

10 CFR 50.55a

RS-14-114

March 28, 2014

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Peach Bottom Atomic Power Station, Units 2 and 3
Renewed Facility Operating License Nos. DPR-44 and DPR-56
NRC Docket Nos. 50-277 and 50-278

Quad Cities Nuclear Power Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-29 and DPR-30
NRC Docket Nos. 50-254 and 50-265

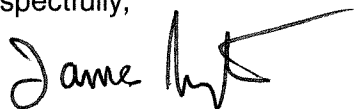
Subject: Proposed Alternative to Utilize Code Case N-513-3, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping Section XI, Division 1," at a Higher System Operating Pressure

In accordance with 10 CFR 50.55a(a)(3)(i), Exelon Generation Company, LLC (Exelon) is requesting a proposed alternative to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," on the basis that the proposed alternative would provide an acceptable level of quality and safety. Specifically, Exelon is requesting to apply the evaluation methods of ASME Code Case N-513-3, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping Section XI, Division 1," to the Class 3 High Pressure Service Water System piping (Peach Bottom Atomic Power Station) and the Residual Heat Removal Service Water System piping (Quad Cities Nuclear Power Station) with a maximum operating pressure of 375 psig.

There are no commitments contained in this submittal.

We request your review and approval of this multi-site request by March 28, 2015.

Respectfully,



James Barstow
Director - Licensing and Regulatory Affairs
Exelon Generation Company, LLC

U.S. Nuclear Regulatory Commission
Proposed Alternative to
Utilize Code Case N-513-3
March 28, 2014
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Attachments: 1) Proposed Alternative to Utilize Code Case N-513-3 at a Higher System Operating Pressure
2) Letter from Structural Integrity Associates, Inc. to Guy Deboo (Exelon), "Technical Basis for N-513-3 Scope Expansion to Higher Pressure," dated March 13, 2014

cc: Regional Administrator - NRC Region I
Regional Administrator - NRC Region III
NRC Senior Resident Inspector - Peach Bottom Atomic Power Station
NRC Senior Resident Inspector - Quad Cities Nuclear Power Station
NRC Project Manager - Peach Bottom Atomic Power Station
NRC Project Manager – Quad Cities Nuclear Power Station

Attachment 1

Proposed Alternative to Utilize Code Case N-513-3 at a Higher System Operating Pressure

**10 CFR 50.55a RELIEF REQUEST:
Peach Bottom Atomic Power Station, Units 2 and 3 Relief Request I4R-55
Quad Cities Nuclear Power Station, Units 1 and 2 Relief Request I5R-12
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**Request to Use Code Case N-513-3 at a Higher System Operating Pressure in
Accordance with 10 CFR 50.55a(a)(3)(i)**

1. ASME Code Component(s) Affected:

All American Society of Mechanical Engineers (ASME), Section XI, Class 3 High Pressure Service Water (HPSW) System piping that operates at a pressure less than or equal to 375 psig but greater than 275 psig in Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, and all American Society of Mechanical Engineers (ASME), Section XI, Class 3 Residual Heat Removal Service Water (RHRSW) System piping that operates at a pressure less than or equal to 375 psig but greater than 275 psig in Quad Cities Nuclear Power Station (QCNPS), Units 1 and 2.

2. Applicable Code Edition and Addenda:

| <u>PLANT</u> | <u>INTERVAL</u> | <u>EDITION</u> | <u>START</u> | <u>END</u> |
|--|-----------------|------------------------------------|------------------|------------------|
| Peach Bottom Atomic Power Station, Units 2 and 3 | Fourth | 2001 Edition, through 2003 Addenda | November 5, 2008 | November 4, 2018 |
| Quad Cities Nuclear Power Station, Units 1 and 2 | Fifth | 2007 Edition, through 2008 Addenda | April 2, 2013 | April 1, 2023 |

3. Applicable Code Requirement:

ASME Code, Section XI, IWD-3120(b) requires that components exceeding the acceptance standards of IWD-3400 be subject to supplemental examination, or to a repair/replacement activity.

4. Reason for Request:

In accordance with 10 CFR 50.55a(a)(3)(i), Exelon Generation Company, LLC (Exelon) is requesting a proposed alternative from the requirement to perform repair/replacement activities for degraded HPSW/RHRSW piping which has a maximum operating pressure in excess of 275 psig. Moderately degraded piping could require a plant shutdown within the required action statement timeframes to repair observed degradation. Plant shutdown activities result in additional dose and plant risk that would be inappropriate when a degraded condition is demonstrated to retain adequate margin to complete the component mission. The use of an acceptable alternative analysis method in lieu of immediate action for a degraded condition will allow Exelon to perform additional extent of condition examinations on the affected systems while allowing time for safe and orderly long term repair actions if necessary. Actions to remove degraded piping from service could have a detrimental overall

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risk impact by requiring a plant shutdown, thus requiring use of a system that is in standby during normal operation.

5. Proposed Alternative and Basis for Use:

Exelon is requesting approval to apply the evaluation methods of ASME Code Case N-513-3, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping Section XI, Division 1," to the HPSW/RHRSW System piping having a maximum operating pressure of 375 psig in order to avoid accruing additional personnel radiation exposure and increased plant risk associated with a plant shutdown to comply with the cited Code requirements.

