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SVP-99-191

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Quad Cities Nuclear Power Station, Unit 1
Facility Operating License Nos. DPR-29
NRC Docket Nos. 50-254

Subject: Response to NRC Request for Additional Information regarding Quad Cities Remediation Plan for Unit 1 IGSCC Susceptible Welds

Reference:
(1) Letter from J. P. Dimmette, Jr. (ComEd) to U.S. NRC, "Results of the Root Cause Analysis of Flaws in Induction Heat Stress Improvement Treated Recirculation system Piping," SVP-98-376, dated January 26, 1999.

(2) Letter from J. P. Dimmette, Jr. (ComEd) to U.S. NRC, "Remediation Plan for the Unit 1 Intergranular Stress Corrosion Cracking Susceptible Welds," SVP-99-025, dated March 31, 1999.

(3) Letter from Robert Pulsifer (U.S. NRC) to Mr. Oliver D. Kingsley (ComEd), Review of Remediation Plan for Quad Cities, Unit 1 IGSCC Susceptible Welds, dated June 14, 1999.

The purpose of this letter is to provide the additional information requested in Reference 3 regarding the remediation plan for the Intergranular Stress Corrosion Cracking (IGSCC) welds at Quad Cities Nuclear Power Station, Unit 1. An assessment of the Quad Cities Unit 1 welds susceptible to IGSCC was performed immediately after discovering flawed welds during the 15th refueling outage. This assessment, Reference 1, evaluated the Induction Heat Stress Improvement (IHSI) and Ultrasonic (UT) inspection data.

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In Reference 3 the staff requested the following:

(1) "That the licensee document the acceptance criteria and provide a detailed account of the assessment process and results on a weld-specific basis."

The second and more detailed assessment of the IHSI process and UT data was completed during March of 1999. This more detailed assessment showed that the IHSI process was more effective than determined during the first assessment. The results of this more detailed assessment, along with the acceptance criteria and detailed account of the assessment process, is presented in Attachments A and B as requested.

(2) "Revise the January 29, 1999, letter by updating the reported results of the IHSI treatment and discussing the reasons for the discrepancies of the two assessments of the effectiveness of IHISI treatment."

The reason for the discrepancies between the two assessments was that some significant IHSI data was not available during the first assessment. Heat transfer calculations, which determined the through-wall ΔT, were not available during the earlier assessment but were incorporated during the second assessment. These calculations were used to determine a through wall ΔT when the minimum outside surface temperature did not meet the 425 °C criterion. The calculated ΔT showed that all but one weld previously reported to have received a marginal or ineffective IHSI treatment actually received an effective IHSI treatment. The results of the first assessment would have produced the same conclusions as the second assessment if these calculations had been available. The acceptance criteria, a detailed account of the assessment process, and results for each weld specified in Reference 1 are provided in Attachments A and B.

(3) "The staff recommends that the inspection schedule of the subject weld should be increased to that of Category D to ensure maintaining the structural integrity of the weld."

The performance of cast austenitic stainless steel has been excellent throughout the history of operation of BWRs. A review of the heat-affected zone on the cast side of this weld was performed, Attachment C, and no concern for IGSCC was identified. Finally, we reviewed the UT data of the overlays adjoining other cast components in both units. The flaws identified and repaired by weld overlay were all on the non-cast side of each weld.

The stress improvement of weld 02AS-F8 was re-evaluated, details are provided in Attachment A and determined to be an effective IHSI treatment. In addition to an effective IHSI treatment, water chemistry meeting the EPRI guidelines for IGSCC mitigation has been maintained and has been enhanced through the application of noble metal chemistry.

The configuration of weld 02AS-F8 is wrought stainless steel pipe to a cast stainless steel valve. This configuration limits the UT inspection to a single-side access inspection from the pipe side, resulting in limited coverage on the cast side of the weld. Therefore, increasing the inspection frequency would not produce conclusive information about the casting's condition.

