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

Serial No.	21-292
NRA/SS	R0
Docket No.	50-423
License No.	NPF-49

DOMINION ENERGY NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 3
ALTERNATIVE REQUEST IR-4-09 FOR USE OF AN ALTERNATIVE BRAZED JOINT ASSESSMENT METHODOLOGY TO DEMONSTRATE STRUCTURAL INTEGRITY OF CLASS 3 MODERATE-ENERGY PIPING

Pursuant to 10 CFR 50.55a(z)(2), Dominion Energy Nuclear Connecticut, Inc. (DENC) requests Nuclear Regulatory Commission (NRC) approval to use an alternative to the requirements of IWD 3132.3(b) of the American Society of Mechanical Engineers (ASME) Code, Section XI, 2013 Edition. The proposed alternative evaluation method would allow for temporary acceptance of brazed joint leakage in moderate energy, copper-nickel and nickel-copper, Class 3, service water piping with cast bronze fittings. Temporary acceptance is based on determining the degree of remaining bonding through ultrasonic (UT) examination of the affected brazed joint (similar to the approach given in ASME Code Case N-874), in combination with performing a structural integrity assessment (utilizing the guidance of ASME Code Case N-513-4). Final repair of a leaking brazed joint would be performed during the next refueling outage following leakage identification. Until a repair is completed, periodic monitoring of a leaking joint would be performed to verify that the assumptions of the structural evaluation remain valid. With this approach, leaking brazed joints can be replaced in a systematic and planned manner, without unnecessary unavailability of safety related systems or components or unnecessary plant shutdowns.

Attachment 1 provides Relief Request IR-4-09. Attachments 2 and 3 provide applicable figures, and applicable brazed joint configurations and materials, respectively. Attachment 4 provides a summary of previous applications of the approved brazed joint assessment methodology and a technical evaluation example. Attachment 5 describes the mechanical testing performed for MPS3. Attachment 6 provides a UT procedure for reference only (which is subject to change). Attachment 7 provides additional technical basis information related to braze shear stress.

If you have any questions regarding this submittal, please contact Shayan Sinha at (804) 273-4687.

Sincerely,

Mark D. Sartain
Vice President Nuclear Engineering & Fleet Support

Attachments:

1. Alternative Request IR-4-09, Use of an Alternative Brazed Joint Assessment Methodology to Demonstrate Structural Integrity of Class 3 Moderate-Energy Piping
2. Applicable Figures
3. Applicable Brazed Joint Configuration and Materials
4. Summary of Previous Methodology Applications and Technical Evaluation Example
5. Mechanical Tests
6. Ultrasonic Test Procedure
7. Additional Basis for Braze Shear Stress

Commitments made in this letter: None

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ATTACHMENT 1

ALTERNATIVE REQUEST IR-4-09, USE OF AN ALTERNATIVE BRAZED JOINT ASSESSMENT METHODOLOGY TO DEMONSTRATE STRUCTURAL INTEGRITY OF CLASS 3 MODERATE-ENERGY PIPING

MILLSTONE POWER STATION UNIT 3
DOMINION ENERGY NUCLEAR CONNECTICUT, INC. (DENC)

Alternative Request IR-4-09
In Accordance with 10 CFR 50.55a(z)(2)

Hardship Without a Compensating Increase in Quality and Safety

1. ASME Code Component(s) Affected

ASME Code Class:	Code Class 3
References:	ASME Section XI, IWD-3132.3(b)
Examination Category:	N/A
Item Number:	N/A
Description:	Alternative Brazed Joint Assessment Methodology
Components:	Service Water System Brazed Piping Joints, Three Inches Nominal Size and Smaller

Figure 1 in Attachment 2 shows a typical brazed joint. Attachment 3 provides additional details concerning applicable brazed joint materials, configuration, and brazing.

2. Applicable Code Edition and Addenda

ASME Section XI, 2013 Edition (No Addenda)

3. Applicable Code Requirement

IWD-3132.3 Acceptance by Evaluation
A component containing relevant conditions is acceptable for continued service if an evaluation demonstrates the component's acceptability in accordance with (a) or (b) below.

(b) Temporary acceptance of flaws in moderate energy piping may be performed in accordance with Nonmandatory Appendix U, Supplement U-S1, and temporary acceptance of degradation in moderate energy vessels and tanks may be performed in accordance with Nonmandatory Appendix U, Supplement U-S2.

The ASME Section XI Nonmandatory Appendix U requirements do not provide guidance specific to evaluation and temporary acceptance of brazed joint leakage. As such, leakage from an unisolable brazed joint could require removal of the unit from service to support isolation and draining of the associated service water train.

DENC is proposing to use an alternative evaluation method that would allow for temporary acceptance of brazed joint leakage in moderate energy, copper-nickel and nickel-copper, service water piping with cast bronze fittings. The proposed alternative evaluation method is similar to the guidance of ASME Code Case N-874, which is expected to be designated an acceptable code case for use in the upcoming Revision 20 of Regulatory Guide 1.147 (ADAMS Accession No. ML20120A631). One difference between this proposed alternative and Code Case N-874 is that additional provisions for acceptance when <60% bond is detectable are also included in the proposed alternative. Any brazed joint leakage that is detected and temporarily accepted using the proposed alternative evaluation criteria would be subject to ongoing monitoring and would be repaired in accordance with ASME Section XI Article IWA-4000 no later than the next refueling outage. The proposed alternative evaluation is also consistent with aspects of ASME Code Case N-513-4, which is listed by the NRC as an acceptable code case for use in the currently approved Revision 19 of Regulatory Guide 1.147.

4. Reason for Request

During the course of plant operation, minor leakage of brazed joints is sometimes observed through a defect in the braze bond between the pipe and fitting. Leakage is considered to be minor when it is at a rate of drops per minute, or if only moisture or salt deposits are visible.

Section XI and Section III of the ASME Code do not have guidance applicable to evaluation of minor leakage through brazed joints caused by defects in braze bonding between piping and fittings. Section XI, IWD-3000, has no requirements pertaining to brazed joints. Therefore, Section XI does not have rules specific to examination and acceptance of relevant conditions observed in brazed joints. Lacking such guidance, the leaking joint must be repaired in accordance with IWD-3132.2.

A safe alternative to the requirement to immediately repair a brazed joint with minor leakage can include a deferred, but planned, repair/replacement activity that permits continued plant operation based on an evaluation of continued acceptable integrity and functionality of the brazed joint. With this approach, leaking brazed joints can be replaced in a systematic and planned manner, without requiring unnecessary unavailability of safety related systems or components or the potential for unnecessary plant shutdowns.

In some cases, performing an ASME Code repair on a degraded brazed joint might render certain safety-related systems or components inoperable, thereby potentially requiring a plant shutdown to comply with Technical Specification requirements. A plant shutdown would unnecessarily cycle plant components, which is not desirable in maintaining the structural integrity of the safety-related components. Additionally, the need to shut down the plant for implementing an ASME Code repair of a brazed joint with minor leakage would result in hardship without a compensating increase in the level of quality and safety when the structural integrity of the degraded joint and associated system functionality can be ensured by appropriate evaluation.

5. Proposed Alternative and Basis for Use

In lieu of the immediate repair requirement of IWD 3132.2, DENC proposes to perform a supplemental ultrasonic (UT) examination and comparison with alternative acceptance criteria. The UT examination will establish the extent of braze bond within the joint. The UT results will be compared with pre-established brazed joint bond levels required for structural integrity of the specific piping under consideration that accounts for the design basis loadings applicable to the condition. This method will establish the basis for determining joint integrity to the extent required for system operability.

The proposed methodology provides for continued monitoring until the nonconforming condition (e.g., minor leakage) is resolved through repair/replacement activities. Periodic monitoring of the joint and its leakage verifies that the assumptions used for the assessment remain valid. The overall methodology has been validated by performance of physical testing on an array of simulated bond configurations, and several brazed joints salvaged from MPS3 piping.

5.1 SCOPE

The alternative is limited to brazed, Class 3, service water piping (typically constructed of copper-nickel or nickel-copper piping and cast bronze fittings) or on-skid equipment piping that has a design pressure of 150 psig or less and a design temperature of 150 degrees Fahrenheit or less. The piping nominal size is limited to three inches maximum.

Basis:
The limitation of pipe sizes to three inches or less ensures that the alternative is applied to piping for which it was intended and is comparable to the range of pipe sizes (two and three inches) included in the physical testing described in Attachment 5. The limitation to service water systems ensures that the operating pressure and temperature are well within the moderate energy range. The fluid contents of the piping are comparable to those examined for potential corrosion effects.

5.2 EXAMINATION

As permitted by IWD-3200, "Supplemental Examinations," the brazed joint will be examined by UT using a straight beam technique that monitors the relative strengths of signals returned from the internal diameter (ID) of the pipe and the fitting. This technique was derived from, and is consistent with, a technique standardized by the U.S. Navy for use on brazed shipboard piping.[1]

The UT procedure in Attachment 6 is provided for reference only and is subject to change. The UT procedure will require that technicians be certified in accordance with ANSI / ASNT CP-189, 1995 Edition. Only Level II or III certified technicians may perform or review the brazed joint UT results, and they must be familiar with brazed joint geometry and signal response characteristics. As a prerequisite, the examination surface must be suitably prepared to obtain satisfactory sound transmission. The joint circumference is marked at a number of locations such that they are spaced no greater than one inch apart. A straight beam longitudinal wave signal is required for the actual examination. At each marked location, the percent bond is recorded based on the relative strengths of signals received from the pipe ID and fitting ID. The procedure provides instructions to distinguish between fittings of the "face fed" and "insert" type, the latter of which have an internal groove in which a ring of braze filler material is inserted before brazing.

The MPS3 UT procedure will provide suitable data sheets for documenting the braze bond readings and calibration data. The data sheets are reviewed by a certified Level II or III reviewer. The data sheets are then forwarded to Engineering for assessment.

<u>Basis for Nondestructive Examination Technique:</u>

The alternative UT examination is based on requirements for UT examination contained in the U.S. Navy standard for fabrication and inspection of brazed piping. It uses basic straight beam UT technology, and was utilized to confirm the quality of critical piping systems in the submarine fleet of the U.S. Navy. A brazed joint is considered acceptable without further evaluation by the standard if the average measured bond reading is 60 percent or more.

Consistent with the referenced standard, the MPS3 procedure will require this work to be performed by certified UT technicians, using calibrated equipment and approved couplants. It will require examination at multiple locations around the circumference of the fitting. It will require review of the data by a Level II or III technician. The UT procedure has been reviewed and approved by a Level III technician in accordance with DENC's quality requirements.

Previous trial demonstrations show that individual bond readings at a location on the fitting may vary, but the average reading is consistent among qualified examiners.

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[1] NAVSEA 0900-LP-001-7000, "Fabrication and Inspection of Brazed Piping Systems", dated January 1, 1973.