The NRC issued Generic Letter 90-05, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping (Generic Letter 90-05)," to address the acceptability of limited degradation in Moderate Energy Piping. The generic letter defines conditions that would be acceptable to utilize temporary non-code repairs with NRC approval. The ASME recognized that relatively small flaws could remain in service without risk to the structural integrity of a piping system and developed Code Case N-513. The Generic Letter 90-05 moderate energy limitations of 200°F and 275 psig were retained in the Code Case to maintain consistency with service conditions previously acceptable to the NRC as defined in Generic Letter 90-05. NRC approval of Code Case N-513 versions in Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," allows acceptance of partial through-wall or through-wall leaks for an operating cycle provided all conditions of the Code Case and NRC conditions are met. The Code Case also requires the Owner to demonstrate system operability due to leakage.

Code Case N-513-3 provides analytical methods to be used for evaluating degraded piping conditions for determining structural integrity. The analytical methods provided in the Code Case are based on ASME Section XI, Appendix C, "Evaluation of Flaws in Piping," with supplemental guidance given in the Code Case specific to through-wall flaws. Linear Elastic Fracture Mechanics (LEFM) principles for evaluation of flaws in ferritic piping are normally employed. The ASME Section XI piping flaw evaluation methods do not place pressure or temperature limits for evaluating flaws in piping. The Code Case also allows evaluation by the branch reinforcement approach to allow evaluation of nonplanar through-wall flaws. The Code Case analytical methods account for flaw length, depth, pipe material toughness, applied stresses, and use of safety factors. These analytical methods do not have a technical basis for limiting use to 275 psig, and would, in fact, be technically appropriate without a pressure limitation.

Exelon has worked with a vendor to better understand the background, history, and effects of using Code Case N-513-3 at a pressure of 375 psig in lieu of the current 275 psig limitation provided in the Code Case. The review identified that the NRC has previously granted relief for leaks with known specific conditions and sizes for pressures up to 2500 psig (see Attachment 2). Exelon is seeking relief for general application for limited degradation in HPSW/RHRSW System raw water piping for a pressure 100 psig greater than the currently approved 275 psig. Raw water piping degradation is a well understood phenomenon and the

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evaluation methods in Code Case N-513-3 are widely applied by the industry in raw water piping systems that operate at a pressure less than or equal to 275 psig without incident.

The structural aspects of raising the allowable operating pressure to 375 psig were evaluated as discussed in Attachment 2. It was determined that Code Case allowable flaw sizes by both the LEFM and branch reinforcement methods used in Code Case N-513-3 were smaller as would be expected. The effects of jet thrust force were evaluated and it was determined there was little difference in force for a 0.56" diameter flaw size at 275 psig versus 375 psig. The study also determined that jet thrust force increases with increasing leakage rate and that it is appropriate to limit the application of this relief request to 375 psig.

Attachment 2 provides:

- 1) A review of relevant NRC approved relief requests
- 2) A structural integrity evaluation that includes:
 - Design minimum wall thickness comparison
 - Code Case N-513-3 allowable flaw size comparison
 - Code Case N-513-3 cover thickness requirement comparison
- 3) A jet thrust force evaluation

Code Case N-513-3 requires that the Owner demonstrate system operability due to leakage. The Code Case does not demonstrate the consequence of leakage so the Owner is required to demonstrate leakage consequence/operability per operability procedures. This evaluation is demonstrated in an Operability Evaluation via Exelon Procedure OP-AA-108-115, "Operability Determinations." The Current Licensing Basis (CLB) requirements and commitments, including the Technical Specifications and Updated Final Safety Analysis Report, are reviewed to establish the conditions and performance requirements to be met for determining operability, as necessary. The scope of an Operability Evaluation needs to be sufficient to address the capability of the System, Structure, and Component (SSC) to perform its specified safety function(s) from both the Code Case N-513-3 structural perspective and leakage perspective. An Operability Evaluation should address the following, as applicable:

- Determine what SSC is degraded, nonconforming, or unanalyzed.
- Determine the extent of condition for all similarly affected SSC.
- Determine the specified safety function(s) performed by the SSC.
- Determine the circumstances of the potential nonconformance, including the possible failure mechanism.
- Determine if the potential failure is time dependent and whether the condition will continue to degrade and/or will the potential consequences increase.
- Determine the requirement or commitment established for the SSC, and why the requirement or commitment may not be met.
- Determine by what means and when the potentially nonconforming SSC was first discovered.
- Determine the basis for declaring the affected SSC operable, through:
 - o analysis,
 - o test or partial test,

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- operating experience, and/or,
- engineering judgment

The HPSW/RHRSW System is a safety-related, open loop cooling water system at PBAPS and QCNPS. The primary function of the HPSW/RHRSW System is to provide cooling water flow, at a pressure greater than the Residual Heat Removal (RHR) System pressure, for removing heat from the RHR heat exchangers. The functional capability for the HPSW/RHRSW pumps is to provide a pressure at the heat exchanger service water outlet greater than the maximum RHR inlet pressure in the containment cooling mode. The HPSW/RHRSW System transfers heat from the RHR System to the service water system during operation in the following plant conditions:

- Normal shutdown
- Post-accident shutdown
- Hot standby
- Refueling
- Normal plant operation

The HPSW/RHRSW System is designed to:

- Support post-accident containment heat removal
- Meet seismic Class I criteria
- Have sufficient capacity and redundancy to perform its safety-related functions
- Be operable during loss of offsite power
- Designed to ANSI B31.1, 1967 Edition

HPSW/RHRSW Systems at QCNPS, Units 1 and 2, and PBAPS, Units 2 and 3 have exhibited a history of degradation similar to raw fresh water systems throughout the nuclear industry. Degradation requiring immediate action to address leakage or observed thinning in the system is generally due to localized corrosion mechanisms.