We are proposing that we continue UT inspections of this weld in accordance with Category "C" provisions and perform a VT-2 (visual inspection) of this weld either during the Class 1 System Pressure Test or while the unit is shutting down for a refueling outage. Since it is an industry accepted position that cast components will leak before they fail, this visual inspection would allow us to detect a leak. Our current Technical Specifications regarding reactor coolant system leakage detection during operation are consistent with industry practices.

Should you have any questions concerning his letter, please contact Mr. C.C. Peterson at (309) 654-2241, extension 3609.

Respectfully,

Joel P. Dimmette, Jr.
Site Vice President
Quad Cities Nuclear Power Station

Attachments:

Attachment A: Quad Cities Unit 1 Assessment for Induction Heat Stress Improvement
Attachment B: Quad Cities Unit 1 IHSI Application Parameters
Attachment C: Quad Cities Unit 1 Review of IGSCC Resistance of BWR Recirculation System Cast Valve and Pump Housings

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector – Quad Cities Nuclear Power Station

1. Acceptance Criteria and Process of the Assessment

A. Introduction

A detailed assessment for Induction Heat Stress Improvement (IHSI) effectiveness reviewed the following IHSI application parameters reported in the IHSI records for each weld. The acceptance criteria used to determine the effectiveness of the IHSI treatment are also provided in the following table and are based on the industry recommended criteria specified in EPRI report NP-3375, Induction Heating Stress Improvement," November 1983.

B. Acceptance Criteria

IHSI Application Parameter:	Acceptance Criteria:
Minimum Outside Surface Temperature	425 °C
Minimum Through-wall ΔT	495 °F (555 °F for Welds to Cast Material)
Minimum Heating Zone Length	1.5 $\sqrt{Rt}$, (R = Radius and t = thickness)
Minimum Heating distance from Weld Centerline	Larger of 0.6" or t/2
Minimum Heating Duration	0.7 t^2/α seconds, (t = thickness and α = diffusivity)
Minimum Water Velocity	4 ft/sec (with or without air pockets)

As a conservative measure, an additional more restrictive criterion for the minimum ΔT was specified for the assessment of welds to cast stainless steel material. Based on a concern for potentially higher yield strength in cast material, a larger through-wall ΔT acceptance criterion of 555 °F was required for an effective IHSI treatment of cast material.

C. Assessment Process

When the minimum outside surface temperature met the acceptance criteria of 425 °C, and the minimum water velocity was met, the requirement for the minimum through-wall ΔT was not assessed. The minimum through-wall ΔT was achieved because the maximum inside surface temperature is limited by the heat transferred to the cooling water. When the IHSI treatment did not meet the minimum outside surface temperature, a heat transfer calculation was performed using the water temperature and flow velocity to determine the through-wall ΔT. The minimum heating zone length and the minimum heating distance from the weld centerline was verified to be acceptable based on the locations of the thermocouples used to measure the outside surface temperatures. These lengths, as well as the heating duration, were based on the larger of the measured through-wall thickness' for the two components welded together. Welds receiving IHSI treatments, which met the above criteria, were determined to be effective. Welds with treatments not meeting the above criteria were determined to have received marginal IHSI treatments.

Significantly less information about the IHSI application was available to assess the effectiveness reported in our January 26, 1999 letter. For this less rigorous assessment, IHSI applications not meeting the minimum outside surface temperature requirement of 425 °C and the induction coil length or position requirements were determined to have received marginal or ineffective IHSI treatments. This previous assessment did not consider the actual through-wall ΔT achieved or the actual heating zone length and position as determined by the thermocouples used to monitor the IHSI application. This ΔT is presented in Attachment B, "Delta T °F".

2. Summary

The IHSI application parameters for the 16 IHSI treated 28-inch pipe welds in question are presented in Attachment B. This report shows that 15 welds received an effective IHSI treatment and 1 weld received a marginal IHSI treatment based on the acceptance criteria used during the assessment. These 15 welds, assessed to be effectively stress improved by the IHSI process, can therefore be considered Category "C" welds for IGSCC inspection purposes.