5.3 ASSESSMENT

An assessment of the joint using this methodology includes the following considerations:

- System performance and indirect effects assessments,
- Adjustment of bond readings to account for uncertainties,
- A review of the design basis stress analysis of the piping to determine required joint strength, and
- Comparison of the adjusted bond readings with the prequalified bond levels that have been shown empirically by physical testing to assure structural integrity.

5.3.1 SYSTEM EFFECTS

As a prerequisite to structural assessment, knowledgeable engineering personnel assess the effect of the leak on the system and other nearby equipment. Typically, a brazed joint with a defect in the braze material bonding will leak only drops per minute. The actual leak rate will be estimated and compared to service water system margins for loss or diversion of flow. In addition, a walkdown will be performed to identify any nearby equipment that may be affected by dripping or impingement spray from the leak. If required, a drip collection device or spray shield will be installed and maintained for the duration that the leak continues.

Basis:

ASME Code, Section XI Code Cases, such as N-513-4, permit continued operation of moderate energy systems with minor leakage when justified by evaluation of system performance. Similarly, the proposed alternative permits continued operation provided that the leakage rate will not adversely affect required flows, and the leakage or spray will not adversely affect safety-related equipment. Typical flow from a brazed joint experiencing minor leakage is in terms of drops per minute. Even in a theoretical worst case of a joint having a total lack of braze material, the close tolerance between the pipe and fitting prevents significant flow. The total diametric clearance of a braze joint is about 0.005 inches. For a three-inch pipe, the maximum possible flow area would be nominally 0.027 square inches (e.g., 3.14 x 3.5 x 0.0025) through which the upper bound flow rate at 100 psig would be about 6 gpm, a very small flow rate in comparison to service water pump capacity. More realistic estimates and actual leak rates would be much lower. Therefore, the maximum potential braze joint leakage is very small. In addition, the proposed alternative requires a specific evaluation to assure that leakage does not unacceptably reduce system margins. Therefore, the system will meet all functional requirements and maintain an equivalent level of quality and safety.

5.3.2 ACCEPTANCE THRESHOLD AND ADJUSTMENT OF BOND READINGS

If the average measured bond reading is 60 percent or more, then no further assessment is required since the bond strength exceeds piping strength. If the average is less than 60 percent, then the bond readings as documented in the UT procedure are adjusted downwards on a sliding scale. The adjustments would be made such that all readings at 10 percent and below are assumed to be zero, and readings above 10 percent are adjusted using the following formula:

b_{adj} = 100 x (reading -10)/(100 - 10) units of percent

For example, a 50 percent UT reading would be adjusted to 44 percent bond level for assessment purposes. For simplicity, the adjustment may be applied to the average of the UT readings, or alternatively to each of the UT readings prior to averaging. The average of the adjusted readings is then used for assessment purposes. For bond readings that are significantly non-uniform around the circumference of the braze, an effective (lower) bond is computed based on the equivalent moment of the adjusted bond areas.

If the average adjusted bond reading is above 55 percent, then the joint strength is considered equal to or better than the piping, and steps 5.3.3 and 5.3.4 below are not performed.

<u>Basis for acceptance threshold and adjustments of readings:</u>

Acceptance of average UT bond readings of 60 percent or more is the same as the acceptance criteria in the U.S. Navy standard that has been used for critical shipboard piping systems. The U. S. Navy criteria are applicable to systems rated 300 psig and greater. The 60 percent threshold criterion is therefore conservative for systems with design conditions of 150 psig or less. For further confirmation of the 60 percent threshold, testing has shown that if true bond in the joint exceeds 30 percent, then the piping collapse load occurs before any bond failure. The testing performed for MPS3 is described in Attachment 5. There is no braze bond failure mode because the piping deforms plastically to relieve the imposed load, and this occurs at loads greater than the maximum load permitted by the licensing basis analysis of the piping. The downward adjustment of bond readings beyond what is required by the U.S. Navy standard is an introduced conservatism used to help correlate the data from actual piping samples, and accounts for uncertainties in bond readings.

5.3.3 CONSTRUCTION CODE QUALIFICATION STRESS ANALYSIS REVIEW

The Construction Code qualification stress analysis of record is reviewed to determine design basis loadings at the subject brazed joint. Pressure, deadweight, and safe shutdown earthquake (SSE) loadings are included. The loads are either used directly or expressed in terms of equivalent pipe stress, so that stress analysis outputs may be used directly. The stress intensification factor (SIF) that may have been applied in Construction Code stress analysis is not required to be included in the summation of nominal stresses used for assessment.

<u>Basis for Stress Analysis Review:</u>

The review of stress analysis required by this proposal is a data gathering activity required to determine the primary loads imposed on the brazed joint. The primary loads consist of maximum operating pressure, deadweight, SSE seismic, and any transient dynamic loads that have been defined for the piping. Since the stress analysis is the calculation of record for qualifying the piping in accordance with licensing basis requirements, it is an acceptable source of input for assessing the structural integrity of brazed joints.

The use of Construction Code stress values implicitly treats piping torsion loads as equivalent to bending moments. This is conservative because in the bonded joint, the torsional shear is half that calculated on an equivalent pipe stress basis.

5.3.4 COMPARISON OF ADJUSTED BOND TO REQUIRED BOND

Equation 3 in Figure 2 of Attachment 2 was developed to give the allowable loading for an equivalent bond level. The equation is used for a comparison that is needed only when the average bond is less than 60 percent. When an equivalent adjusted bond of a brazed joint is determined, as described in Section 5.3.2, an allowable loading ($S_{max}(b_{adj})$) can be obtained from the equation. This is the safe loading level that the joint can withstand. If the joint load demand that has been determined in Section 5.3.3, multiplied by a factor of safety (FS) of 1.5, is less than the allowable ($1.5\ S_{eq} < S_{max}(b_{adj})$), then the brazed joint is concluded to have adequate structural integrity for continued service. The comparison is quantified as shown in Figure 2.

An example of a structural assessment performed for an actual leaking brazed joint is included in Attachment 4. One joint in the example is SWP95-FW-38, which was observed to have a 42 percent average measured bond. The measured bond values were adjusted as described above, and this effective bond level results in a joint load capability of 7.015 ksi nominal pipe stress. The 7.015 ksi load capability is adequate for the design basis loads of this example, since the joint load demand, including an FS of 1.5, is 6.308 ksi. Therefore, the example structural assessment concludes the joint can be left in service provided it is monitored until its permanent repair/replacement activity is completed.

If a joint does not have adequate bond by this assessment, the comparison for determining the adequacy of structural integrity of the joint is not applicable. Prompt repair/replacement of the joint, or temporary non-Code repairs subject to NRC review and approval may be options for the resolution of nonconforming conditions, consistent with considerations in Inspection Manual Chapter (IMC) 0326, "Operability Determinations," dated 10/01/2019.

Basis for Comparison of an Adjusted to Required Bonding:

Brazed joints with reduced bond levels can retain a significant strength that is adequate for the structural integrity of the joint. DENC sponsored tests at an independent testing facility to demonstrate the correlation between reduced bond levels and joint strength. The tests and their results are described in Attachment 5.

The correlation developed by the testing conservatively determined a required bond level for a given intensity of joint loading. The results of these tests support the use of the comparison shown in Figure 2 of Attachment 2 for the structural integrity analysis.

The estimated joint strength obtained using Equation 3 in Figure 2 is confirmed conservative by test results. Each of the tested joints achieved a collapse load above the load which would be predicted for a 7.5 ksi braze shear strength. This also confirms the acceptability of the 7.5 ksi maximum braze shear stress assumption that is used as an input to the Equation 3, shown in Figure 2. Additional basis for acceptability of this value is contained in Attachment 7.

The evaluation of the test results considers the adjustment of bond readings imposed by this methodology, a joint load capacity that is based on a 7.5 ksi shear stress, and an imposed FS of 1.5 on loads and pressure. With all these considerations, the tests demonstrate that a margin of greater than 1.5 exists between test results and estimated allowable joint load capacity from the actual piping removed from plant service. This margin provides an FS equivalent to what is provided by the ASME Code, Sections III and XI as discussed below.

The ASME Code, Section III, Appendix F has been referenced by the NRC for evaluation of degraded conditions.[1] Appendix F, paragraph F-1331.1 (a) permits primary stress at levels up to $0.7S_u$ (code specified ultimate tensile strength) and in paragraph (c), it permits primary membrane plus bending stress at levels up to $(1.5)(0.7S_u) = 1.05S_u$. The maximum FS resulting from these comparisons is 1.4 relative to ultimate strength. For shear across a section, paragraph F-1331.1 (d) limits shear to $0.42S_u$ for an FS of 1.37 relative to $(1 / \sqrt{3})S_u$. The 7.5 ksi shear limit used at the braze bond is well below this Appendix F limit of $0.42S_u$ for the pipe and fitting materials.

The ASME Code, Section XI permits acceptance of planar flaws for which Appendix C requires an FS of 1.4 for circumferential flaws (paragraph C-2621) and requires an FS of 1.3 for axial flaws for faulted loads (paragraph C-2622). These FSs from Appendix C are also incorporated by reference in Code Case N-513-4.

Considering the ASME Code references described above, an FS of 1.5 for design basis loadings in ductile materials provides an equivalent and acceptable level of safety as compared to the plant design basis and permitted methodologies for evaluation of flaws.

5.4 MONITORING

The proposed alternative assessment methodology requires periodic monitoring to assure that the assumptions of the assessment remain valid. This monitoring will be in addition to the normal daily plant operator rounds, during which personnel observe for signs of leakage. The monitoring will be by visual observation of the appearance of the joint and its leak rate, plus re-examination of the joint by UT to reconfirm the percent bonding. The frequency of the monitoring will be approximately once every three months. The monitoring will continue as described until the joint is repaired or replaced. If there are changes in the nonconforming condition of an evaluated brazed joint with minor leakage that may impact its assessment for adequate structural integrity or its functionality, a Condition Report will be generated in accordance with the Millstone Power Station Corrective Action Program. The UT readings on the joint will also be repeated and reassessed.

[1] NRC Inspection Manual, Inspection Manual Chapter 0326, "Operability Determinations," October 1, 2019.

Monitoring Basis:

The degree and frequency of periodic monitoring is conservative because the braze defect that permits this form of leakage stems from original construction or fabrication and is not the result of a progressive degradation mechanism. Conditions that are applicable to the use of this methodology arise from defects in braze material inside a socket joint and will have a very low leak rate.

At MPS3, there have been no conditions where the piping has disengaged from brazed fitting sockets. Consequently, no conditions have been observed that would have impacted the ability to maintain adequate system flow. This positive operating experience is due to the inherent structural integrity of brazed joints in service water systems.

To further address the potential for degradation, a search and review of external operating experience was performed. Braze failures in closed loop and electrical cooling systems such as generator stator cooling have been attributed to corrosion. However, there was no operating experience indicating progressive failure for open loop seawater systems. To confirm the conclusion that no progressive failure mechanism applies, DENC disassembled and examined two specimens that had already been removed from Millstone Power Station seawater service, and that were reported to have low bonding. The surface examination of the separated fitting and pipe surfaces did not reveal evidence of braze metal corrosion product. Since these examined joints are typical of plant construction and had seen nearly 20 years of service with no degradation of the bond, it is concluded that periodic visual monitoring of leak rate for this condition is acceptable, and monitoring may be scheduled on a quarterly basis. The periodic visual monitoring of leak rate will ensure that degradation to system functional margins does not occur.