Peach Bottom Atomic Power Station System Description

The major flow paths of the HPSW System consist of two independent parallel flow loops serving each unit. Each flow loop contains two HPSW pumps which discharge to a common header serving two RHR heat exchangers, connected in parallel, and then discharging through a pipe which is common to both loops. The HPSW pumps take suction from the Conowingo Pond through the Service Water Pump Bay and the HPSW loops discharge through a common pipe for each unit to the discharge pond. The discharge pipe contains a normally open motor-operated isolation valve and a pipe connection to the Emergency Cooling Water (ECW) System to provide an alternate discharge in the unlikely event that the Conowingo Dam fails or the pond floods. When the alternate discharge is used, the ECW System serves as a supply to the HPSW pumps through the pump bay. See Enclosure 1 for a flow diagram of the Peach Bottom HPSW System.

A cross connection line connecting the two HPSW loops on each unit is provided including a normally closed motor-operated isolation valve. A cross connection line with two normally

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closed manual isolation valves is also provided between one Unit 2 HPSW loop and one Unit 3 HPSW loop. The cross connection lines provide the flexibility to establish alternate flow alignments if required under emergency conditions. A supply connection from the HPSW System to the RHR System, through two normally closed motor-operated valves, is provided from one HPSW loop per unit to permit the HPSW System furnishing a backup water supply to RHR for containment flooding. This is also known as Ultimate Cooling. The RHR and HPSW Systems are designed such that HPSW operates at a higher pressure than RHR; however, during standby conditions the RHR System pressure is maintained greater than HPSW. The RHR and HPSW Systems are standby systems that typically operate during testing or plant shutdown. Under this design, if there is an internal leak within a RHR heat exchanger, RHR water, which is normally torus water, leaks into the HPSW System and is discharged into the Conowingo Pond until the HPSW System pressure exceeds that of the RHR System.

Quad Cities Nuclear Power Station System Description

A separate RHRSW System serves each unit. Each RHRSW System includes two redundant subsystems. In the case of QCNPS, Units 1 and 2, there is a cross-tie connection that allows Unit 1 RHRSW to support Unit 2 and vice-versa. See Enclosure 2 for a flow diagram of the QCNPS's RHRSW System.

The RHR and RHRSW Systems are designed such that RHRSW operates at a higher pressure than RHR; however, during standby conditions the RHR System pressure is maintained greater than RHRSW. The RHR and RHRSW Systems are standby systems that typically operate during testing or plant shutdown. Under this design, if there is an internal leak within a RHR heat exchanger, RHR water, which is normally torus water, leaks into the RHRSW System and is discharged into the Mississippi River until the RHRSW System pressure exceeds that of the RHR System.

Cross System Leakage Monitoring

Each RHR heat exchanger contains a tube-to-shell differential pressure alarm, which is the first indication that there is an internal leak resulting in cross contamination from the RHR System to the HPSW/RHRSW System. Additionally, there are radiation monitors installed downstream of the HPSW/RHRSW System that indicate if there is cross system leakage. Between these alarms and established Operations and Chemistry procedures, the systems are maintained such that unacceptable RHR System leakage into the HPSW/RHRSW System does not occur. HPSW/RHRSW piping through-wall leaks in an operating HPSW/RHRSW train would not contain unacceptable levels of radionuclides due to the actions described above to address system cross contamination and maintaining the HPSW/RHRSW System at a higher operating pressure than the RHR System. These actions assure any HPSW/RHRSW piping through-wall leaks would not result in an increase in the probability of release of radionuclides to the environment.

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Summary

Exelon will apply ASME Code Case N-513-3 and Regulatory Guide 1.147, Revision 16 (or later NRC defined revision as applicable) for evaluation of HPSW/RHRSW piping flaws at the plants defined in Section 2 of this relief request. Exelon will apply a 375 psig maximum operating pressure in lieu of the 275 psig maximum operating pressure defined in paragraph 1(b) of the Code Case. In addition, Exelon will apply a 100 gpm leak limit to this relief request to limit the effects of jet thrust force even when evaluation of leakage effects would allow a higher leakage rate. Any leakage, if present, will be limited to the leakage allowed by the evaluation or 100 gpm, whichever is lower. This alternative retains acceptable structural and leakage integrity as described in the above paragraphs and would avoid the additional personnel radiation exposure and increase in plant risk associated with an unnecessary plant shutdown.