3. Remediation Plan

For these 15 welds, 12 welds will be inspected to the Category "C" frequency and 3 welds, 02AS-S3, 02BD-S6 and 02BS-F2, will be inspected during the 16^{th} refueling outage, currently scheduled for October 2000. These 3 welds have an inconsistent UT history and will be re-evaluated after inspection to determine if they will be inspected to Category "C" or "D" frequency in the future. Should any of these 3 welds be found unacceptable they will be dispositioned in accordance with the GL 88-01 Program provisions.

Pipe weld 02BD-F8 was assessed to have received a marginal treatment because the more conservative minimum through-wall ΔT criterion for cast material was not met. This weld, as previously recommended, is scheduled to be mechanically stress improved during the 16^{th} refueling outage. A successful MSIP would allow this weld to be categorized as Category "C", otherwise it will remain Category "D". The other 10 welds listed in table 4.2.4.2, in Reference 1, were previously overlayed except for, 02AS-S4, 02AD-F12 and 02BS-F4, which are scheduled to be overlayed during the 16^{th} refueling outage.

Attached Table

ATTACHMENT B Quad Cities Unit 1 IHSI Application Parameters
Quad Cities Nuclear Power Station Unit 1, Page 1 of 2

Weld Id / *Configuration*	*Dia. (in.)*	*Cast* / *Tm*	*IHSI Date* / *Overlay Date*	*Heating Durations* *Req.* / Actual(sec.)*	*Water Rate (gpm) /* *Water Velocity (ft/s)*	*Water Temp °F /* *MOS Temp °C**	*Delta T °F** / *MHZ Met **	*IHSI Results* / *IHSI Comments*	*Proposed Category*
02AD-F1 Tee-Cross	28	☐ 2.60	05/04/1984	762.3 / 809.7	28,000 / 21.9	70 / 354	575° ☑	Effective High flow.	C
02AD-F9 Valve to Pipe	28	☑ 1.40	04/20/1984	222.3 / 286.6	16,000 / 10.3	80 / 412	624° ☑	Effective Casting low temperature. FN = 10-15.	C
02AD-S2 Pipe to Tee	28	☐ 1.40	05/02/1984	744.3 / 761.6	27,500 / 17.6	70 / 376	591 ☑	Effective High flow, tee side thicker.	C
02AD-S6 Pipe to Elbow	28	☐ 1.40	04/18/1984	228.7 / 237.3	16,000 / 10.2	71 / 465	Acceptable ☑	Effective	C
02AS-F5 Pipe to Pipe	28	☐ 1.20	05/08/1984	180.3 / 255.1	22,000 / 13.7	68 / 400	602° ☑	Effective Low temperature is at end of coil.	C
02AS-F8 Pipe to Valve	28	☑ 1.20	05/05/1984	167.8 / 225.8	26,000 / 16.3	60 / 358	555° ☑	Effective Low temperature is at pipe end of coil. Casting side has low delta ferrite (FN < 5).	C
02AS-S3 Pipe to Elbow	28	☐ 1.30	04/20/1984	216.0 / 289.0	12,500 / 8.2	85 / 490	Acceptable ☑	Effective Elbow is thicker.	C
02BD-F1 Tee-Cross	28	☐ 2.60	05/08/1984	762.3 / 840.2	26,500 / 20.9	68 / 312	505° ☑	Effective	C
02BD-F12 Pipe to Pump	28	☑ 1.40	04/28/1984	231.9 / 307.8	27,000 / 17.4	80 / 504	Acceptable ☑	Effective	C
02BD-F8 Elbow to Valve	28	☑ 1.40	05/01/1984	225.5 / 434.4	28,000 / 17.9	79 / 341	524° ☑	Marginal Casting temperature is low.	D

Attached Table

ATTACHMENT B Quad Cities Unit 1 IHSI Application Parameters
Quad Cities Nuclear Power Station Unit 1, Page 2 of 2

