminated by the losses due to pressure load, gasket compression load, thermal effects

and the motor operator closing force. Loss of pre-load would have allowed the RC-V1 gasket to leak.

When the RC-V1 gasket was replaced during the 10U2 outage, the studs were well lubricated and torqued to 120 ft-lbs in accordance with the updated vendor recommendations. The additional pre-load provides sufficient sealing integrity. Therefore, the current motor operator torque setting is acceptable.

B. Laboratory Analysis of RC-V1 Bolting:

Three (3) studs were sent to the B&W Lynchburg Technology Center (LTC) for laboratory examination. A review and followup evaluation of the LTC analysis results was performed by GPUN Reading Laboratory.

It was determined that the material properties, as determined by examining the microstructure, material composition and hardness, all conform to the requirements of ASTM A-193M for B7 studs. No deficiencies in the material properties were found that would contribute to the stud corrosion failure.

A deposit sample collected from one of the studs was analyzed for chemical composition. It was determined that the major constituent of the deposit is boric acid. No other foreign material compounds that could have contributed to the failure were found in the deposit sample.

The LTC report states: "The fibrous appearance of the corrosion attack, as revealed by stereovisual examination, scanning electron microscope (SEM) examination, and metallographic cross-sections, indicates that these studs corroded at a high corrosion rate. The presence of boron and the appearance of the corroded surfaces (which indicate a high corrosion rate) are consistent with boric acid attack."

C. Boron Sample Dating:

From Boron Dating calculations[3] of the samples which were taken, the majority of the boron from the valve was dated at approximately 50 days.

D. Root Cause Determination:

The cause of the Pressurizer Spray Valve (RC-V1) body-to-bonnet leak was loss of bonnet stud pre-load as a result of increasing the valve closing force. The root cause was an inadequate evaluation process because it did not consider the affects of the higher motor operator torque switch setting on the fastener pre-load. It was determined that increasing the operator closing torque provided sufficient reduction in the stud pre-load to initiate a body-to-bonnet gasket leak.

The gasket was not over-compressed or improperly installed. Additionally, per discussion with the gasket manufacturer, there is no service life limit for this type of gasket in this environment. Therefore, based on the gasket as-found condition and the eight years of leak tight service, it was concluded that the gasket and original gasket installation did not contribute to the joint leak.

The body-to-bonnet leak resulted in rapid boric acid corrosion (BAC) of the bonnet studs as confirmed by the laboratory analysis. The configuration of the valve insulation may have been a factor which contributed to the rapid corrosion rates by containing the leak and maintaining a wet boric acid environment around the studs.

The failure to completely remove the insulation and perform a thorough examination of the RC-V1 bonnet bolts and identify the leak as a body-to-bonnet leak during the 10U1 outage was also a contributing factor. A complete inspection would have identified the area of the leak so that repair would have been completed prior to significant stud damage.

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[3] Boron deposit dating is based on the ratio of Cs-137 to Cs-134.

An extensive history of packing problems, the problem created by errors when replacing the packing during the 10R outage, and the packing/carbon bushing conditions discovered during 10U1 were contributing factors to an inaccurate assumption that the 10U1 leakage was a packing leak and not a body-to-bonnet leak.

VII. Automatic or Manually Initiated Safety System Responses:

No safety system responses occurred or were required to occur.

VIII. Assessment of the Safety Consequences and Implications of the Event:

There were no safety consequences experienced from the degraded condition of the RC-V1 bonnet bolting and resultant leakage, however GPUN recognizes there are several significant safety implications. Throughout the event RCS leakage never exceeded the Technical Specification 3.1.6.1 limit of 10 gpm for identified leakage. No RB purge was in progress or initiated during the valve joint leak. No other safety related equipment was damaged or rendered inoperable by the leak.

Increased leakage rate would have forced a shutdown upon reaching the Technical Specification leakage limits for identified leakage (10 gpm). However, leakage over a long period of time with no action taken to isolate it and accelerated corrosion due to the steady flow of boric acid across the studs, the joint could have failed. If the bolting had failed completely and the bonnet separated, a Small Break Loss of Coolant Accident (SBLOCA) could have resulted. SBLOCAs are within the design basis, and covered by plant procedures and training.