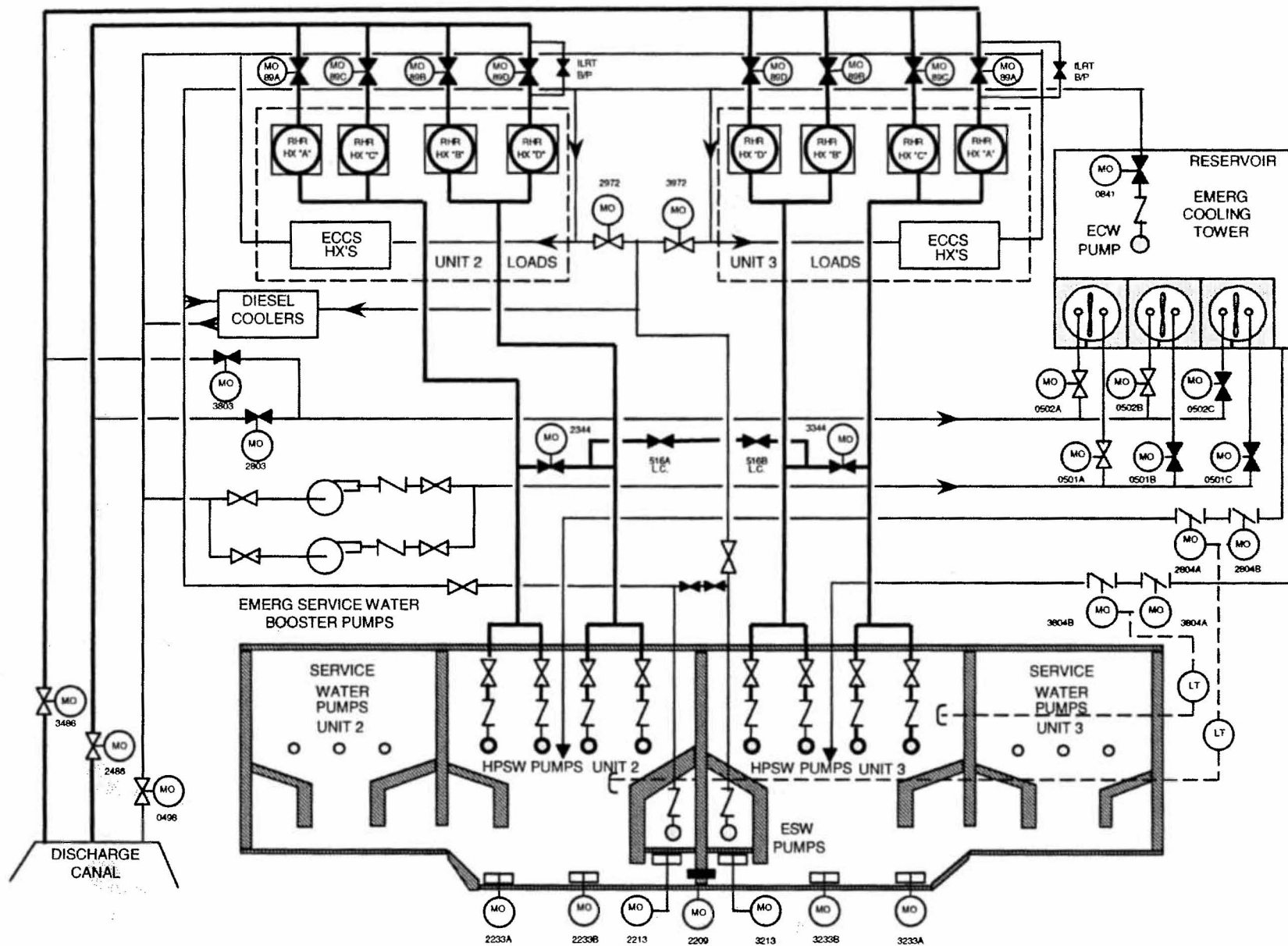
6. Duration of Proposed Alternative:

The proposed alternative is for use of Code Case N-513-3 for HPSW/RHRSW Class 3 piping having a maximum operating pressure of 375 psig for the remainder of each plant's 10-year inservice inspection interval as specified in Section 2. A Section XI compliant repair/replacement will be completed prior to exceeding the allowable period defined in Code Case N-513-3 Section 1(e) and Regulatory Guide 1.147 or the next refueling outage, whichever comes first.

