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10 CFR 50.55a

RS-14-316

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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: Response to Request for Additional Information - 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

References:

1. Letter from J. Barstow (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "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," dated March 28, 2014

2. E-Mail from J. Weibe (U.S. Nuclear Regulatory Commission) to T. Loomis (Exelon Generation Company, LLC), "Peach Bottom & Quad Cities---RAI questions for Relief Request I4R-55 TAC MF3799, MF 3800, MF3801 and MF3802," dated September 8, 2014

In the Reference 1 letter, Exelon Generation Company, LLC (Exelon) requested 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." Specifically, Exelon requested 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.

In the Reference 2 e-mail, the U.S. Nuclear Regulatory Commission requested additional information. Attached is our response to that request.

If you have any questions concerning this letter, please contact Tom Loomis at (610) 765-5510.

There are no commitments contained in this submittal.

Respectfully,

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

Attachments:
1) Response to Request for Additional Information
2) Proposed Alternative to Utilize Code Case N-513-3 at a Higher System Operating Pressure, Revision 1
3) 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 (Precedents Revised)

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

Response to Request for Additional Information

Question:

1. In the relief request, the licensee referenced several precedents. It does not appear to the NRC staff that the precedents provided address relief for a generic (addressing a future leak) long term (up to 18-24 months), higher pressure (greater than 275 psi), and raw water application. Please discuss the applicability of the precedents to Relief Request I4R-55.

Response:

In response to this question, the precedents provided in the relief request are being deleted except for ML101440381. The precedents removed in this RAI response involved use of ASME Code requirements beyond defined limits for one specific component/condition that had known degradation. The retained precedent involved application of Code Case N-513-2 to future defined degradation in systems operating beyond the defined temperature limit. Exelon is requesting to use Code Case N-513-3 to address future degradation in piping operating at a pressure higher than that allowed by the Code Case. The remaining precedent involves applying Code Case N-513-2 to three specific Class 2 and 3 systems that operate at a temperature up to 275°F in lieu of the Code Case maximum operating temperature of 200°F. The relief request was submitted as a contingency to address known degradation in these systems until long-term corrective action could be completed for the systems. This relief request allowed use beyond a defined Code Case limitation for three specific systems for future discovered degradation and allowed continued operation within the limitations of the Code Case.

Exelon Generation Company, LLC (Exelon) is requesting use of Code Case N-513-3 for one specific Class 3 service water system at each site that operates at a higher pressure than specified in the Code Case. The precedent that limited use of Code processes beyond the specified application limits is acceptable when appropriate controls and limitations are applied. This precedent has direct application to the Exelon request to apply Code Case N-513-3 at a higher pressure.

Question:

2. The concepts of what constitute moderate energy piping and the limitation of ASME Code Case N-513 to moderate energy systems is well established. The NRC staff believes that authorizing the proposed alternative may create confusion regarding these issues. It is not clear to the NRC that the justification provided for the proposed alternative is sufficient given the potential confusion which may be created. Please provide comments regarding this issue.

Response:

This relief request addresses corrosion related degradation that is periodically observed, and to support extent of condition examinations that will evaluate the long-term health of the High Pressure Service Water (HPSW) and Residual Heat Removal Service Water (RHRSW) Systems. Examinations to assess the current condition of the systems may identify degraded conditions that do not meet ASME Section XI requirements but are acceptable for continued service based on both structural and leakage evaluations. Code repairs to operable but degraded components often require extensive planning and implementation time in order to minimize overall risk to the plant. The purpose of this relief request is to allow Exelon time to perform required repairs for degraded conditions in a manner that minimizes overall risk to the plant. When a Code repair for a degraded condition can reasonably be completed within the defined Technical Specification completion times, Exelon intends to complete the repair in lieu of implementation of this relief request.

Generic Letter 90-05 provides guidance for evaluating Class 3 piping components with Inner Diameter (ID) initiated degradation in systems with operating pressures greater than 275 psig. Generic Letter 90-05 was the predecessor to Code Case N-513. The various revisions of Code Case N-513 have included lessons learned and refinements through use of both methods. The Code Case retained the moderate energy limitation even though the evaluation methods could be applied to higher energy components. Similar to the application of Generic Letter 90-05, Code Case N-513-3 rules will be applied to allow the operable but degraded piping to remain in service until the next scheduled outage in which a Code repair can be performed without outage extension or increased risk to the plant but no later than restart from the next refueling outage.