No personnel were injured during the inspections, torquing attempts, or the bonnet gasket replacement work. Because the procedure/policy for retorquing components did not require an adequate pre-verification of the stud integrity, a significant increase in leakage or a complete failure of the bonnet studs could have occurred during the initial torquing attempt. The valve was not isolated during the initial attempt to torque the bonnet studs and a significant increase in the leakage could have resulted in personnel injury.

IX. Previous Events of a Similar Nature:

There have been no previous LERs at TMI-1 related to degraded RCS component bolting.

X. Corrective Actions:

A. Corrective Actions Taken:

1. Repair of RC-V1 Body-to-Bonnet Gasket Leak:

RC-V1 was repaired during the 10U2 Outage and the boric acid leakage in the area was cleaned up. The failed SST/asbestos spiral wound gasket was replaced with a SST/graphite filled spiral wound gasket provided by the valve manufacturer, Velan.

RC-V1 insulation was modified to ensure that no portion around the circumference of the body-to-bonnet joint is blocked from view. Since the studs do not extend through the lower flange, complete removal of insulation from the lower flange is not necessary.

2. Review of TMI BAC Program and Applicable Inspections:

A review of the BAC program was documented in a Plant Experience Report. As a result of this review, appropriate changes have been identified to assure an extremely low probability of serious damage to the RCPB due to BAC. (See Corrective Actions Planned, Items B.4 and B.5.)

3. Inspection of Similar Bolted Connections:

Prior to the 10U2 Outage, Engineering developed list of other bolted bonnet valves in the RB which incorporate fasteners that might be susceptible to boric acid degradation in a fashion similar to RC-V1. These valves were inspected in accordance with the ASME Code during startup in mid October 1993. However, following the discovery of RC-V1 fastener degradation, another thorough examination was performed prior to and during the 10U2 Outage.

Only one of these valves (MU-V113), although not leaking, showed evidence of prior leakage. MU-V113 exhibited some boric acid degradation, although not as severe as that of RC-V1. Three out of the eight MU-V113 studs required replacement. The other five MU-V113 studs were acceptable for use. To facilitate future inspections, the insulation around MU-V33A/D, MU-V38 and MU-V39 was permanently removed.

During the June, 1994 planned outage (10P3)[4], the mirror insulation around MU-V113 was permanently removed to allow uninhibited VT-2 inspections of the valve bonnet bolts.

B. Corrective Actions Planned to Prevent Recurrence:

1. The RC-V1 motor operator torque switch setting has been reviewed and a setpoint lower than the current (maximum) setpoint has been established which will adequately seat the valve. The lower torque switch setting will reduce the load against the bonnet studs and increase the available excess pre-load. During the 11R Outage, which is scheduled to begin in September 1995, RC-V1 will be retested at the revised torque switch setting. As discussed in Section VI.A above, the current setting is acceptable.

2. An initial review of the MOV Program shows that where torque settings were changed, the magnitude of increase change does not appear to be sufficient to adversely affect the body-to-bonnet sealing integrity. GPUN will complete the evaluation to determine if there have been any effects on bonnet fasteners from changes in motor operator torque settings and complete any recommended changes during the 11R Outage.

[4] The third outage during cycle 10 operation, "planned" in that immediate shutdown was not required.

TEXT (If more space is required, use additional copies of NRC Form 366A) (17)

3. The process for evaluating motor operator torque switch setting changes will be revised by November 1994 to include consideration of the effects on bonnet fastener pre-load.

4. Procedures will be revised by December 1994 to:

   a. Require an inspection of bonnet fasteners whenever changes are made to an MOV torque switch setting.

   b. Provide guidance for the inspection of fasteners for evidence of BAC.

   c. Incorporate personnel safety precautions when torquing RCPB fasteners on pressurized operating systems/components.

5. The use of corrosion resistant bolting materials will be re-evaluated for bolted bonnet valves which are susceptible to BAC, i.e. RC-V1, MU-V113, etc. This evaluation will be completed by February 1995.

6. This event will be reviewed with Operations, Chemistry, Maintenance, and Engineering Support Personnel (as appropriate) to reinforce an awareness of the potential for BAC on borated water system components and, in particular, the fasteners for bolted connections. GPUN expects to complete this training by January 1995.