7. Precedent:

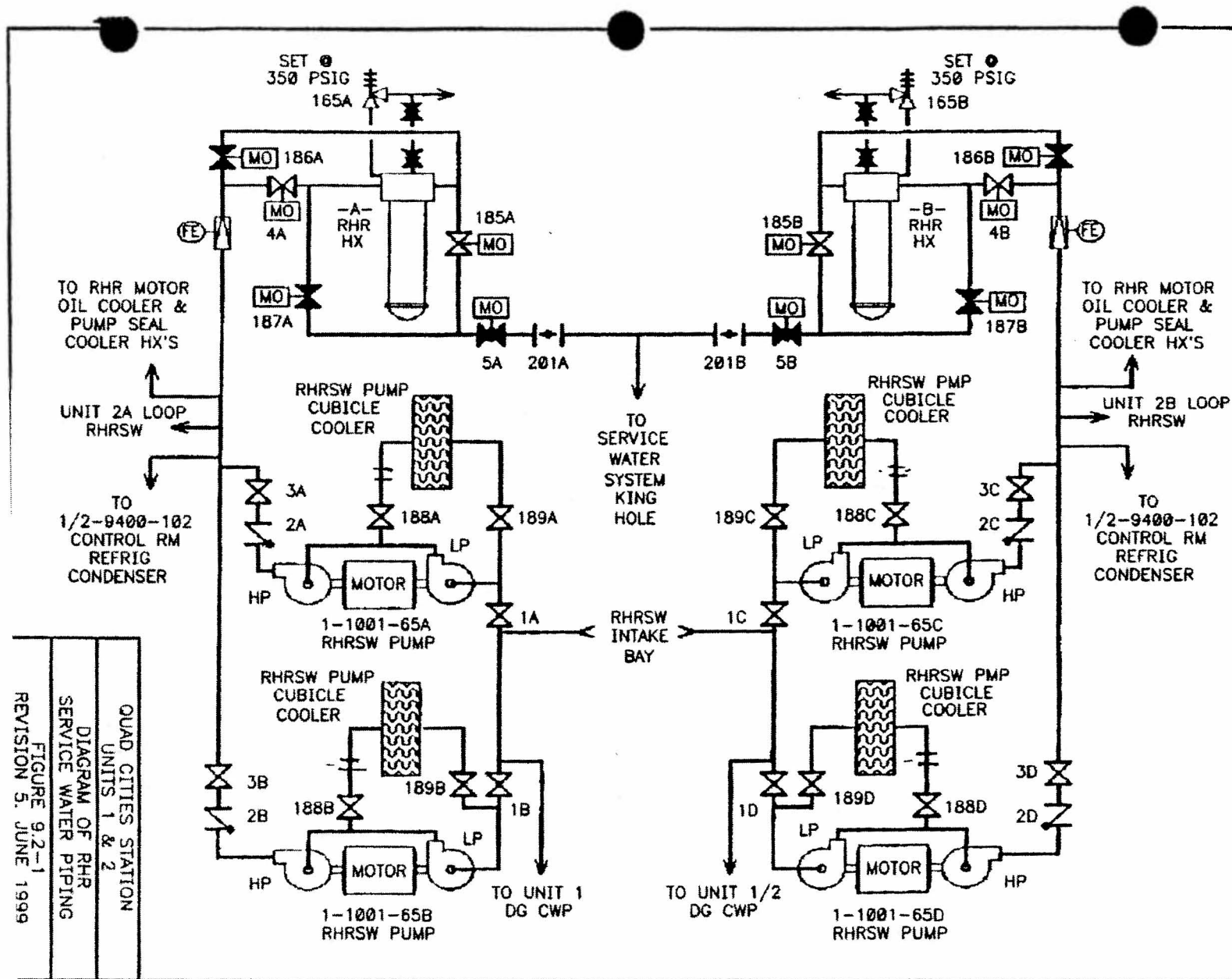
See Attachment 2

Enclosure 1
Peach Bottom HPSW Flow Diagram



COMBINED SYSTEM FLOWPATH

Enclosure 2
Quad Cities RHRSW Flow Diagram



Attachment 2

Letter from Structural Integrity Associates, Inc. to Guy DeBoo (Exelon), "Technical Basis for N-513-3 Scope Expansion to Higher Pressure," dated March 13, 2014



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March 13, 2014

Report No. 1400176.401.R0

Quality Program: ☒ Nuclear ☐ Commercial

Guy DeBoo
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555-4012

Subject: Technical Basis for N-513-3 Scope Expansion to Higher Pressure

- References:
1. ASME Code Case N-513-3, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping Section XI, Division 1," Cases of the ASME Boiler and Pressure Vessel Code, January 26, 2009.
 2. Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 16, October 2010.
 3. NRC Generic Letter 90-05, "Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping," (June 15, 1990).
 4. NRC Inspection Manual, Part 9900, "Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety," Issue Date 4/16/08.
 5. NRC Standard Review Plan, NUREG-0800, Branch Technical Position 3-3, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," Revision 3, March 2007.
 6. American National Standard, "Pipe Flanges and Flanged Fittings," ASME B16.5-2003.
 7. ASME Code Case N-597-1, "Requirements for Analytical Evaluation of Pipe Wall Thinning Section XI, Division 1," Cases of the ASME Boiler and Pressure Vessel Code, September 7, 2001.
 8. ASME Boiler and Pressure Vessel Code, Section III, Division 1 – Subsections NC/ND, 2004 Edition.
 9. NRC Standard Review Plan, NUREG-0800, Part 3.6.2, "Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping," Revision 2, March 2007.

Dear Guy:

This letter report provides a technical basis for the scope expansion of ASME Section XI Code Case N-513-3 to a higher pressure. It is intended that this technical basis will support a generic NRC Relief Request for the Exelon nuclear fleet by demonstrating that the proposed scope expansion will reduce plant burden without any adverse effect on safety.

Toll-Free 877-474-7693

| | | | | | |
|----------------------------|---------------------------------|----------------------------------|-------------------------------|---------------------------------|-----------------------------------|
| Akron, OH 330-899-9753 | Albuquerque, NM 505-872-0123 | Austin, TX 512-533-9191 | Charlotte, NC 704-597-5554 | Chattanooga, TN 423-553-1180 | Chicago, IL 815-648-2519 |
| Denver, CO 303-792-0077 | Mystic, CT 860-536-3982 | Poughkeepsie, NY 845-454-6100 | San Diego, CA 858-455-6350 | San Jose, CA 408-978-8200 | State College, PA 814-954-7777 |
| | | | | | Toronto, Canada |

BACKGROUND

Code Case N-513-3 [1] provides evaluation rules and criteria for the temporary acceptance of flaws, including through-wall flaws, in moderate energy piping. Moderate energy piping is defined as those piping systems where the maximum operating pressure and temperature do not exceed 275 psig and 200°F, respectively. The provisions of this Code Case are focused on preventing gross failure of the affected pipe for a temporary period while permitting leakage within the plant's Technical Specification. The Code Case provides rules for the evaluation of degraded pipe and tube for a short operating period, with inspection and monitoring requirements of the degraded condition as part of the overall integrity assessment. The application of the Code Case is restricted to moderate energy Class 2 and Class 3 systems, so that the safety issues regarding short-term system operation are minimized. Code Case N-513-3 is conditionally approved by the NRC in Regulatory Guide 1.147 [2]. The single condition deals with a requirement to perform the repair or replacement activity, temporarily deferred, during the next scheduled outage and as such, it is unrelated to the pressure limit. Since the introduction of this Code Case, many utilities have used it as a basis for continued operation of degraded piping in moderate energy systems and that has resulted in significantly fewer relief requests to the NRC. Consequently, the industry has benefited from substantial cost savings while maintaining safety. To date, there have been no known instances where the use of the Code Case has resulted in any safety issues at the plants.