<u>Question</u>:

3. The NRC staff believes that authorization of the proposed alternative may establish precedent for the use of Code Case N-513 at pressures above the current limits for moderate energy piping at plants other than Peach Bottom and Quad Cities. The NRC staff believes that establishing such a precedent may have far reaching consequences, some of which may be adverse. Any information which is known by the licensee regarding the extent to which other plants and/or licensees may have piping systems which are similar to those for which relief is requested would be useful in the NRC's decision making process. The NRC is aware that the licensee may have no knowledge of such systems and is not asking the licensee to acquire such information. To the extent which information regarding similar piping systems at other locations is available, please provide a discussion of the extent to which similar piping systems exist within the industry.

<u>Response</u>:

Exelon plants other than Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3 and Quad Cities Nuclear Power Station (QCNPS), Units 1 and 2 do not need similar relief requests for their similar RHR service water systems. Exelon owns or provides contracted services for operation of approximately 25% of the U.S. Nuclear Fleet. This relief request only applies to the BWR Mark I containment plants without isolation condensers, i.e., PBAPS, Units 2 and 3 and QCNPS, Units 1 and 2. Exelon is requesting this relief for one specific system at each plant that occasionally operates at a pressure greater than that allowed by Code Case N-513-3. The damage mechanism (corrosion degradation) associated with this relief request for a raw water system is a well-understood condition within Exelon and the industry.

<u>Question</u>:

4. The licensee submitted both relief requests under Title 10, Code of Federal Regulations, Part 50 (10 CFR), 55a(a)(3)(i) which specifies that the proposed alternative provides an acceptable level of quality and safety. This means that the proposed alterative would provide an equivalent level of quality and safety as that of an ASME Code repair. The NRC

staff believes that the use of the proposed alternative, i.e., continued operation with through wall leakage provides a lower level of quality and safety when compared with an ASME Code compliant repair. The NRC staff believes that requesting the use of the proposed alternative under 10 CFR 50.55a(a)(3)(ii) may be more appropriate. Please justify it is appropriate to make this request under 10 CFR 50.55a(a)(3)(i) rather than 10 CFR 50.55a(a)(3)(ii).

Response:

Exelon agrees that this relief request is more appropriately requested under 10 CFR 50.55a(a)(3)(ii) and has revised the relief request as required. Attachment 2 is the revised relief request.

Code repairs to operable but degraded components often require extensive planning and implementation time in order to minimize overall risk to the plant and avoid unnecessary plant shutdowns. Unnecessary plant shutdowns result in increased personnel dose, added plant cycling, and an increase in the overall plant risk as compared to performing repairs during planned system or plant outages. Allowing additional time before completing Code repairs on non-safety significant degradation allows completion of surveys on adjacent system segments to determine the overall system health and best approach for long-term management of degradation in the system. Unnecessary plant shutdowns result in a hardship without a compensating increase in the level of quality and safety that would be obtained by use of the proposed code case.

Question:

5. The relief request states that the operating pressure is less than or equal to 375 psi for the HPSW and RHRSW system piping at Peach Bottom and Quad Cities, respectively. (a) Discuss the design pressure, design temperature and the maximum operating temperature of the HPSW and RHRSW systems. (b) Discuss any segment of the HPSW and RHRSW piping that is inaccessible for visual and ultrasonic examinations (e.g., buried underground, covered with insulation, and interferences). In this discussion include how periodic monitoring of the leakage of any inaccessible segment(s) can be conducted as required by Code Case N-513-3. (c) Provide all pipe diameters and wall thickness of the HPSW and RHRSW to which the proposed alternative will be applicable.