Weld Id / Configuration	Dia. (in.)	Cast / Tm	IHSI Date / Overlay Date	Heating Durations Req.* / Actual(sec.)	Water Rate (gpm) / Water Velocity (ft/s)	Water Temp °F / MOS Temp °C*	Delta T °F* / MHZ Met *	IHSI Results / IHSI Comments	Proposed Category
02BD-F9 Valve to Pipe	28	☑ 1.40	04/29/1984	222.3 / 246.1	31,000 / 19.8	85 / 389	595° ☑	Effective. Casting temperature is low. Conservative flow.	C
02BD-S2 Pipe to Tee	28	☐ 1.40	04/20/1984	744.3 / 772.1	17,000 / 11.0	95 / 350	516° ☑	Effective Tee is thicker.	C
02BD-S6 Pipe to Elbow	28	☐ 1.40	04/30/1984	228.7 / 297.4	26,000 / 16.7	80 / 471	Acceptable ☑	Effective.	C
02BS-F2 Safe End to Elbow	28	☐ 1.30	05/03/1984	212.9 / 273.8	28,500 / 18.0	70 / 388	601° ☑	Effective Low temperature at Safe End end of coil.	C
02BS-F6 Tee to Valve	28	☑ 2.50	04/27/1984	698.9 / 795.5	25,000 / 19.3	73 / 348	564° ☑	Effective Multiple attempts to heat. Casting is low temperature.	C
02BS-S3 Elbow to Pipe	28	☐ 1.30	05/05/1984	216.0 / 320.5	27,000 / 17.3	85 / 462	Acceptable ☑	Effective Elbow is thicker.	C

**** Notes: The Heating Duration required is the Minimum Heating Duration***
Delta T is the calculated Outside Surface Temperature
MOS is the actual Minimum Outside Temperature
MHZ is the Minimum Heating Zone Length

Overview

The purpose of this report is to review current understandings concerning the performance of large cast stainless steel valves and pump housings in operating BWRs. This information can aid the Quad Cities Nuclear Power Station in its assessment of the risk that any castings in its plants have intergranular stress corrosion cracking (IGSCC) present that has any engineering significance. By bringing together this information it will be possible to establish that there is a large amount of data that supports the resistance of these components to IGSCC. Secondly, if cracking is present it would be small and localized and any further initiation or crack propagation will continue to be mitigated by the hydrogen water chemistry (HWC) operating environment at the plant. In addition, ComEd has also implemented Noble-Chem (and will implement Noble-Chem at all BWR units), which will enhance the benefits of HWC. Therefore, the low delta ferrite content has no engineering significance and no further actions are required for Quad Cities Unit 1 castings with low delta ferrite contents.

The key factors that will be presented to support this assessment will include the overall characteristics of stainless steel castings in their installed condition, the laboratory and field experience in assessing the susceptibility of cast material to IGSCC, and the understanding regarding the effectiveness of the hydrogen water chemistry (HWC and Noble-Chem) at Quad Cities in mitigating IGSCC. Based on these factors, with particular emphasis on the excellent history of IGSCC resistance in the CF8 and CF8M type material, ComEd position is to not inspect the casting Heat Affected Zones (HAZs). This is also justified by the lack of a qualified inspection technique for detection of IGSCC in austenitic cast stainless steel. The nuclear power generation industry through the Electric Power Research Institute (EPRI) recognizes that UT of castings is not meaningful.

Background

The performance of cast austenitic stainless steel has been excellent throughout the history of operation of BWRs. CF8 and CF8M cast duplex microstructures have been used for all of the valve bodies and pump housings in the primary recirculation piping. The standard desired range of ferrite levels were selected to be from 5% to 30%. While the requirements for specific ferrite levels and restrictions on carbon levels are only applicable to recent plant components, general practice has dictated that there be adequate ferrite to avoid casting defects during the casting of the part. These practices were followed by the limited number of vendors such as Bingham and Byron-Jackson that supplied these components during original construction. These components have essentially been free of any environmental cracking in the GE BWRs.