The genesis of Code Case N-513 is NRC Generic Letter (GL) 90-05 [3]. Prior to Code Case N-513, this GL was the only available guidance for plants regarding operational leakage in moderate energy piping (even though its use required relief from the NRC). The definition of moderate energy piping in Code Case N-513 is consistent with GL 90-05. The scope of GL 90-05 is limited to Class 3 piping, but does address moderate and high energy systems. While non-code repairs are allowed by GL 90-05 (with NRC review) for the temporary period of operation prior to Code compliant repair/replacement, an additional requirement for the repair having load-bearing capability is necessary for high energy pipe applications. Both GL 90-05 and the latest approved revision of Code Case N-513 are identified as methods available to evaluate the structural integrity of piping with a discovered flaw in the NRC Inspection Manual Part 9900 [4].

The definition of moderate energy (the 200°F and 275 psig limits) was first introduced in a NRC letter from A. Giambusso to licensees in 1972 to address postulated piping breaks in fluid systems outside containment (discussed in the Branch Technical Position 3-3 of the current Standard Review Plan [5]). The importance of the 200°F temperature limit being below the boiling point of water at atmospheric pressure is clear in the definition of moderate energy piping. However, the basis for the pressure limit of 275 psig is less evident. Future revisions of Code Case N-513 are developed in the ASME Section XI Working Group on Pipe Flaw Evaluation and it is desirable that the Code Case be expanded to cover as many Class 2 and 3 piping systems as possible to further reduce industry burden in seeking relief from the NRC. Discussions regarding the basis behind the 275 psig pressure limit have taken place in an effort to expand the scope of N-513 to higher pressure Class 2 and Class 3 systems. Based on conversations with the NRC Working Group membership, there appears to be a link between the 275 psig limit and the recommended working pressure limit for Class 150 pipe flanges and flanged fittings given in the ASME B16.5 standard [6]. This basis is not known to be documented.

A technical approach and basis are presented below in order to justify the application of the Code Case N-513-3 methods to Class 2 or Class 3 piping systems with a maximum operating pressure of **375 psig** and maximum operating temperature of 200°F or less.

TECHNICAL APPROACH

The technical approach includes several elements that support the following objectives: (i) show NRC precedent in approving relief requests for through-wall leakage in piping or components operating at high energy pressure, (ii) show that structural integrity is not overly impacted when comparing flaw evaluations between piping systems operating at 275 and 375 psig, and (iii) show that possible jet thrust forces resulting from leaking flaws are not of concern. An outline of the technical basis detailing the elements used to support these objectives follows:

- Review of Relevant NRC Approved Relief Requests
- Structural Integrity Evaluation
 - Design minimum wall thickness comparison
 - Code Case N-513-3 allowable flaw size comparison
 - Code Case N-513-3 cover thickness requirement comparison
- Jet Thrust Force Evaluation

TECHNICAL BASIS

Review of Relevant Relief Requests

A search of the NRC ADAMS database was conducted to identify any relief requests for continued operation of degraded high pressure piping or components. Document titles were searched for “relief” and “ASME,” “high pressure,” and “90-05.” Approximately 1,100 records met the search criteria. These were filtered to several hundred records based on the full title of each document. Next, these records were further reduced to 31 entries by reviewing each document. Of the remaining records, only seven were deemed applicable to the current project. These are summarized in Table 1. Note that two relief requests from plant Hatch for high pressure Class 3 piping were reviewed; however, they are not included in Table 1 since they were seeking approval for the use of an NRC unapproved wall restoration Code Case.

Many of the requests for systems with high pressure involved thinning due to flow accelerated corrosion (FAC) and referenced ASME Code Case N-597-1 [7]. Although these initially appear to be beyond the scope of the objective of this effort, it is interesting to note that, with the exception of establishing a re-inspection interval not greater than the time to the next scheduled outage, none of these submittals committed to actions beyond those required by N-597-1.

Generic Letter 90-05 and various revisions of ASME Code Case N-513 appear in submittals as the technical basis for acceptance. In all cases, the submittals did not commit to any actions beyond the GL 90-05 and N-513 requirements. Note that a request to operate for an additional

cycle (ML072130503) in moderate energy piping with a through-wall leak was ultimately withdrawn.

Table 1: Summary of Relevant Relief Requests

| ADAMS Accession Number | Plant / Operating Condition | Description | Status |
|------------------------|---|---|-----------|
| ML040070165 | Watts Bar U1 / 1,185 psig | Application to use N-597-1 for part-wall thinning | Approved |
| ML050970082 | Watts Bar U1 / 1,185 psig | Application to use N-597-1 for part-wall thinning | Approved |
| ML072140851 | McGuire, U1 / 2,500 psig | Application for continued operation of leaking valve | Approved |
| ML092740312 | Oconee U2 / 1,440 psig | Application for continued operation of leaking buried piping | Withdrawn |
| ML101440381 | San Onofre U2, U3 / < 275 psig (275° F) | Generic application for continued operation of high temperature through-wall leaking pipe | Approved |
| ML072130503 | Palisades / moderate energy | Request to operate one additional cycle with through-wall pipe flaw | Withdrawn |
| ML13199A396 | Columbia / 1,450 psig | Request for non-Code repair on 4-inch leaking pipe | Approved |

* The maximum interval for re-inspection is defined as the time to the next scheduled outage.