Response:

The following response is provided for PBAPS, Units 2 and 3:

(a) The HPSW system piping design pressure is 450 psig and piping design temperature is 100°F. The HPSW maximum operating temperature is 92°F upstream of the RHR Heat Exchanger and approximately 130°F downstream of the RHR Heat Exchanger during the design basis accident scenario. The piping system and supports were analyzed to 178°F in this portion of the piping. A flow path is procedurally established prior to the start of a HPSW pump in order to avoid over pressurization of the system. The highest expected normal operating pressure occurs when placing a second HPSW pump in service prior to valving in the second RHR heat exchanger in that loop. This results in a conservatively calculated pressure that does not exceed

375 psig. The second pump is started prior to valving in the second heat exchanger to avoid diversion of single pump flow to two heat exchangers. The time at this condition is generally limited to the time required to start the pump and bring the second heat exchanger into service with two pumps operating. During normal plant shutdown conditions the system is in service to support Shutdown Cooling and generally operates at approximately 295 psig. There are times when the operating pressure is maintained as high as 350 psig in order to limit flow to a lower output in order to achieve the desired cooling. During Inservice Testing (IST) the system operates at approximately 295 psig. IST is performed at least quarterly for each HPSW pump, and routine system testing is performed monthly.

(b) Code Case N-513-3 cannot be applied to inaccessible locations because NDE data is required to evaluate a flaw. Any location where the Code Case will be applied will be accessible for required examination and monitoring in accordance with the Code Case. Insulated piping is considered accessible for examination; however, buried piping is not considered accessible for application of Code Case N-513-3 unless uncovered for a specific purpose such as follow-up inspection due to other inspection processes such as guided wave ultrasonic examination. Paragraph 5(a) of the Code Case and Generic Letter 90-05 both require augmented examination of susceptible and accessible piping locations to determine extent of condition of the affected system. Exelon intends to comply with this Code Case requirement.

(c) The main segments of the HPSW system range from 14 inches Nominal Pipe Size (NPS) to 18 inches NPS, and the piping wall thickness is 0.375 inch. The HPSW piping has an outside diameter of 14 inches NPS immediately after the RHR heat exchangers. After passing through an expander, the piping reaches 18 inches NPS. The 18-inch NPS piping comes to a tee where the piping reaches 24 inches NPS. This 24-inch NPS piping is only present immediately prior to the discharge pond where the need for the Code Case would no longer apply. The HPSW system has smaller branches and drains and vents that range from ½ inch NPS to 3 inches NPS.

The following response is provided for QCNPS, Units 1 and 2:

(a) The RHRSW system design pressure is 350 psig and design temperature is 150°F. The maximum operating pressure is limited by the RHRSW system relief valve that is set at 350 psig. RHRSW system operating temperature is dependent upon river temperature and does not have a specified maximum operating temperature. During normal plant shutdown conditions the system is in service to support Shutdown Cooling and operates at or below 350 psig. During IST, the system operates at approximately 255 psig. IST is performed at least quarterly for each RHRSW pump.

(b) Code Case N-513-3 cannot be applied to inaccessible locations because NDE data is required to evaluate a flaw. Any location where the Code Case will be applied will be accessible for required examination and monitoring in accordance with the Code Case. Insulated piping is considered accessible for examination; however, buried piping is not considered accessible for application of Code Case N-513-3 unless uncovered for a specific purpose such as follow-up inspection due to other inspection processes such as guided wave ultrasonic examination. Paragraph 5(a) of the Code Case and Generic Letter 90-05 both require augmented examination of susceptible and accessible piping locations to determine extent of condition of the affected system. Exelon intends to comply with this Code Case requirement.

(c) The main segments of the RHRSW system consist of piping that is 12 inches NPS and 16 inches NPS, each with a wall thickness of 0.375 inches. The RHRSW system has smaller branches and drains and vents that range from ½ inch NPS to 4 inches NPS.

Question:

6. The relief requests stated that both HPSW and RHRSW systems are used only during testing and plant shutdown. It appears that both systems will not be used during plant operation. The NRC staff understands that when both systems are needed to be functional during plant shutdown, performing an ASME Code repair would be a hardship.

   (a) However, if a leak occurs during the normal plant operation while the HPSW and RHRSW systems are not being used, discuss why the proposed alternative is needed and why an ASME Code repair cannot be performed.