5.5 REPAIR / REPLACEMENT

If the assessment concludes that a brazed joint with leakage retains adequate structural integrity and functionality, an operability determination can be used to document an 'operable but not fully qualified' status. A timely repair/replacement activity can be planned in accordance with 10 CFR Part 50, Appendix B. Consistent with the Millstone Power Station Corrective Action Program, the permanent Code repair/replacement for this type of nonconforming condition will be considered timely if completed during the next cold shutdown of sufficient duration, or the next refueling outage, whichever comes first.

If a joint does not have adequate bond by this assessment, the methodology for determining the adequacy of structural integrity of the joint is not applicable. Prompt repair/replacement of the joint, or temporary non-Code repairs subject to

NRC review and approval may be options for the resolution of nonconforming conditions, consistent with considerations in IMC 0326.

Basis:

The bases for continued operation prior to repair of the joint are that system functionality is maintained as justified in Section 5.3.1 above, structural integrity of the joint is maintained as justified in Section 5.3.4, and there is no progressive braze bond failure mechanism that would alter these conclusions over time. Compensatory actions for the condition are administratively controlled under the Millstone Power Station Corrective Action Program. These include, but are not limited to, the periodic monitoring of leakage for the condition or housekeeping measures to contain minor leakage from affected piping. The application of this methodology will be consistent with considerations of IMC 0326 for the resolution of nonconforming conditions. The permanent repair/replacement of the brazed joint assessed using this methodology will be in accordance with ASME Code, Section XI, IWA-4000.

5.6 AUGMENTED EXAMINATION:

If minor leakage is observed at a brazed joint, five similar brazed joints will be selected for augmented leakage examination. The additional joints will be selected based on consideration of adjacency, train, fitting type, or other factors that may be evident from the specific condition. Selected joints for augmented examination will be consistent with ASME Code Case N-513-4. If leakage is observed in similar joints, the resolution of each nonconforming condition will be evaluated in accordance with the Millstone Power Station Corrective Action Program, and the extent of condition will be documented and addressed.

Basis:

The examination of the additional joints is consistent with current practice for the resolution of nonconforming conditions, (e.g., application of ASME Code Case N-513-4). Augmented examinations provide information regarding the extent of condition being evaluated and are consistent with current Millstone Power Station procedures for responding to leakage in service water piping.

5.7 CONCLUSION:

It is proposed that in lieu of the immediate repair requirement of IWA-3132.2, DENC will perform a supplemental UT examination and comparison with alternative acceptance criteria. As justified above, DENC concludes that the proposed brazed joint assessment methodology, as an alternative to immediate ASME Code repair or replacement, provides reasonable assurance of structural integrity of degraded brazed joints. Therefore, pursuant to 10 CFR 50.55a(z)(2), the proposed alternative concludes that performance of an immediate ASME

Code repair or replacement of MPS3 degraded brazed joints that are considered to be acceptable using the proposed methodology would result in hardship without a compensating increase in the level of quality and safety.

6. Duration of Proposed Alternative

This proposal requests approval for the use of an alternative brazed joint assessment methodology for the duration of MPS3's fourth 10-year Inservice Inspection (ISI) interval, which began on February 23, 2019, and ends on February 22, 2029.

7. Precedents

A similar request for alternative was granted for the second ISI interval (Relief Request IR-2-38) per letter dated February 28, 2007 (ADAMS Accession No. ML070580514), and for the third ISI interval (Relief Request IR-3-04) per letter dated November 30, 2009 (ADAMS Accession No. ML093221042).

ATTACHMENT 2

APPLICABLE FIGURES

MILLSTONE POWER STATION UNIT 3
DOMINION ENERGY NUCLEAR CONNECTICUT, INC.

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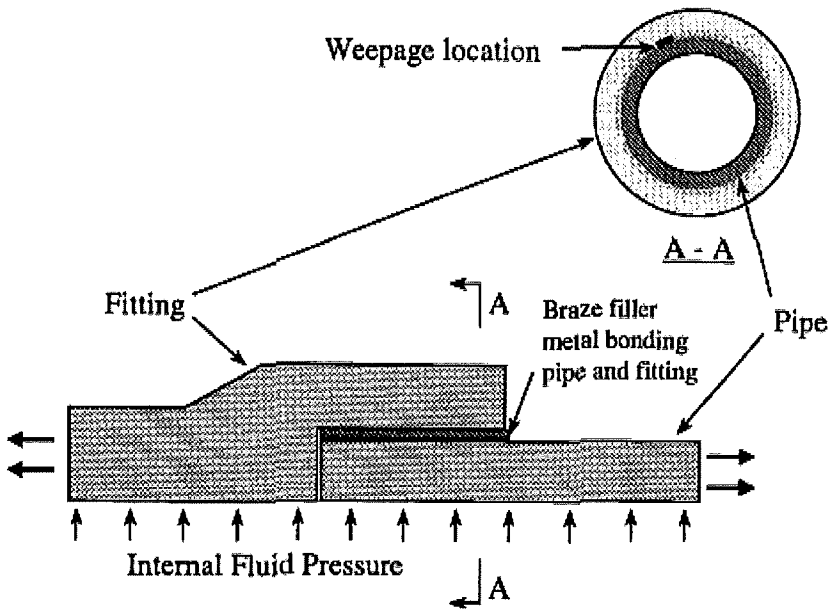


Figure 1: Typical Brazed Joint Configuration

$$1.5 \cdot S_{eq} < Smax\left(b_{adj}\right) \qquad (1)$$

$$S_{eq} = S_{lp} + S_{dl} + S_{sse} + S_{dyn} \qquad (2)$$

S_{lp} = longitudinal pressure stress

S_{dl} = deadload stress

Unintensified pipe stresses from Code qualification analysis

S_{sse} = SSE seismic stress

S_{dyn} = dynamic stress (if defined)

$$S_{max}\left(b_{adj}\right) = \frac{\pi}{4} \cdot \frac{D^2 \cdot L_{ins} \cdot \tau_{max}}{Z_{pipe}} \cdot b_{adj} \qquad (3)$$

D = pipe outside diameter

L_{ins} = depth of fitting socket excluding any insert groove

Z_{pipe} = piping section modulus

τ_{max} = 7500 psi (maximum braze shear stress)

b_{adj} = adjusted effective bond

Figure 2: Equations for Brazed Joint Assessment Comparison of Brazed Joint Load vs. Capacity

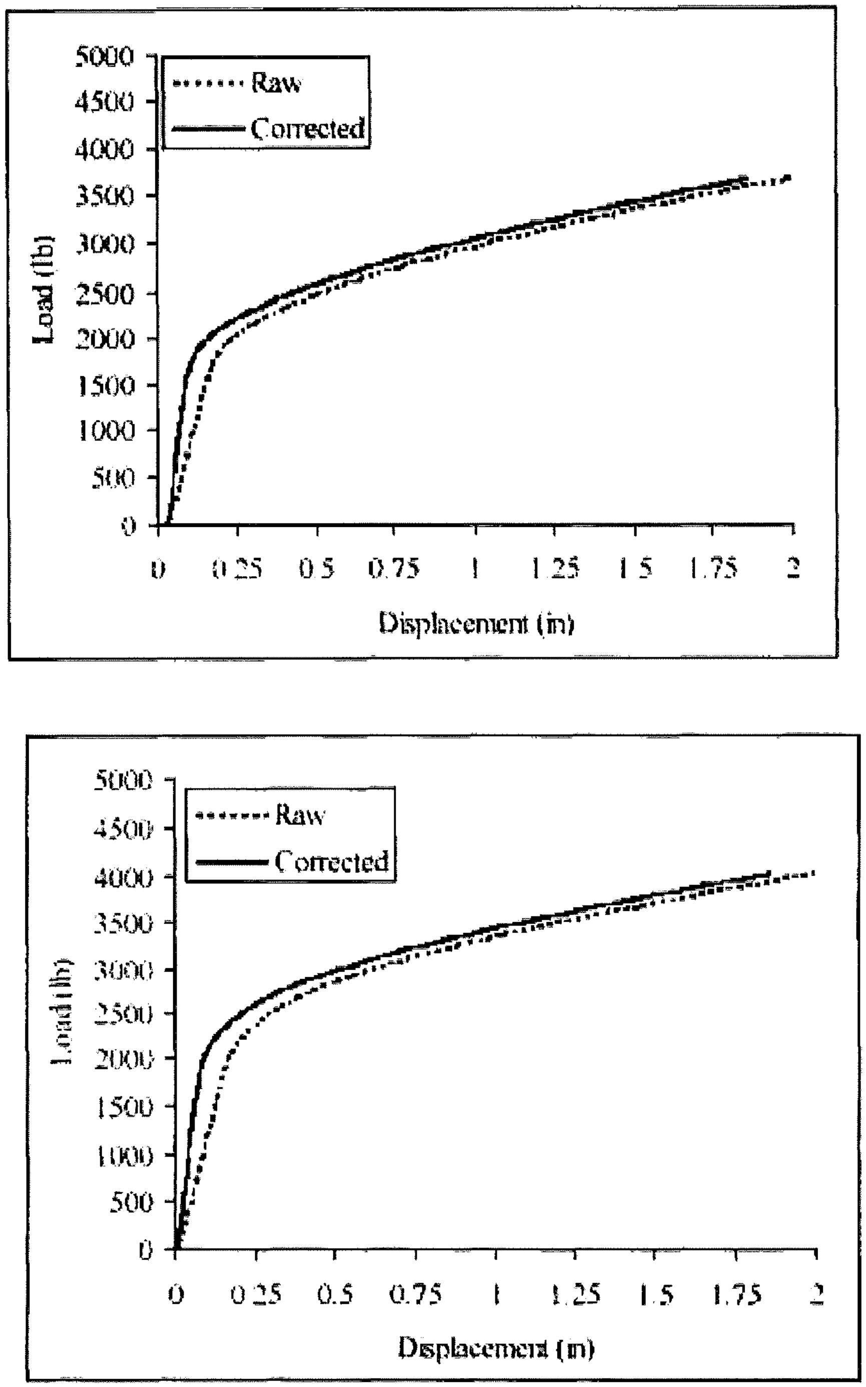


Figure 3: Two Inch Couplings; Fabricated Samples at (a) 30% (above) and (b) 60% bond