Structural Integrity Evaluation

Design minimum wall thickness comparison

ASME Section III [8] defines the design minimum wall thickness required for pressure loading, t_{min} , as (without a corrosion allowance):

$$t_{min} = \frac{pD_o}{2(S + 0.4p)} \quad (1)$$

where:

p = Design pressure
D_o = Outside pipe diameter
S = Material allowable stress.

Substituting maximum operating pressure for design pressure in Equation 1, the minimum required wall thickness increases 36% with an increase in pressure from 275 to 375 psig. While this percentage increase appears significant, the actual change in minimum required wall thickness is relatively low as the hoop stress at these pressures is small. Table 2 shows a comparison of minimum wall thicknesses for various pipe sizes. From a design standpoint, pipe schedule selection most likely was not impacted by system operating pressures varying by 100 psi.

Table 2: Minimum Required Wall Thickness Comparison

| Nominal Pipe Size | t_{\min} for 275 psig* (in) | t_{\min} for 375 psig* (in) |
|-------------------|-------------------------------|-------------------------------|
| 6-inch | 0.06 | 0.08 |
| 12-inch | 0.12 | 0.16 |
| 24-inch | 0.22 | 0.30 |

* A material allowable stress of 15 ksi is assumed.

Code Case N-513-3 allowable flaw size comparison

Code Case N-513-3 allows for nonplanar, through-wall flaws to be evaluated as two independent planar through-wall flaws, one orientated in the axial direction and one orientated in the circumferential direction (i.e., a planar characterization approach). The Code Case acceptance criteria require the flaw region be bounded by the area defined by the allowable axial and circumferential flaw sizes. Several example N-513-3 calculations were conducted illustrating the influence of higher pressure on allowable flaw size. Following the Code Case guidance, a linear elastic fracture mechanics (LEFM) evaluation was performed for various carbon steel pipe sizes to determine the maximum allowable flaw sizes at 275 and 375 psig. Table 3 summarizes the results and several notes are provided giving more details regarding the analysis inputs.

The influence of the higher pressure is clearly seen and a greater impact is observed in the axial direction as expected since pressure hoop stress is twice the axial membrane stress due to pressure. While the higher pressure does decrease the allowable flaws sizes, the effect is small and does not impact the functionality or validity of the Code Case approach.

Table 3: Allowable Axial and Circumferential Flaw Size Comparison

| Nominal Pipe Size | Axial Direction (in) | | | Circumferential Direction (in) | | |
|--------------------------------|----------------------|----------|------------|--------------------------------|----------|------------|
| | 275 psig | 375 psig | % Δ | 275 psig | 375 psig | % Δ |
| 6-inch $M_b = 40$ in-kips | 3.1 | 2.4 | 23% | 2.8 | 2.4 | 14% |
| 12-inch $M_b = 170$ in-kips | 3.0 | 2.1 | 30% | 3.3 | 2.7 | 18% |
| 24-inch $M_b = 290$ in-kips | 1.5 | 0.9 | 40% | 3.0 | 2.1 | 30% |

Notes:

- Piping material assumed A106 Grade B; standard schedule thickness.
- Applied bending moment for each pipe size results in a stress ratio of about 0.25 at 275 psig.
- Allowable flaw sizes based on Service Level B structural factors.
- Analysis based on a conservative lower shelf toughness value of 45 in-lb/in².

Code Case N-513-3 cover thickness requirement comparison

Code Case N-513-3 provides a branch reinforcement method to evaluate nonplanar through-wall flaws. As part of the branch reinforcement approach, an opening is modeled such that its diameter fully bounds the leaking flaw. In practice, there could exist a remaining wall ligament within the modeled opening. Equation 9 of Code Case N-513-3 provides assurance against pressure blowout (i.e., wall ligament failure) by requiring an average cover thickness, $t_{c,avg}$, within the modeled opening:

$$t_{c,avg} \geq 0.353d_{adj}\sqrt{\frac{p}{S}} \quad (2)$$

where:

d_{adj} = Modeled opening diameter
 p = Maximum operating pressure
 S = Material allowable stress.

The average cover thickness requirement increases about 17% with an increase in maximum operating pressure from 275 to 375 psig. As with the minimum required wall thickness, the actual change in the average cover thickness requirement is relatively low. Figure 1 illustrates the average cover thickness required as a function of adjusted diameter for 275 and 375 psig. Note that a material allowable stress of 15 ksi is assumed. Typically, modeled openings are < 1 in and the change in the required cover thickness is not significant (< 10 mils).