   (b) Discuss whether these two piping systems are needed to be operable during an emergency condition. If yes, justify why the proposed alternative is permitted to be used during the emergency condition.

Response:

(a) If a leak or thinned area below minimum wall thickness is identified while the plant is operating, the PBAPS, Units 2 and 3, Technical Specification (TS) 3.7.1, and the QCNPS, Units 1 and 2, TS 3.7.1, allows 7 days for restoration unless the condition can be declared operable but degraded using an evaluation method acceptable to the NRC. Code repairs often require changing plant conditions and mobilization of personnel and parts that cannot be completed within the time limits.

(b) The HPSW and RHRSW systems are required during emergency conditions. Application of Code Case N-513-3 guidance assures structural integrity of the degraded area is maintained. Leakage integrity is evaluated to assure there are no detrimental effects to plant components including flooding. NRC Inspection Manual Chapter 0326, Appendix C, provides guidance that components having adequate structural integrity may be considered degraded but operable. This same approach is applied to all other locations in which the Code Case may be applied without NRC relief.

Question:

7. The Summary section of the relief requests states that the allowable leakage of the HPSW or RHRSW piping is 100 gallons per minute (gpm). This is a significant leak rate. The NRC staff notes that NRC Branch Technical Position 3-3, Revision 3, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," and Branch Technical Position 3-4, Revision 2, " Postulated Rupture Locations in Fluid System Piping Inside and

Outside Containment," of Standard Review Plan, NUREG-0800, provide guidance on flooding analysis.

(a) Discuss whether a 100 gpm leak rate is within the design basis flooding analysis associated with the rooms, buildings, and compartments that HPSW and RHRSW piping are located in light of a significant allowable leak rate of 100 gpm.

(b) Discuss whether the pumps of these two systems have the capacity to make up the mass flow to compensate for a 100 gpm leak rate to maintain the intended function of both HPSW and RHRSW systems.

(c) If the leak rate exceeds 100 gpm, discuss corrective actions.

(d) The NRC staff believes that an allowable leak rate of 100 gpm is too high of a limit. Provide either a justification for such a high allowable leak rate or lower the allowable leak rate.

Response:

(a) The design basis flooding analysis is considered for each leak and evaluated using the Exelon Operability Evaluation process. The evaluation process must consider requirements or commitments established for the system, continued degradation and potential consequences, operating experience, and engineering judgment. In some cases, much smaller leaks than the maximum defined could be appropriate. The original relief request required that leakage be limited to the maximum allowed by evaluation or 100 gpm. Exelon has revised the relief request to require a 30 gpm maximum limit in order to add additional margin in application of this relief request.

(b) For PBAPS, Units 2 and 3, the HPSW system normally operates at approximately 4900 gpm with a design requirement of 4500 gpm. This provides a margin of 400 gpm as a makeup to the 100 gpm loss. Exelon has also reduced the allowed maximum leakage from 100 gpm to 30 gpm to provide additional margin.

For QCNPS, Units 1 and 2, each RHRSW pump is required to produce greater than 3500 gpm to the RHR heat exchanger at a discharge pressure of greater than 199 psig corrected for river level and pressure instrument inaccuracies in all operating and shutdown modes. The RHRSW pumps are tested to ensure a total flow rate of 3883 gpm is produced. Each RHRSW pump is verified to produce up to 4100 gpm as part of a biennial performance test. This provides a margin of 217 gpm as a makeup to the 100 gpm loss. Exelon has also reduced the allowed maximum leakage from 100 gpm to 30 gpm to provide additional margin.

(c) Exelon has revised the maximum allowed leakage to the maximum allowed by evaluation or 30 gpm whichever is lower. If a degraded area exceeds defined leakage or structural limits the piping must be declared inoperable and the Technical Specification Action statements for the applicable system must be followed.

(d) Exelon has revised the relief request leakage limit to the maximum allowed by evaluation or 30 gpm, whichever is lower.

Question:

8. Page 6 of Attachment 2 discussed the average cover thickness calculated for 275 psi and 375 psi pressure. The average cover thickness and average diameter equations as specified in Code Case N-513-3 are to demonstrate acceptability under the branch reinforcement requirements. Demonstrate that a leaking pipe with a leak rate of 100 gpm at a pressure of 375 psi will satisfy the branch reinforcement requirements of Code Case N-513-3.