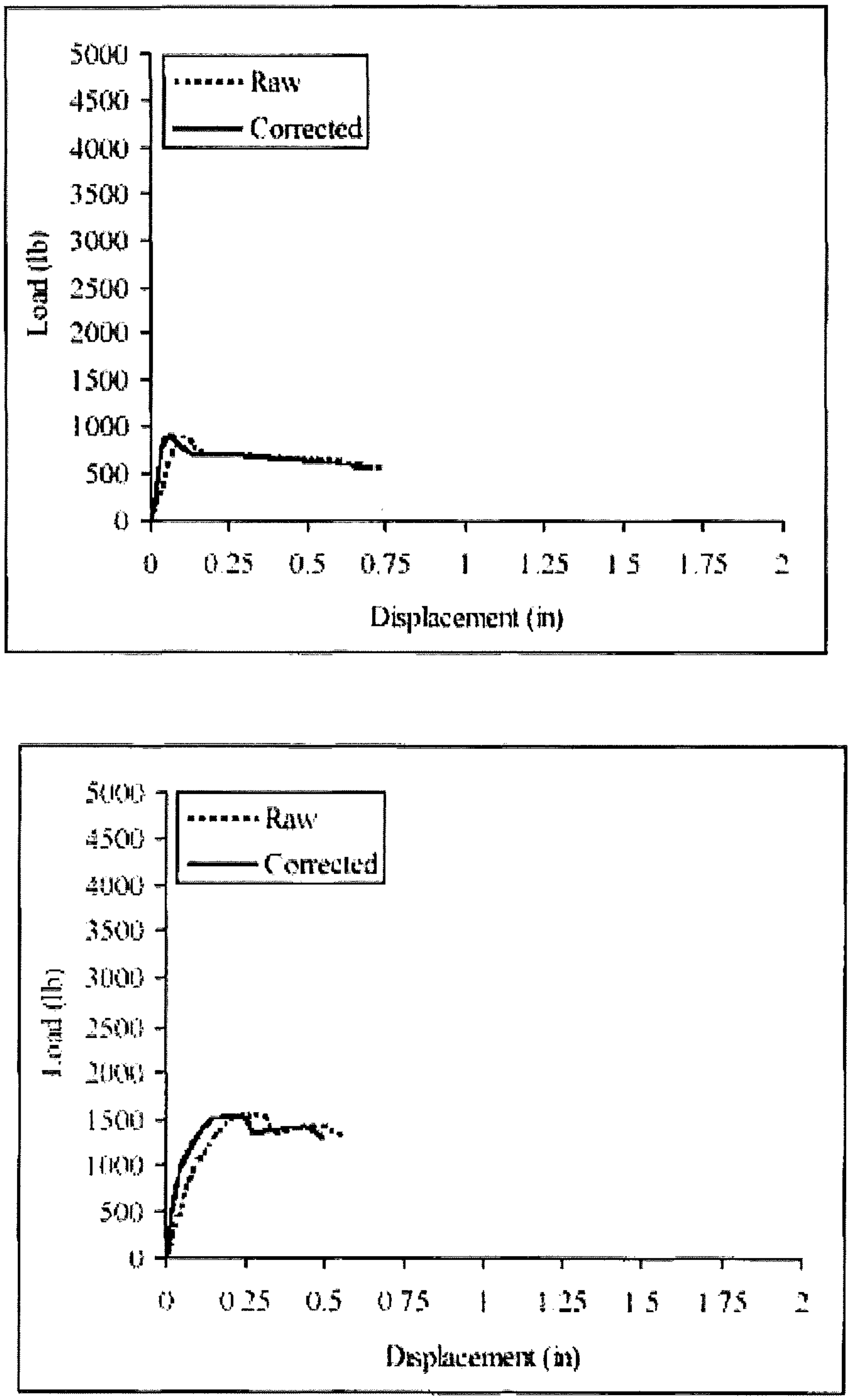
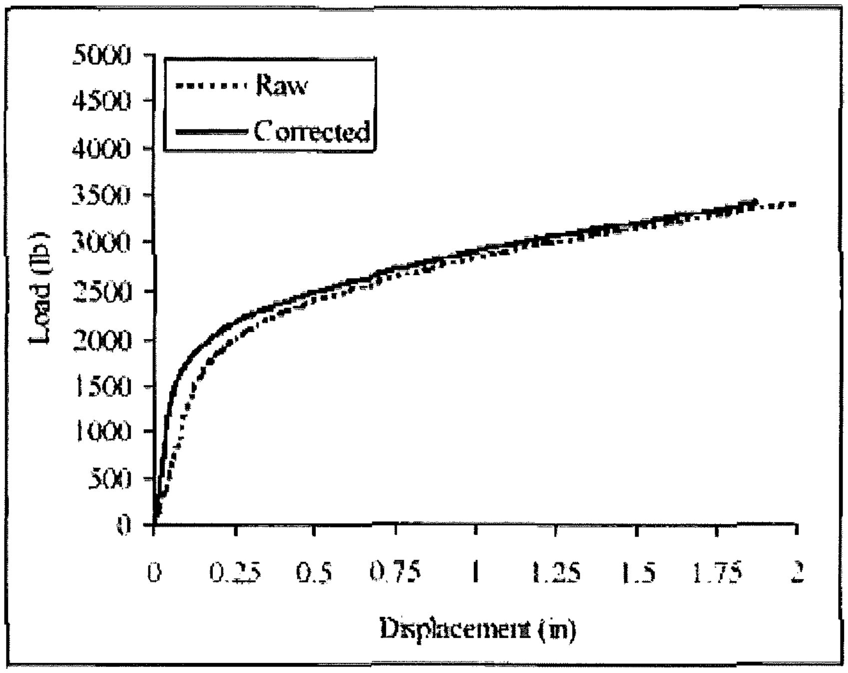