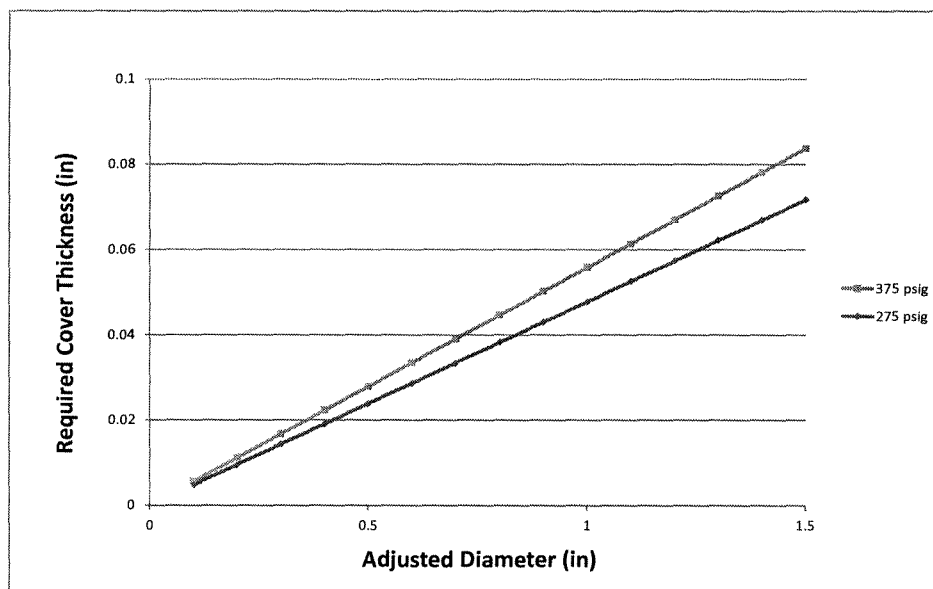


Figure 1: Required Cover Thickness vs. Adjusted Diameter for 275 and 375 psig

Jet Thrust Force Evaluation

Part 3.6.2 of the NRC Standard Review Plan [9] provides a simplified dynamic analysis model to quantify the jet thrust force, T , of water from a pipe break. The following equation is given:

$$T = KpA \quad (3)$$

where:

K = Thrust coefficient (2.0 for subcooled, nonflashing water)
 p = System pressure prior to pipe break
 A = Pipe break area.

Figure 2 shows a comparison of jet thrust force for pressures of 275 and 375 psig over a range of through-wall opening diameters. For small through-wall opening diameters (< 0.5 in), the difference in the jet thrust force is small. Assuming an opening diameter of 0.5 in and modeling the hole as a flat orifice, the expected leakage flow rate would be near 90 gpm. It is unlikely larger openings would be tolerated by the plant as this would result in excessive leakage and possibly impact system operability.

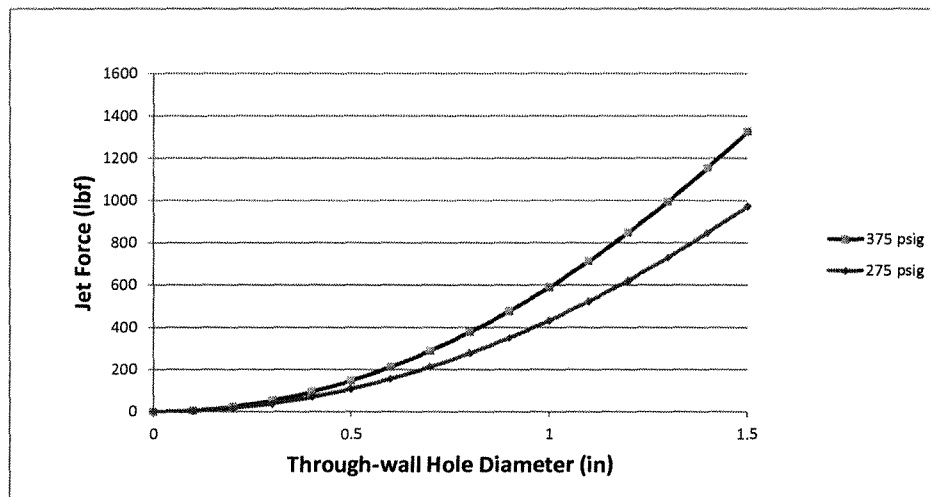


Figure 2: Jet Force vs. Through-wall Hole Diameter for 275 and 375 psig

ADDITIONAL REQUIREMENTS

Implementation of Code Case N-513-3 requires additional actions be satisfied by the plant including observing leakage daily to confirm analysis conditions used in the evaluation remain valid, frequent periodic inspections to track flaw growth and augmented examinations to assess degradation of the affected system. No change to these requirements is recommended for the generic Relief Request.

It is recommended, however, that a limit on the leakage rate be defined in the generic Relief Request in order to “tighten” the Code Case requirements considering the expanded scope to higher pressure systems. A leakage limit of 100 gpm is recommended which approximately corresponds to an actual opening area of 0.25 in^2 (i.e., a 0.5 in x 0.5 in square opening or an opening with a 0.56 in diameter).

CONCLUSIONS

This letter report provides a technical basis for the scope expansion of ASME Section XI Code Case N-513-3 to a higher pressure, specifically from 275 to 375 psig. The technical basis is comprised of three primary elements demonstrating that the proposed scope expansion has precedent and will not adversely impact component, system or plant safety.

First, relevant NRC relief requests were reviewed. They demonstrate the continued operation and/or non-Code repairs of high energy applications have been approved. In each of these requests, the licensee did not make any commitments beyond those already in Code Case N-597-1, Code Case N-513 or Generic Letter 90-05.

Second, a structural integrity evaluation was performed to determine the impact of the 100 psi increase in pressure on design minimum wall thickness, N-513-3 allowable flaw sizes and the N-513-3 cover thickness requirement. While the influence of the higher pressure was observed in the evaluation, the effect was small and structural integrity was not significantly impacted. The functionality and validity of the Code Case methods at higher pressure were confirmed.

Finally, jet thrust forces were estimated for a leaking pipe at 275 and 375 psig. A significant change in jet thrust forces was only seen with large opening areas that resulted in high leak rates, i.e., rates that would challenge system functional or local spray and/or compartment flooding requirements.

As part of the generic Relief Request, it is recommended that a limit on the leakage rate be defined in order to "tighten" the Code Case requirements considering the expanded scope to higher pressure systems. A leakage limit of 100 gpm is recommended which approximately corresponds to an actual opening area of 0.25 in² (i.e., a 0.5 in x 0.5 in square opening or an opening with a 0.56 in diameter).

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