Response:

Exelon has reduced the allowable leak rate to the maximum allowed by evaluation or 30 gpm, whichever is lower. See below for a simplified computation for branch connection reinforcement determination in a 20-inch nominal diameter, ferritic steel pipe, that is 0.375 inch nominal wall thickness and operating at 375 psi as an example. The allowed hole diameter in this case is 1.482 inch. It should be noted that for through-wall flaws the planar flaw criteria is generally applied by evaluating the axial extent and circumferential extent as planar flaws.

$$D_o := 20 \cdot in$$

$$t_n := 0.375 \cdot in \qquad R := \frac{(D_o - t_n)}{2} \qquad R = 9.813 \cdot in$$

$$P := 375 \cdot psi$$

$$S := 15000 \cdot psi$$

$$t_{min} := \frac{P \cdot D_o}{2(S + 0.4 \cdot P)} \qquad t_{min} = 0.248 \cdot in$$

Area Replacement Limit for a uniform hole through a nominal wall thickness:

$$t_{adj} := t_n$$

$$d_{adj} := \frac{1.5 \cdot \sqrt{R \cdot t_{adj}} \cdot (t_{adj} - t_{min})}{t_{min}} \qquad d_{adj} = 1.482 \cdot in$$

Question:

9. Page 6 of Attachment 2 discusses the result of jet thrust force calculations between a pressure of 275 psi and 375 psi. Demonstrate that the jet thrust force calculated at a pressure of 375 psi will not be detrimental to the adjacent safety-related systems, structures and components.

Response:

The evaluation process must consider requirements or commitments established for the system, continued degradation and potential consequences, operating experience, and engineering judgment. In some cases much smaller leaks than the maximum defined could be appropriate. The original relief request required that leakage be limited to the maximum allowed by evaluation or 100 gpm. Exelon has revised the relief request to require a 30 gpm maximum limit in order to add additional margin in application of this relief request. Exelon has experience with managing raw water leaks less than 30 gpm. The need to evaluate the effect on adjacent equipment is appropriate whether the system, in which the leak is occurring, is safety-related or nonsafety-related because safety-related components could be adjacent to nonsafety-related leaking pipes. The evaluation process must consider functionality of electrical equipment based on ability to resist water intrusion or actions must be taken to prevent wetting of the equipment. The ability of the adjacent area to remove the water volume must be addressed. The evaluation must consider and address all postulated negative effects of leakage regardless of pressure and conclude there are no unacceptable resultant conditions; otherwise, the leakage would be deemed unacceptable.

Question:

10. Page 7 of Attachment 2 states that a pipe opening (hole) with a diameter of 0.5 inches will result in a leak rate of 90 gpm. Provide the detailed calculation to show how 90 gpm is derived from a 0.5-inch diameter hole.

Response:

Exelon has revised the relief request to require a 30 gpm maximum limit in order to add additional margin in application of this relief request.

The computation below provides the leak rate from a ½ inch diameter orifice plate. The computation is based on "Blevins, Robert, Applied Fluid Dynamics Handbook, Van Nostrand Reinhold Company, New York, 1984, pp. 81."

Flow Through an Orifice Plate

Temperature = 200^0F

Pipe Pressure = 375 psig [In psig = Δp]

C = 0.6

Hole Diameter = 0.5 inch

Density = 60.1 lb_m/ft^3

Hole Velocity = 144.3 ft/s (Equation. 6-38)

Hole Area = 0.001364 ft^2

Flow Rate = 88.3 gpm

Hole Area = 0.1963495 in^2

Attachment 2

Proposed Alternative to Utilize Code Case N-513-3 at a Higher System Operating Pressure, Revision 1

Request to Use Code Case N-513-3 at a Higher System Operating Pressure in Accordance with 10 CFR 50.55a(a)(3)(ii)

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:

PLANT	INTERVAL	EDITION	START	END
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)(ii), 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 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 relief request will be applied to HPSW/RHRSW piping with corrosion degradation only if Code repairs cannot be reasonably completed within the Technical Specification required time limit.