Figure 4: Two Inch Joints: Two Fabricated Samples with 12% Bond



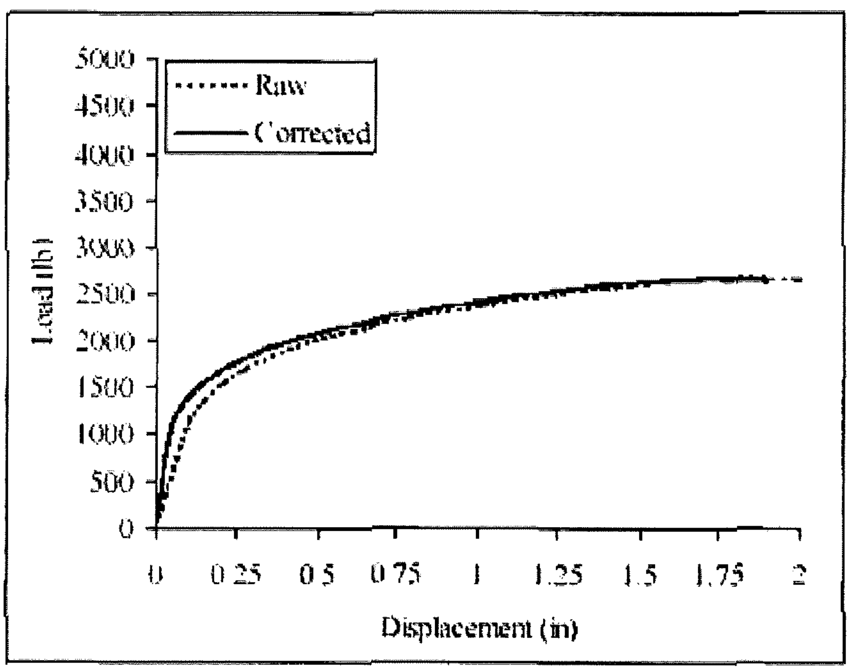


Figure 5: Arc Segment Disbondment, (a) 90 (above) and (b) 126 Degrees Arc

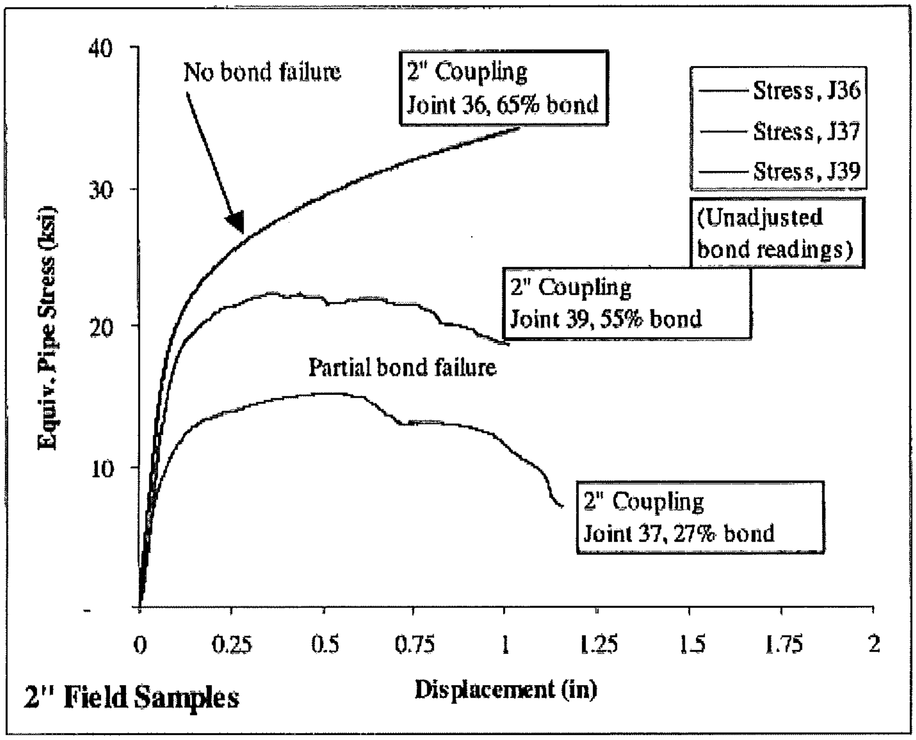


Figure 6: Two Inch Braze Field Sample Test Curve

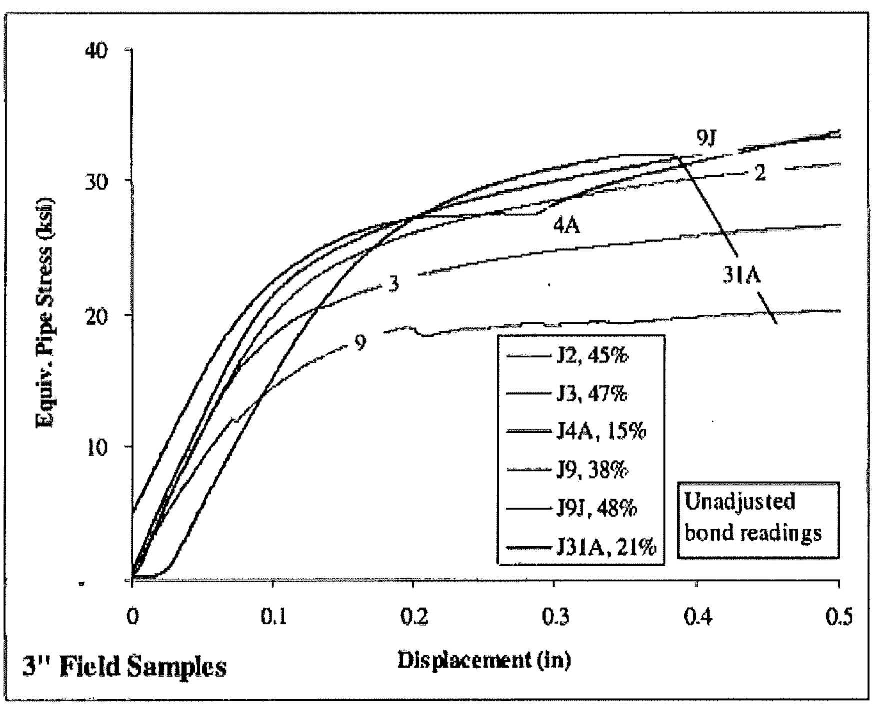


Figure 7: Three Inch Braze Field Sample Test Curve

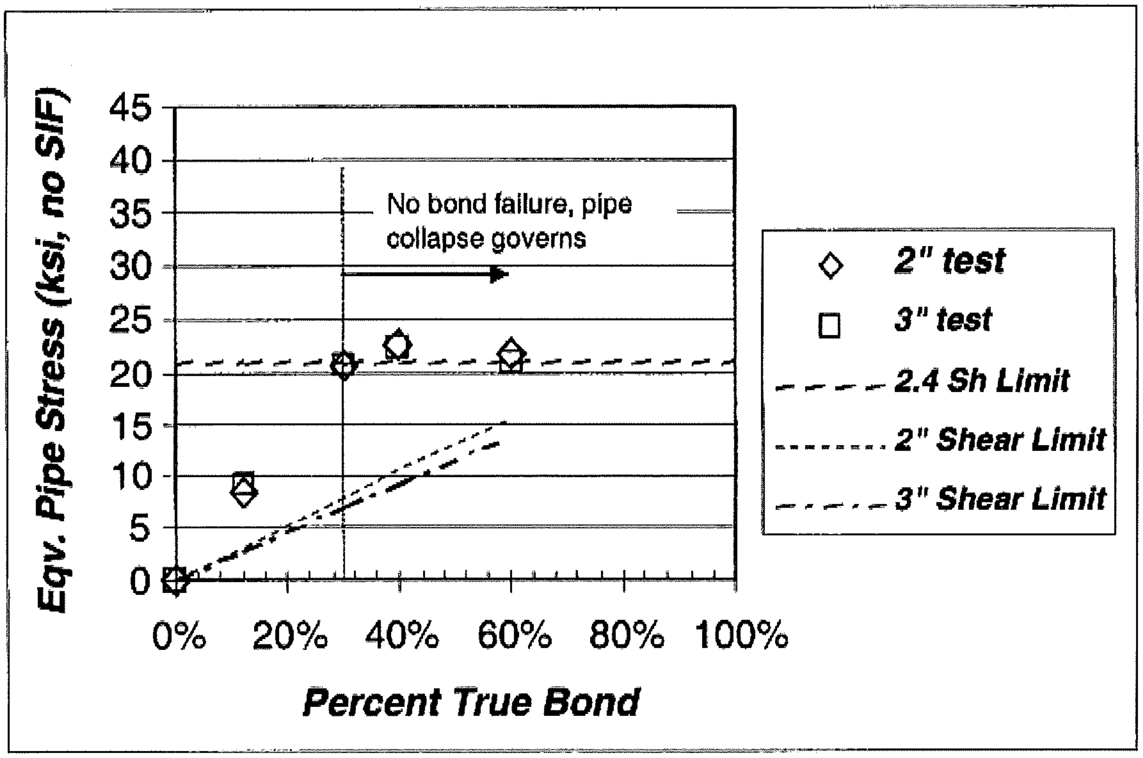


Figure 8: Test Results for Specially Fabricated Joints

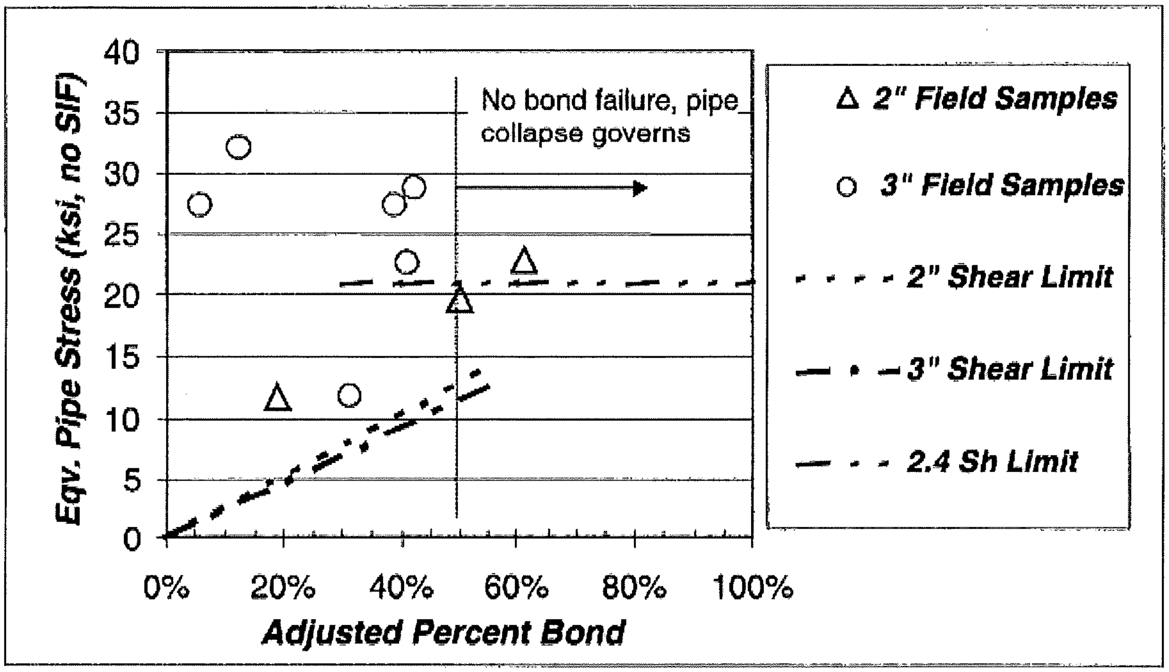


Figure 9 - Test Results for Joints Removed From Service

ATTACHMENT 3

APPLICABLE BRAZED JOINT CONFIGURATION AND MATERIALS

MILLSTONE POWER STATION UNIT 3
DOMINION ENERGY NUCLEAR CONNECTICUT, INC.

1.0 MATERIALS

Typical materials of construction for brazed piping are copper-nickel (SB-466) or nickel alloy (SB-165) annealed piping, and cast bronze fittings and valves (SB-61 or SB-62) dimensioned to MIL-F-1183. The brazing alloy is SFA 5.8 BAg-1, BAS-1a, or BAg-7. ASME, Section III Code minimum properties of the piping and fitting materials are:

Material	Item	S_h, ksi	Yield, ksi	Ultimate, ksi
SB466 CDA706	Pipe	8.7	13	38
SB-165	Pipe	17.5	28	70
SB-61	fitting	8.5	16	34
SB-62	fitting	7.5	14	30

2.0 CONFIGURATION

As shown in Figure 1 of Attachment 2, a typical brazed joint fitting has a deep socket for inserting the pipe. Although it appears similar to a socket welded joint, the fabrication and structural behavior are quite different. Whereas the socket weld achieves its joint strength by a fillet weld, resulting in fusion of similar material between the pipe and the outer face of the fitting, the braze achieves its strength by surface bonding of the outside of the pipe to the inside of the fitting socket using a dissimilar metal braze filler of silver alloy. The resulting braze filler metal is very thin (approximately 1 to 5 mils). The load transfer between pipe and fitting is thus primarily by shear through the braze filler. It is noted that there is no inherent stress concentration factor like that normally applicable to socket welds because there is no significant pipe wall bending induced by the shear load transfer over a length that is several wall thicknesses long.

The following has been excerpted from a standard piping handbook.[1]

> *The length of lap in a joint, the shear strength of the brazing alloy, and the average percentage of the brazing surface area that normally bonds are the principal factors determining the strength of brazed joints. The shear strength may be calculated by multiplying the width by the length of lap by the percentages of bond area and by taking into consideration the shear strength of the alloy used.*

For the standard braze joint fittings used at MPS3, the joint overlap is about four to one. The smallest overlap occurs in a three-inch joint, with an overlap length of 3.6 times pipe wall thickness.

[1] Crocker and King, *Piping Handbook*, 5th Edition, McGraw-Hill Book Company, page 7-212

3.0 BRAZED JOINT FUNCTIONAL CHARACTERISTICS

Since the piping loads causing longitudinal stress in the pipe are all transferred by shear stress through the brazed bond, the shear stress in the brazed bond is directly related to longitudinal pipe stress divided by a factor equal to the overlap ratio. Thus, for a fully bonded brazed joint, the shear stress is about one fourth of the piping longitudinal stress. If the bond is only 50 percent of maximum, then the bond shear stress will be about half the piping longitudinal stress. Given that piping and brazing filler metals have similar strength, a brazed joint has more than enough residual strength to tolerate moderate bond imperfections. Consequently, the joint is not the weak link in the piping assembly.

Consistent with this inherent over-design of brazed joints, the Construction Codes, such as Section III of the ASME Code and ANSI B31.1, require only visual inspection of the resulting bond. ND-5360, Visual Acceptance Standards for Brazed Joints, states "Brazing metal shall give evidence of having flowed uniformly through a joint by the appearance of an uninterrupted, narrow, visible line of brazing alloy at the joint." Surface exams such as by liquid penetrant are not required. Volumetric exams are not specified or even defined for brazed joints.

If the lack of bond is severe, then the brazed joint becomes the weak link in the piping assembly. It fails by shear failure of the brazed bond. Brazing with a lower level of bond may however be acceptable if the piping design basis loads are low enough. A brazing material defect with minor leakage is not the result of a flaw in the pipe or fitting pressure boundary. The pressure-retaining boundary retains its structural integrity. Although the shear load transfer between the pipe and fitting is clearly a pressure boundary function, the brazing material functions more as a sealant between the connected components and less like a pressure boundary.

With regard to structural integrity, imperfections in the sealant function of the braze material are permissible, provided its load transfer function retains adequate margin. Thus, because there is no direct degradation of the pressure boundary, the available flaw evaluation methodologies such as in ASME Code Case N-513-4 or Generic Letter 90-05, are not directly applicable. In addition, the characterization of braze imperfections is very different from the planar flaws or loss of wall thickness that are addressed in ASME Code, Section III, IWA-3000.

ATTACHMENT 4

SUMMARY OF PREVIOUS METHODOLOGY APPLICATIONS AND TECHINCAL EVALUATION EXAMPLE

MILLSTONE POWER STATION UNIT 3
DOMINION ENERGY NUCLEAR CONNECTICUT, INC.