The casting suppliers never had specifically measured the delta ferrite in the supplied components. The range of delta ferrite has not been positively identified nor has the variations through the cast thickness been specified or evaluated. However, the casting supplied to Quad Cities used the same compositional guidance by vendors such as Bingham and Byron-Jackson as was supplied thoughout the United States (US) BWR fleet.

With this background, it is appropriate to bring together additional understanding of the fleet casting performance in order to justify that the cast components continue to follow the Quad Cities 88-01 program schedule for future inspection. This understanding will include (1) US field casting and weld cracking experience, (2) Laboratory data on IGSCC Susceptibility and Behavior of Castings and Weld Materials, (3) understanding gained from piping replacement activities, (4) overview of valve and pump housing visual inspections, (5) ferrite knowledge from Quad Cities components, (6) overseas cracking experience, and (7) the positive impact of the current operating conditions at ComEd Units.

(1) United States Field cracking experience: welds and castings

Both high carbon and low carbon austenitic stainless steel weld metals and castings have exhibited excellent resistance to IGSCC over the history of operating BWRs. The largest information base is for Type 308 and Type 308L welds that were used for the majority of the recirculation piping welds as well as for the reactor internals fabrication. The volumetric (ultrasonic), surface (penetrant tests) and visual inspections (VT-2) that are part of standard outages have revealed very few incidences of weld metal cracking in these components. In that the operating BWRs were constructed beginning in the 1960's when there were no specific ferrite and carbon controls for the weld metal, this provides strong evidence of the robustness of the duplex weld metals against Stress Corrosion Cracking (SCC). The few instances where cracking has occurred, metallurgical examinations have verified that the ferrite levels are extremely low and the characteristics of the duplex microstructure are gone and the weld metal has the microstructure of purely austenitic material. Table 1 details five instances of field cracking that were investigated. In all cases the ferrite levels at the crack tip termination were on the order of 0.5% to 2.8%. It must be remembered that there is significant variations in composition through a casting, especially large ones such as the recirculation loop valve castings will likely result in no single ultra low delta ferrite path from the Inside Diameter (ID) to the Outside Diameter (OD) of the castings. Less than 0.5% of the pipe welds that have experienced IGSCC (well over 1000 in the BWR fleet) have shown cracking in the weldment. This provides strong field evidence of IGSCC resistance in duplex materials (welds and castings) even without stringent ferrite requirements.

Visual inspections of the pressure vessel cladding have also added confirmation to the high resistance of weld metal to SCC with no instances observed. This weld metal has been post weld heat treated leading to reduction in ferrite level as well as aiding the kinetics for any carbide precipitation and the concurrent chromium depletion. Likewise, no cracking of weld buildup pads for attachments has been reported, even though for many BWRs these pads are Type 308 and furnace sensitized.

For austenitic stainless steel castings, there have been no reported field instances of stress corrosion for US plants except where there was carburization attributable to the mold material or due to the hardfacing process. This is to be expected due to the inherent resistance of the duplex microstructure and the structural margin leading to lower stresses. As will be discussed in later sections, the number of inspections for components in operation are limited due to the difficulty in performing UT inspections. However, those inspections have not revealed any cracking.

(2) Laboratory data on IGSCC Susceptibility and Behavior of Castings and Weld Materials

At GE, as well as at other laboratories, many studies have also been conducted to evaluate the resistance of weld metal as well as duplex castings. The largest and most thorough studies were pipe test studies conducted to reproduce field pipe cracking as well as to qualify improved piping materials as replacements. In each of the over 70 tests conducted, there were generally 12 circumferential welds made using Type 308 weld metal that was procured with a composition that would produce 5% to 8% ferrite in the as-deposited condition. None of these welds exhibited any cracking even though the testing conditions were severe and the deposited ferrite was expected to range from approximately 3% to over 8%.