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 for moderate energy piping 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 on specific systems operating at temperatures greater than 200°F (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 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:
  - analysis,
  - test or partial test,

- 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 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.

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 if Code repairs cannot reasonably be completed within the Technical Specification required time limit. 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 30 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 30 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.

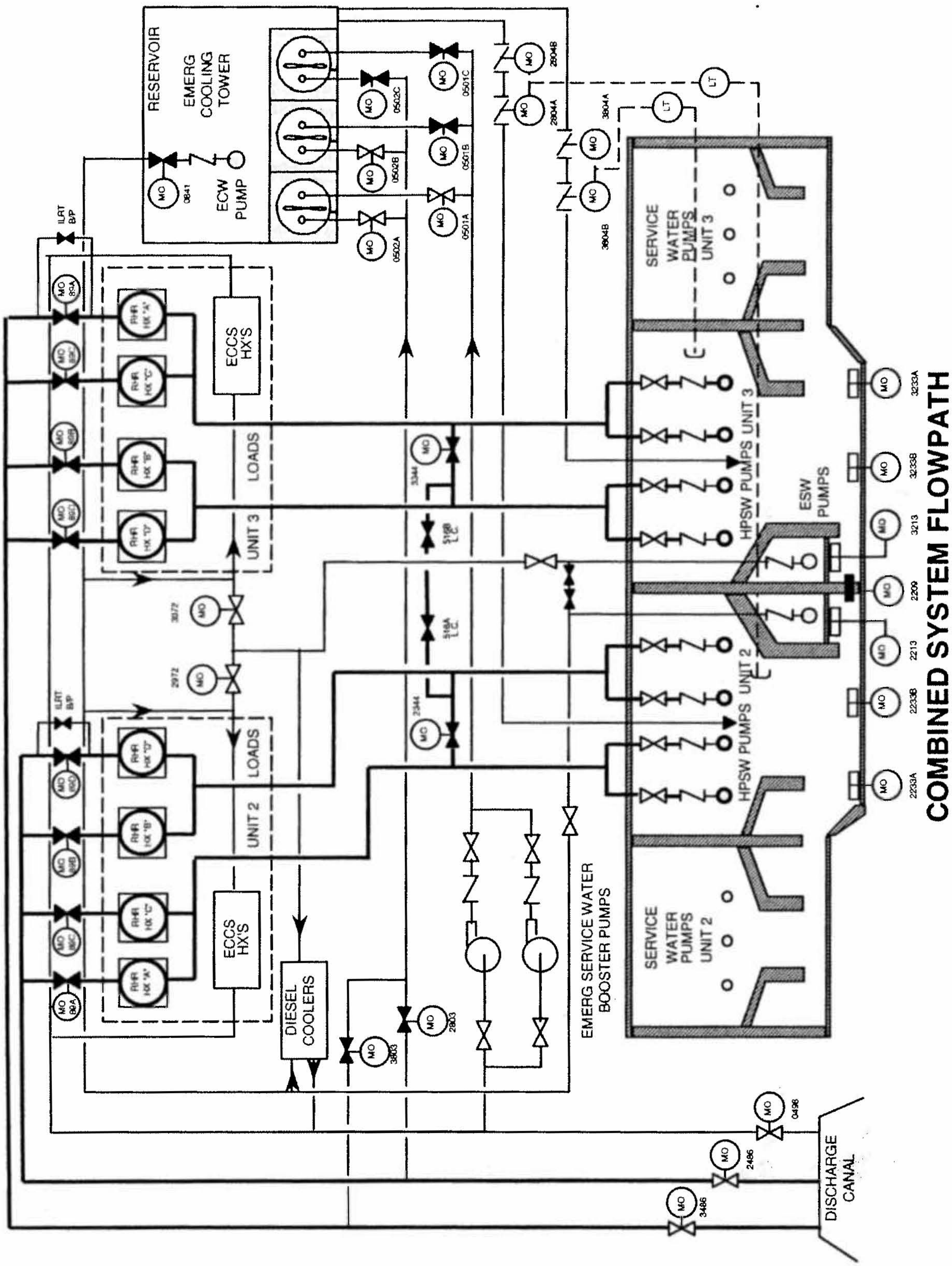
6. Duration of Proposed Alternative:

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.