Summary of Previous Methodology Applications

During the second MPS3 inservice inspection (ISI) interval, the brazed joint methodology, as approved, was employed in three instances (under IR-2-38). In two of the instances, the leaking joints were repaired within 90 days of discovery and in the third instance, the repair was performed at the next refueling outage. For the third instance, this attachment provides a summary of the original assessment, subsequent UT monitoring, and final repair.

During the third MPS3 ISI interval, there were no instances which required use of the brazed joint methodology as approved by the NRC under alternative request IR-3-04.

Example of Methodology Application

This example relates to a brazed joint that was discovered to be leaking on March 4, 2008. The following activities were then performed.

Date	Activity	Document	Remarks
3/11/2008	UT Examination	AWO M30802596	Attached to Technical Evaluation
3/13/2008	Engineering Assessment	Technical Evaluation M2-EV-=08-0006	Included with this attachment.
5/29/2008	UT Re-examination	AWO M30804182	Inspection sheet included with this attachment.
8/26/2008	UT Re-examination	AWO M30804183	Inspection sheet included with this attachment.
10/8/2008	Begin MPS3 refueling outage	NA	
11/2/2008	Brazed Joint Repair	AWO M30802598, per DM3-00-0192-08	Brazed joints replaced with butt welds and socket welds

The table shows the 90-day reinspection frequency requirement of the methodology was satisfied.

Note: The first examination and technical evaluation addressed nearby brazed joints that were not leaking and therefore met construction code requirements. These additional examinations were done for information only. Subsequent examinations addressed the leaking joint only.

QA ☒ Non-QA ☐

DB or LB document change required? yes ☐ no ☒

TECHNICAL EVALUATION

for

Evaluation of Unit 3 Service Water Brazed Joint Flaw, Line 3SWP-075-V222

Millstone Unit 3

M3-EV-08-0006

Rev. 00

3/13/2008

~~18~~ 19 pages MJR 3/13/08

Glenn A Gardner 3/13/08

Preparer – Glenn Gardner — Date

Thomas A. Steahr 3/13/08

Independent Reviewer – Thomas Steahr — Date

Martin L Van Haltern 3/13/08

Engineering Approver – Martin Van Haltern — Date

1.0 PURPOSE

The purpose of this evaluation is to determine the structural integrity of a leaking brazed joint in service water instrumentation piping to flow indicator FT-43B, upstream of root valve 3SWP*V222. This ¾" piping branches off line 3SWP-030-095-3. The brazed joint was identified as having evidence of leakage in CR-08-02368. A subsequent UT exam characterized the extent of brazed joint bond (Reference 3.3). This document provides a structural evaluation to support continued operation pending repair and summarizes requirements to monitor its condition.

2.0 BACKGROUND

A method for evaluating the structural integrity of degraded brazed joint was developed in Reference 3.4 and accepted by the NRC in Reference 3.5. The Reference 3.4 Technical Evaluation provides a spreadsheet based evaluation tool to assess the structural acceptability of degraded (including leaking) brazed joints. This Technical Evaluation, in conjunction with the UT procedure (Reference 3.6), provides the basis and specific instructions for examination, structural evaluation and reinspection requirements for degraded brazed joints in Millstone Unit 3 service water piping. Procedure MP-24-ENG-FAP947 (Reference 3.8) summarizes all requirements for responding to service water leaks.

The spreadsheet documented in the Reference 3.4 Technical Evaluation implements the approved methodology for evaluating brazed joint integrity. Its data inputs include calculated piping stress levels and the UT bond readings for the joint. The sheet is self documenting and provides a conclusion on whether the joint is acceptable for design basis loading. Specific directions for use of the spreadsheet are contained in Reference 3.4 and are not repeated here.

3.0 REFERENCES

3.1 CR-08-02092, Unplanned TRM for Minor Seepage From A SWP Strainer Backwash Line 3-SWP-003-021-3 Brazed Joint, dated 3/04/2008.

3.2 . Drawing No. 25212-21001 sheet 21, Rev. 9

3.3 Ultrasonic Examination Straight Beam Measurements, AWO Number M3-08-02596, dated 03/11/2008 (Attachment 1).

3.4 Technical Evaluation M3-EV-05-0002 "Examination and Structural Assessment of Brazed Joints" Revision 01 dated 7/17/07.

3.5 "Safety Evaluation by the Office of Nuclear Reactor Regulation, relief Request IR-2-38", US NRC, Transmitted by the letter dated February 28, 2007, Dominion licensing file 07-0153.

3.6 Procedure MP-UT-45 Rev 00-01 "Ultrasonic Examination Procedure for Examination of Brazed Joints – Millstone Unit 3 Service Water Piping".

3.7 Calculation No. NP-SWP-95-V222, Rev. 2 Change 0, "Root Valve Piping: Support Requirement Verification".

3.8 Procedure MP-24-ENG-FAP947, Rev. 001-01, "Non-Code Repairs in Safety Class 3 Piping", dated 9/24/2007

4.0 DISCUSSION

The UT was obtained on three brazed joints, FW-37, FW-38 and FW-8. Only FW-38 was leaking and that degraded condition is the one specifically evaluated here. FW-37 was not leaking and had greater braze bond than FW-38. FW-8 was at a flange that had interfering studs so only a partial set of readings was obtained on it; however it had readings comparable to FW-38. As discussed in Reference 3.4 the ASME Code does not have a requirement for minimum braze bond. Thus there is no degraded or non-conforming condition for either FW-37 and FW-8 and they are not considered to be a structural integrity concern requiring detailed evaluation. For information only the braze bond readings and evaluation summary for FW-37 are attached.

The formal evaluation of the leaking braze joint FW-38 is documented on the following spreadsheet pages. The braze bond UT readings are transcribed directly into the 'UT Readings' sheet. To account for 12 data points, the data input range for the average bond was modified to only consider the 12 data points, and zero percent bond readings were input for the other eight data point inputs that were not needed. A similar change was made on the 'Bond Calcs' sheet for the "BPress" on lines 29 and 65. Finally, on the summary sheet, the plot range was changed in order to show only the relevant 12 data points. Note that the methodology does specify a minimum number of UT data points and 12 points on the approximately 1.5" OD of the elbow fitting give a data point spacing of about 0.4 inches which is comparable with the UT probe size.

Braze Bond Structural Assessment Joint SWP95-FW-38

Ref: TE M3-EV-05-0002 Rev. 1 this sheet revised 07/17/2007

Part 1 Basic Data (dashed boxes are inputs)

	Inputs:
Line No:	SWP-075-V222
Sys Function:	FT-43B upstrm instr tubing
Piping Iso:	CI-SWP-95 Sh 2
Joint:	SWP95-FW-38
Side of Joint:	Dnstrm
Jt. Orientation:	na

	Inputs:
Pipe Dia	1.05 in
Nom. Wall Thk	0.154 in
Pipe Mat'l	SB 466 CDA 706
Fitting Mat'l	SB 61or 62
Ref. Bond Strength:	7,500 psi
Bond Adjustment	10%

Measured Ave. Bond 42% (calculated. For bond measurements, see sheet 'UT Readings')

42 % >= 60 % ? No, Detailed assessment required

Part 2 Bond Data Summary (data from sheet 'Bond Calcs')

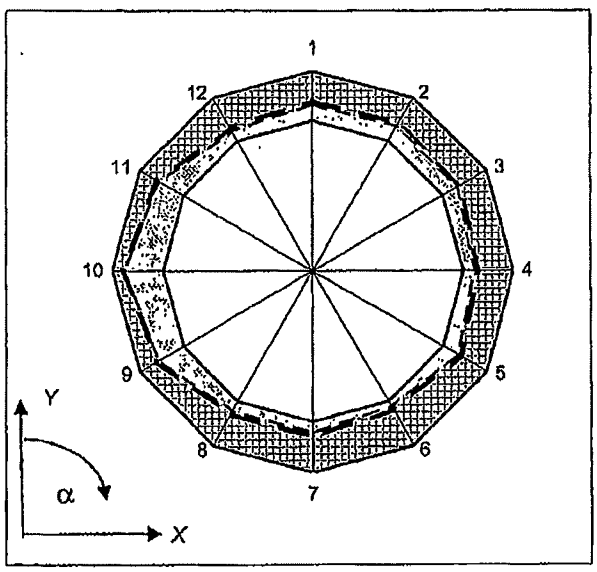
Offsets based on adjusted bond:

Dxx	-0.117	in
Dyy	0.038	in
Doffset	0.123	in (23% of pipe radius)
Alpha	-12.5	degrees - rotation angle of principal axes

Calculated effective bond data are in principal axes system, and are based on adjusted bond.

	Actual	Adjusted
Bxx	46%	40%
Byy	34%	27%
Bbend	34%	27%
Bpress	42%	35%

Note: Plot is figurative only, actual braze bond is cylindrical, not through-wall.



Braze Bond Structural Assessment Joint SWP95-FW-38

Part 3 Calculated Bond Load Capability

D	1.05	in
tnom	0.154	in
Pipe Z	0.085	in^3
Linsert	0.344	in (from lookup table at right)
Smax(100%)	26,169	psi (from formula at right)

Lookup Tbl: L.insert per MilSpec

D.nom	D.od	Linsert
3/4	1.05	11/32
1	1.315	7/16
1.5	1.9	5/8
2	2.375	21/32
2.5	2.875	25/32
3	3.5	53/64

Load Capability (Allowable Nominal Pipe Stress)
(Based on bond levels from Part 2)

	Actual	Adjusted	
Sxx	12,134	10,391	psi
Syy	8,984	7,015	psi
Sallow	8,984	7,015	psi

stress based on shear allow. and percent bond

$$S_{max}(b_{adj}) = b_{adj} \cdot \left(\frac{\pi D^2 \cdot L_{insert}}{4 \cdot Z_{pipe}} \right) \cdot \tau_{max}$$

Part 4 Pipe Stress Data

(stress calc inputs)

Stress Calc:	NP-SWP-95-V222
Rev / CCN	Rev. 2, CCN 0
Line No:	SWP-075-V222
Sys Function:	FT-43B upstrm instr tubing
Piping Iso:	CI-SWP-95 Sh 2
Joint:	SWP95-FW-38

(data from Part 1)

Pipe Dia	1.05 in
Nom. Wall Thk	0.154 in
Pipe Mat'l	SB 466 CDA 706
Fitting Mat'l	SB 61or 62
A.pressure	0.825 in^2
Z.pipe	0.085 in^3

inputs:

Stress Node	n/a
Alt. Stress Node	n/a
SIF Used	2.1
Primary SIF	1.575

$$S_{p\_offset} = D_{offset} \cdot \frac{P_{max} A_{press}}{Z_{pipe}}$$

$$S = \frac{S - S_{lp}}{psif} + S_{p\_offset} + S_{lp} \cdot \frac{B_{bend}}{B_{press}}$$

Inputs:

			Calculated Nominal Stresses	
Design Pressure	100 psig			
Max Op. Pressure	100 psig			
Slp	170 psi	Sp_offset	119	psi
Eq. 8 (P+DL)	2448 psi	Sust'd 8'	1695	psi
Eq. 9 (N/U)	5238 psi	N/U 9'	3466	psi
Eq. 9F (Design Basis0	6402 psi	Faulted 9F'	4205	psi
		Max Pipe Nominal Stress	**4205**	**psi**
		Apply Safety Factor of 1.5	**6308**	**psi**

Part 5 Structural Integrity Determination Joint SWP95-FW-38

Joint Load Capability	7,015	psi	(from Part 3)
1.5*Design Basis Load	6,308	psi	(from Part 4)

Check: **6,308 < 7,015 ===>** **Braze is adequate for design basis loads**
Monitor until repair/replacement

Braze Bond Measurements Joint SWP95-FW-38

							R	Rmin
	Bond Adjustment		10%				1	0.75
Reading	Angle	Meas. Bond	Adj Bond	PlotValue	Adj Plot		Max	Min
1	0	40%	*33%*	0.850	0.833		1	0.75
2	30	40%	*33%*	0.850	0.833		1	0.75
3	60	40%	*33%*	0.850	0.833		1	0.75
4	90	30%	*22%*	0.825	0.806		1	0.75
5	120	40%	*33%*	0.850	0.833		1	0.75
6	150	20%	*11%*	0.800	0.778		1	0.75
7	180	30%	*22%*	0.825	0.806		1	0.75
8	210	30%	*22%*	0.825	0.806		1	0.75
9	240	60%	*56%*	0.900	0.889		1	0.75
10	270	80%	*78%*	0.950	0.944		1	0.75
11	300	60%	*56%*	0.900	0.889		1	0.75
12	330	30%	*22%*	0.825	0.806		1	0.75
13	360	0%	*0%*	0.750	0.750		1	0.75
14	390	0%	*0%*	0.750	0.750		1	0.75
15	420	0%	*0%*	0.750	0.750		1	0.75
16	450	0%	*0%*	0.750	0.750		1	0.75
17	480	0%	*0%*	0.750	0.750		1	0.75
18	510	0%	*0%*	0.750	0.750		1	0.75
19	540	0%	*0%*	0.750	0.750		1	0.75
20	570	0%	*0%*	0.750	0.750		1	0.75

Nreadings	12	Ave	42%	35%	G9:G21
dTheta	30	Min	20%	11%	
degrees		Max	80%	78%	

Braze Bond Calculations

Joint SWP95-FW-38

Boffset	Nreadings
10%	12

D 1.05

Aoffset input
0 degrees
0.000 rad

Equivalent bond based on measured bond readings, without adjustment

Angle	Meas. Bond	cos(theta)	db*cos	db*cos^2	db*sin*cos	sin(theta)	db*sin	db*sin^2
0	40%	1.000	0.400	0.400	0.000	0.000	0.000	0.000
30	40%	0.866	0.346	0.300	0.173	0.500	0.200	0.100
60	40%	0.500	0.200	0.100	0.173	0.866	0.346	0.300
90	30%	0.000	0.000	0.000	0.000	1.000	0.300	0.300
120	40%	-0.500	-0.200	0.100	-0.173	0.866	0.346	0.300
150	20%	-0.866	-0.173	0.150	-0.087	0.500	0.100	0.050
180	30%	-1.000	-0.300	0.300	0.000	0.000	0.000	0.000
210	30%	-0.866	-0.260	0.225	0.130	-0.500	-0.150	0.075
240	60%	-0.500	-0.300	0.150	0.260	-0.866	-0.520	0.450
270	80%	0.000	0.000	0.000	0.000	-1.000	-0.800	0.800
300	60%	0.500	0.300	0.150	-0.260	-0.866	-0.520	0.450
330	30%	0.866	0.260	0.225	-0.130	-0.500	-0.150	0.075
360	0%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
390	0%	0.866	0.000	0.000	0.000	0.500	0.000	0.000
420	0%	0.500	0.000	0.000	0.000	0.866	0.000	0.000
450	0%	0.000	0.000	0.000	0.000	1.000	0.000	0.000
480	0%	-0.500	0.000	0.000	0.000	0.866	0.000	0.000
510	0%	-0.866	0.000	0.000	0.000	0.500	0.000	0.000
540	0%	-1.000	0.000	0.000	0.000	0.000	0.000	0.000
570	0%	-0.866	0.000	0.000	0.000	-0.500	0.000	0.000
		0.000	0.023	2.100	0.087	0.000	-0.071	2.900
Bpress		check=0	ry	Bpyy	Bpxy	check=0	rx	Bpxx
	42%		0.055	0.175	0.007	0.417	-0.169	0.242
		Roffset	Yoffset	Byy	Bxy	Byy+Bxx	Xoffset	Bxx
		0.093	0.029	0.174	0.011	0.403	-0.089	0.230
		BByy		35% Bave		40% BBxx		46%
		Byy_p		0.172			Bxx_p	0.232
				34%				46%

Byy-Bxx=0	Bxy=0	tan 2alpha	cos 2alpha	sin 2alpha	tan check	alpha
-0.056	0.011	-0.396	0.930	-0.368	-0.396	-0.188 rad
FALSE	FALSE					-10.8 deg

$$b_{adj} = \frac{b - b_{offset}}{1 - b_{offset}}$$

Equivalent bond based on adjusted bond readings

Angle	Adj. Bond	cos(theta)	db*cos	db*cos^2	db*sin*cos	sin(theta)	db*sin	db*sin^2
0	33%	1.000	0.333	0.333	0.000	0.000	0.000	0.000
30	33%	0.866	0.289	0.250	0.144	0.500	0.167	0.083
60	33%	0.500	0.167	0.083	0.144	0.866	0.289	0.250
90	22%	0.000	0.000	0.000	0.000	1.000	0.222	0.222
120	33%	-0.500	-0.167	0.083	-0.144	0.866	0.289	0.250
150	11%	-0.866	-0.096	0.083	-0.048	0.500	0.056	0.028
180	22%	-1.000	-0.222	0.222	0.000	0.000	0.000	0.000
210	22%	-0.866	-0.192	0.167	0.096	-0.500	-0.111	0.056
240	56%	-0.500	-0.278	0.139	0.241	-0.866	-0.481	0.417
270	78%	0.000	0.000	0.000	0.000	-1.000	-0.778	0.778
300	56%	0.500	0.278	0.139	-0.241	-0.866	-0.481	0.417
330	22%	0.866	0.192	0.167	-0.096	-0.500	-0.111	0.056
360	0%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
390	0%	0.866	0.000	0.000	0.000	0.500	0.000	0.000
420	0%	0.500	0.000	0.000	0.000	0.866	0.000	0.000
450	0%	0.000	0.000	0.000	0.000	1.000	0.000	0.000
480	0%	-0.500	0.000	0.000	0.000	0.866	0.000	0.000
510	0%	-0.866	0.000	0.000	0.000	0.500	0.000	0.000
540	0%	-1.000	0.000	0.000	0.000	0.000	0.000	0.000
570	0%	-0.866	0.000	0.000	0.000	-0.500	0.000	0.000
		0.000	0.025	1.667	0.096	0.000	-0.078	2.556
Bpress		check=0	ry	Bpyy	Bpxy	check=0	rx	Bpxx
	35%		0.072	0.139	0.008	0.352	-0.223	0.213
		Roffset	Yoffset	Byy	Bxy	Byy+Bxx	Xoffset	Bxx
		0.123	0.038	0.137	0.014	0.333	-0.117	0.196
		BByy		27% Bave		33% BBxx		39%
		Byy_p		0.134			Bxx_p	0.199
				27%				40%

Byy-Bxx=0	Bxy=0	tan 2alpha	cos 2alpha	sin 2alpha	tan check	alpha
-0.058	0.014	-0.467	0.906	-0.423	-0.467	-0.219 rad
FALSE	FALSE					-12.5 deg

$$B'_{yy} = \frac{1}{N}\sum b_i \cos(\theta_i)^2$$

$$B'_{xx} = \frac{1}{N}\sum b_i \sin(\theta_i)^2$$

$$B'_{xy} = \frac{1}{N}\sum b_i \sin(\theta_i)\cos(\theta_i)$$

$$B_{yy} = B'_{yy} - r_{yy}^2 b_{av}$$

$$B_{xx} = B'_{xx} - r_{xx}^2 b_{av}$$

$$B_{xy} = B'_{xy} - r_{xy} b_{av}$$

$$\tan(2\alpha) = \frac{2 B_{xy}}{(B_{yy} - B_{xx})}$$

$$\cos(2\alpha) = \frac{|B_{yy} - B_{xx}|}{\sqrt{(B_{yy} - B_{xx})^2 + 4 B_{xy}^2}}$$

$$\sin(2\alpha) = \frac{\mathrm{sgn}(\tan(2\alpha)) \cdot |2 \cdot B_{xy}|}{\sqrt{(B_{yy} - B_{xx})^2 + 4 B_{xy}^2}}$$

$$\alpha = \frac{1}{2}\operatorname{asin}(\sin(2\alpha))$$

$$B_{p\_yy} = \frac{B_{yy} + B_x}{2} + \frac{B_{yy} - B_x}{2}\cos(2\alpha) + B_{xy}\sin(2\alpha)$$

$$B_{p\_xx} = \frac{B_{yy} + B_x}{2} - \frac{B_{yy} - B_x}{2}\cos(2\alpha) - B_{xy}\sin(2\alpha)$$

$$B_{p\_xy} = B_{xy}\cos(2\alpha) - \frac{B_{yy} - B_x}{2}\sin(2\alpha)$$

Measured Bonds

Bond values calculated at A_offset angle			
Yoffset	Byy	Xoffset	Bxx
0.029	35%	-0.089	46%

Adjusted Bonds

Bond values calculated at A_offset angle			
Yoffset	Byy	Xoffset	Bxx
0.038	27%	-0.117	39%

5.0 SAFETY SIGNIFCANCE

This technical evaluation is prepared in support of an operability determination and is not a change to the design or operation of the plant as described in the licensing basis. Therefore a 50.59 screen is not required. Because the evaluation shows the piping meets approved evaluation criteria there is no impact on safety of plant operations.

6.0 CONCLUSIONS

The degraded socket welded fitting described in CR Reference 3.1 has been evaluated according to the NRC approved methodology documented in Reference 3.4 and determined to be structurally acceptable for continued service until such time a Code Repair can be performed. According to NRC agreement documented in Reference 3.4 and 3.5, the limitations for use require repair of FW-38 at the earliest of the following:

- next schedule outage of sufficient duration to complete repairs, or a scheduled shutdown greater than 30 days
- next refueling outage
- time at which the flaw/leak size is predicted to exceed the flaw/leak size accepted by evaluation

In addition, compliance with the accepted methodology requires periodic reassessments of FW-38 and augmented examination of five other similar joints, as detailed in Reference 3.8, Sections 2.6 and 2.4 respectively.