Several other laboratory studies have been performed to evaluate the resistance of weld metal to crack initiation. These studies include slow strain rate tests (SSRT), constant load (CL) tests, creviced bent beam (CBB) tests as well as standard ASTM A262, practice E corrosion tests. Most of the weld metal specimens were given a post weld heat treatment at 621°C for 24 to 40 hours. This treatment would promote carbide precipitation leading to sensitization. The heat treatment also reduced the ferrite levels from those achieved in the original deposition. Early CL studies verified that weld metal having ferrite levels from 1% to 11% and carbon levels up to 0.07% did not crack at stresses up to the material's yield strength.

Finally, there is also laboratory data on the crack growth rate behavior for duplex materials. This data was developed as part of the Large Diameter Pipe program to understand the resistance and rates for IGSCC cracks that might have initiated and grown into the weld metal. At the low carbon and moderate ferrite levels (8% to 11%), cracking is arrested after limited penetration. At higher carbon (typical of Type 308) and lower ferrite levels, 1.9 to 3.3%, the initiated cracks did continue to grow. However, the rates measured were slower than sensitized stainless steel and on the order of 3×10^{-6} in/hr under slow cyclic loading. This information is very consistent with data from the Swedish experience to be discussed later. It is clear that the nature of the duplex microstructure lends overall added resistance to IGSCC.

(3) Pipe Replacement experience

The pipe replacement activities in the 1980's provided an opportunity to evaluate cast hardware that had been in service since the beginning of operation. In all cases it was both desirable and necessary to continue to re-use the pumps and valves along with the replacement pipe. In order to prepare the castings, the original heat affected zones were refurbished prior to joining to the new piping. GE as part of its installation instructions required that the weld prep and refurbished counterbores be penetrant examined consistent with the ASME Code. These practices were followed at the several plants which included Peach Bottom Units 2 and 3 and Pilgrim where GE was responsible for the actual installation and at Vermont Yankee and Hatch Units where GE developed the installation procedures. No evidence of cracking was found at any of these plants in the cast material. Based on our current understanding of IGSCC initiation, the prior time of operation would have provided adequate time for crack initiation if there were any regions of susceptibility or regions of manufacturing induced defects that became open to the ID surface. This adds confidence that the population of castings installed in GE plants were exhibiting IGSCC resistant characteristics over the full range of carbon and ferrite levels.

The only ComEd plant to replace piping was Dresden Unit 3. The valves and pump housings were also reused and went through similar preparation and penetrant inspection. There were no instances of IGSCC even though the plant had been operating for over 10 years. The valve and pump housings were made in the same time frame as those for the Quad Cities Units.

(4) Overview of Valve and Pump Housing Visual Inspections

As part of ASME requirements, valves and pump housings that are accessible due to maintenance need to be given a VT-3 inspection. While the number of inspections performed is far less than those required for piping welds, the fleet as a whole has inspected a reasonable number of components. In the US, there is no current knowledge of any significant findings. In many ways, this also supports the resistance of the overall population of large cast components.

Specifically, at ComEd plants, Code requires VT-3 inspection of one valve or pump in each category (which is defined by design, type, or function, etc.) once every 10-year interval if and only if the valve or pump is scheduled for maintenance. For valves, no IGSCC has been identified at ComEd plants. Quad Cities, Dresden, and LaSalle at one time or another have disassembled recirculating pumps and performed VT-3 on the interior surface, and again no IGSCC was identified. In addition, VT-2 inspections are performed and no leakage from cast components has been observed.

(5) Quad Cities Casting Assessments

The castings at Quad Cities have undergone limited assessments. Recent efforts were also made to assess the valve ferrite levels by performing field measurements on the exterior of the castings. All but one casting had ferrite levels greater than 10 percent. Only one had low readings; several locations were measured >5FN and two other locations were <5FN and >10FN. Table 2 gives the measured values. Given the field performance, these castings appear typical of those at the plants that performed piping replacements and who found no indications of IGSCC during those activities such as Peach bottom Units 2 and 3. The one low reading may very well be significantly lower than the counterbore region, which is away from the casting outer skin. This would be expected based on the historical range used by the valve and pump suppliers. Finally, it must also be noted that the valve castings will likely result in no single ultra low delta ferrite path from the ID to the OD of the castings, which would provide a crack path for leakage. Where ferrite readings have been made at Quad Cities, the ferrite values appear to be good; there is no reason to believe that there is widespread low ferrite in the pump casings and valve bodies at Quad Cities.