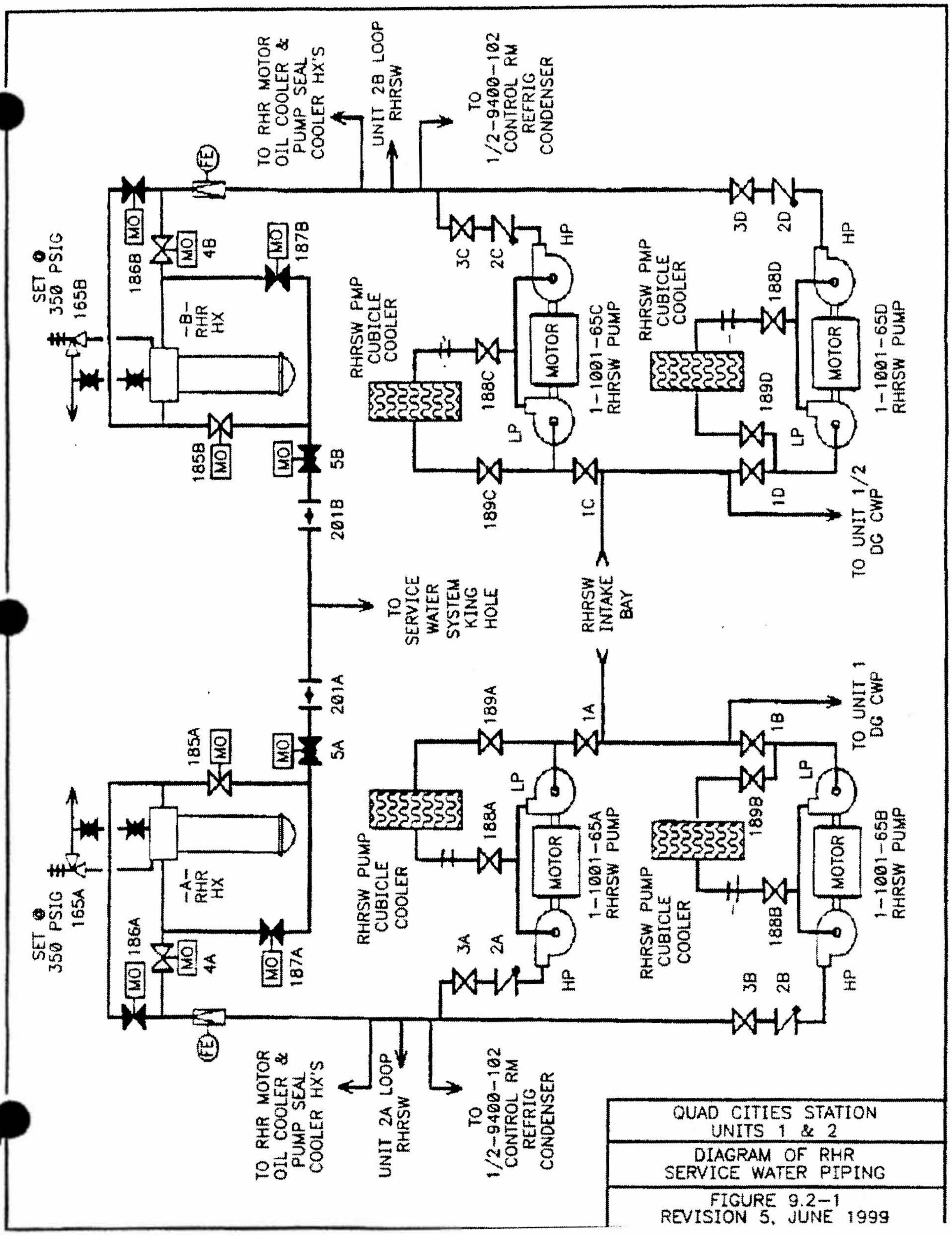
7. Precedent:

See Attachment 3

Enclosure 1
Peach Bottom HPSW Flow Diagram



Enclosure 2
Quad Cities RHRSW Flow Diagram



Attachment 3
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
(Precedents Revised)

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March 13, 2014
Report No. 1400176.401.R0
Quality Program: ☒ Nuclear ☐ Commercial

Guy DeBoo
Exelon Nuclear
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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.