(6) Review of Valve and Pump Housing cracking at OKG

While the casting performance in the US has been very good, in 1995 cracking was discovered in some valve and pump housings in Sweden associated with the Oskarshamn 1. These inspections were performed in conjunction with an extensive outage associated with the plant's shroud replacement project, the FENIX effort.

During this inspection, ID cracks were found in eight valve bodies with minor cracks found in three pump housings. The valves were all of a European niobium stabilized stainless steel. These components were manufactured in the late 1960s or early 1970s and had been in service for approximately 25 years. The cracking could be seen visually. Assessments were made to assess the probable cause for cracking. The majority of cracks were attributed to hot cracking/reheat cracking defects that occurred during original manufacture. This was determined to be the most probable cause of cracking. This was confirmed by evaluation of the outside surfaces of the castings that contained similar cracking patterns. The evaluation did find cracking associated with ferrite/austenite interfaces as well as low ferrite regions where the cracking was found in purely austenite regions which had evidence of chromium depletion. All of the cracks contained heavy oxide. Therefore, it was hard to rule out that crack extension had not taken place during operation. However, any crack growth would have been at a very slow rate. The cracking was removed by EDM and structural analyses established a large amount of margin. Even though cracking was found, the behavior was not inconsistent with the significant experience and lab understanding that establishes the high IGSCC resistance of austenitic castings used in the US BWR fleet.

(7) Impact of Operating Environment at Quad Cities

The final factor is the plant's efforts to maintain an environment that minimizes the risk of IGSCC. The water chemistry that has been present over the last several cycles at the Quad Cities Unit 2 has included hydrogen injection. In particular, the last cycle is a good measure of the water chemistry quality that will be present in the upcoming cycle with significant mitigation enhancement after Noble-Chem injection. The key parameters are the conductivity as well as the specific anionic species in the coolant. The average conductivity over the last cycle, which is the most representative of the future operational levels for Unit 1, was 0.09 μS/cm (Unit 2 was 0.01 μS/cm). The yearly chloride and sulfate levels have also been very low, well below the EPRI Guidelines levels of 5 ppb. Hydrogen was injected for 91.7% of the time. With Noble-Chem, the ECP levels would be easily reduced below –230 mV SHE. Therefore, the past and future operating environment, will limit the potential for any further degradation in the castings if it were to have been present due to localized regions without any ferrite.

Summary

In summary, the field and laboratory experience provides strong evidence that the valves and pump housings at Quad Cities Unit 1 are resistant to IGSCC. For castings, there has been an absence of reported cases of IGSCC in the Type CF8 and CF8M austenitic cast stainless steel. Secondly, there is also cumulative information gained through many pipe replacement inspections and routine valve body inspections that also confirm the resistance to IGSCC. Therefore, ComEd does not deem it necessary to perform additional inspections of the casting HAZ of CF8 and/or CF8M materials beyond the current scope of the Quad Cities 88-01 program.

Table 1: Determined Ferrite Levels in Field Piping Welds with Cracking

Piping Location	Ferrite Level (%)
Bypass A	0.5
Bypass B	0.5
Bypass C	2.4
Inst. Line	2.8
Core Spray	0.5

Table 2: Measured Ferrite Levels in Quad Cities Castings

Valve EPN	FN Readings (Random Locations)
1-0202-4A	<5FN 6 places >5FN, <10FN 1 place
1-0202-5A	>10FN, <15FN 6 places
1-0202-6A	>20FN 6 places
1-0202-4B	>10FN, <15FN 5 places >15FN, <20FN 1 place
1-0202-6B	>20FN 6 places