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

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Table 1: Summary of Relevant Relief Requests

ADAMS Accession Number	Plant / Operating Condition	Description	Status
ML101440381	San Onofre U2, U3 / < 275 psig (275° F)	Generic application for continued operation of high temperature through-wall leaking pipe	Approved

DELETED TEXT

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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/in^2.

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:

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

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).

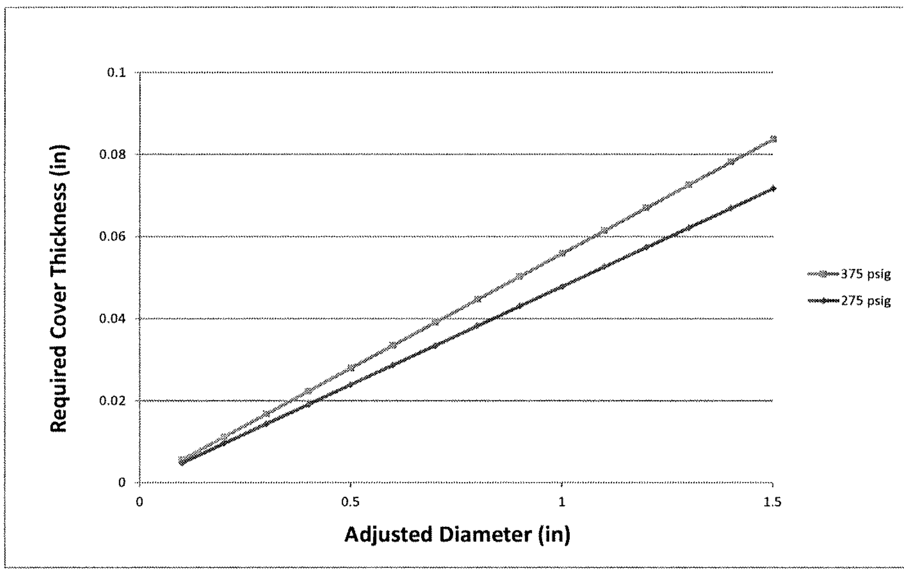

Figure 1: Required Cover Thickness vs. Adjusted Diameter for 275 and 375 psig

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:

$$T = KpA \tag{3}$$

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.

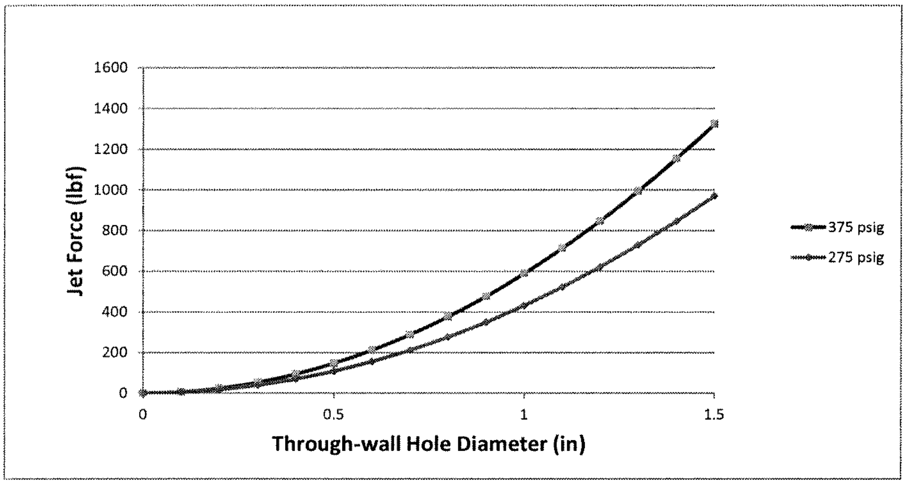

Figure 2: Jet Force vs. Through-wall Hole Diameter for 275 and 375 psig

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 in^2 (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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