7.0 ATTACHMENTS

Item	Description	No. Pages
1	Braze Bond UT Readings	5
2	Structural Assessment of FW-37 (info)	4
3	Independent Review Comments	1
	Total pages of attachments	10

M3-EV-08-0006 Rev. 0 Pg 10

ATTACHMENT 1
ULTRASONIC CALIBRATION DATA SHEET

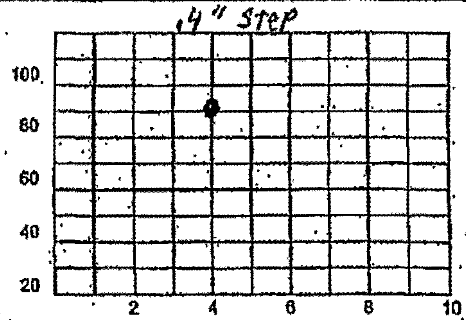
Plant: Millstone Unit: 3
Purpose: Eng. Info.
Cal Block Number 94-7794
DWG No. 25212-21001 SH 21

Page 1 of 4
AWO Number: M3-08-02596
Cal Block Temp N/A
Thermometer S/N & Due Date N/A

Search Unit	
Manufacturer	KBA
Style or Type	Gamma
Frequency	5 MHz
Size & Shape	.25"
Mode T or C	C
Search Unit Angle	0°
Measured Angle	N/A
Serial Number	J06463
Cable Type, Length	Dual/6'
No. of Connectors	0

Instrument & Settings	
Mfg./Model	KB
Serial Number	00CLXR
Range	1.0"
Material Velocity	.1960 US
Delay	-.242
Pulser	Dual
Reject	0%
Frequency	2.8
Damping	1000 OHM
Zero Value	4.129
Pulse Rep Rate	High
Gain Setting	N/A

.4" Step



Attachments (Check)	
Sketch Sheet	N/A
Supplements	✓

Calibrations	Time
Initial Calibration	1700
Final Calibration	N/A
Final Calibration	2000

CRT Setup	Inches
Metal Path	N/A
Depth	1.0"

Couplant Data	
Brand	Soundsafe
Batch Number	06130A
SAP Batch Mgmt. No.	0000075238

Component ID	Component Type	Comments
FW 8, FW 37 and FW 38	Braze Joints	Joints upstream of 3SWPXV232

Examiner (Print & Sign) Michael Brehler / Michael Brehler Level II Date 3/11/08
Examiner (Print & Sign) N/A Level N/A Date N/A
Reviewer (Signature) ______ Level ______ Date ______

Level of Use
Reference

STOP THINK ACT REVIEW

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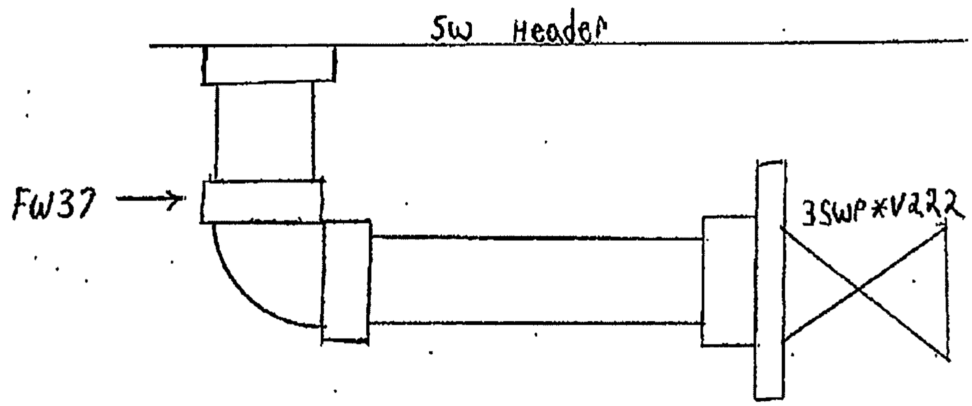
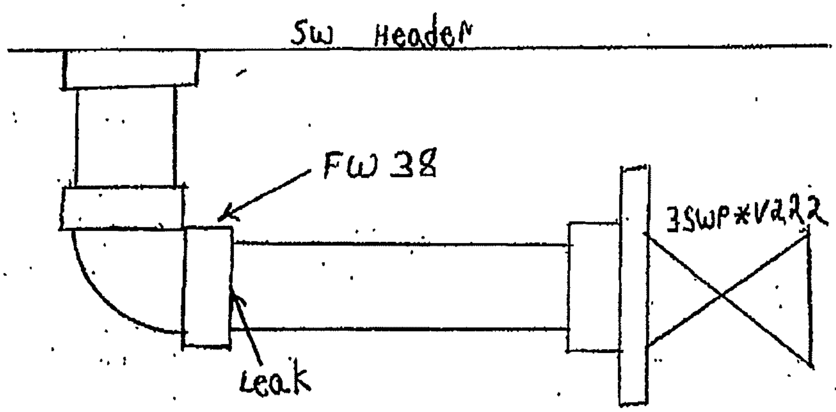
FW-37

Point No.	1st Signal (no bond)	2nd Signal (bond)
1	60	40
2	60	40
3	20	80
4	40	60
5	50	50
6	20	80
7	40	60
8	60	40
9	40	60
10	20	80
11	20	80
12	60	40
13	N	
14		
15		A
16		
Total		
Average		



FW-38

Point No.	1st Signal (no bond)	2nd Signal (bond)
1	60	40
2	60	40
3	60	40
4	70	30
5	60	40
6	80	20
7	70	30
8	70	30
9	40	60
10	20	80
11	40	60
12	70	30
13	N	
14		
15		
16		A
Total		
Average		



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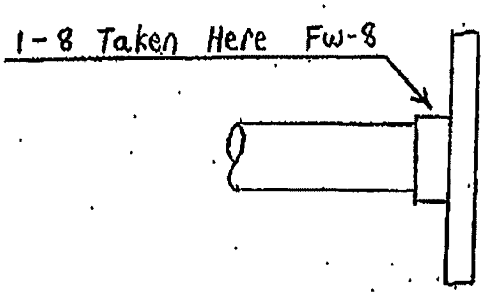
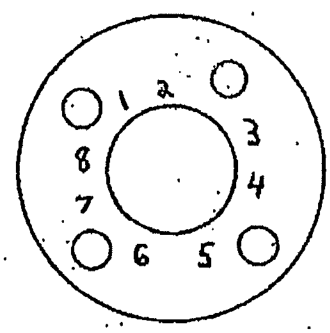
FW-8

Point No.	1st Signal (no bond)	2nd Signal (bond)
1	60	40
2	50	50
3	60	40
4	60	40
5	NP	NP 40
6	NP	NP 60
7	40	60
8	40	60
9		
10	N	
11		
12		
13		
14		
15		A
16		
Total		
Average		

Limited amount of Data due to Flange Bolting





M3-EV-08-0006 Rev0 pg 14

Attachment 1 Exam Data Sheet

Millstone Power Station — **ULTRASONIC EXAMINATION STRAIGHT BEAM MEASUREMENTS**

Plant Millstone Unit 3	Page 1 of 1
System & Zone No. 3326	Exam Data Sheet No. N/A
Component ID 3/4" Piping US of 3SWP*V222	AWO Number M3-08-02596
Component Description 3/4" pipe	Drawing No. 25212-21001 SH 21
Examination Purpose Eng. Info.	Line No. N/A

Instrument & Settings	
Manufacturer	KB
Model No.	USN 52L
Serial No.	00CLXR
Range	1.0"
Velocity	.196 US
Delay	-.242 US
Zero Value	4.179 US
Cal Tolerance	±.005"

Calibration Block(s)		
Type	Serial No.	Material
Step Blk	94-7794	CU/Ni
N/A	N/A	N/A

Component Data	
Component T_{nom}	.154"
Component Dia.	3/4"
Attachments.	

Calibration Checks		Block Thickness		Instrument Reading	
Type	Time	Min.	Max.	Min.	Max.
Initial	2000	.100"	.400"	.100"	.400"
Intermediate	N		N		N	
Intermediate	A		A		A
Final	2030	.100"	.400"	.100"	.400"

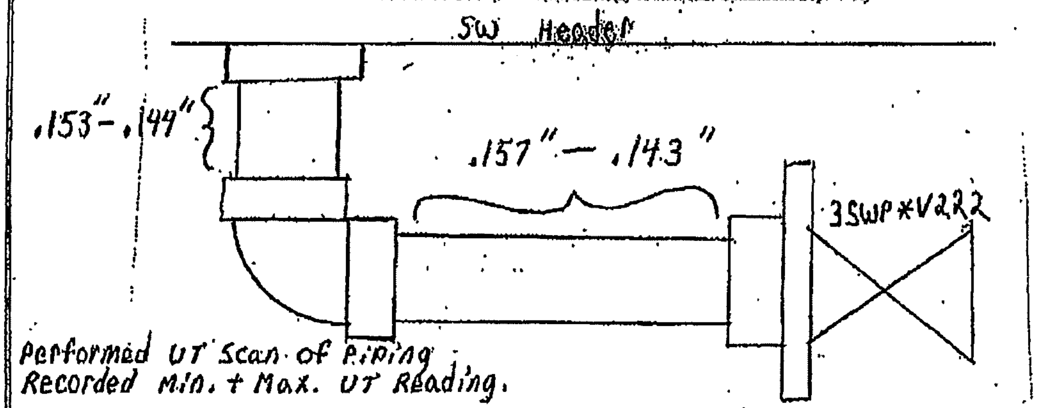
Search Unit Data	
Manufacturer	KBA
Type No.	Gamma
Serial No.	J06463
Frequency	5 MHZ
Size	.25"

Couplant Data	
Brand	Soundsafe
Batch No.	06120A
SAP Batch Mgmt. No.	0000075238

Coatings Factor Data	
Surface Painted	NO
ACT* mils =	N/
ACT X 3 mils =	/A

* Average Coating Thickness

Sketch/Comments Area - Attach Photo(s) of Relevant Conditions Separately



Performed UT Scan of Piping
Recorded Min. + Max. UT Reading.

Examiner (print & sign) Michael Brehler / [signature] Level II Date 3/11/08

Reviewer (sign) ______ Level ______ Date ______

ANI/ANII If Required (Sign) N/A Date N/A

Level of Use **Reference**

STOP THINK ACT REVIEW

Braze Bond Structural Assessment Joint SWP95-FW37

Ref: TE M3-EV-05-0002 Rev. 1 this sheet revised 07/17/2007

Part 1 Basic Data (dashed boxes are inputs)

	Inputs:		Inputs:
Line No:	SWP-075-V222	*Pipe Dia*	1.05 in
Sys Function:	FT-43B upstrm instr tubing	*Nom. Wall Thk*	0.154 in
Piping Iso:	CI-SWP-95 Sh 2	*Pipe Mat'l*	SB 466 CDA 706
Joint:	SWP95-FW37	*Fitting Mat'l*	SB 61or 62
Side of Joint:	Upstrm	Ref. Bond Strength:	7,500 psi
Jt. Orientation:	later	Bond Adjustment	10%

Measured Ave. Bond 59% (calculated. For bond measurements, see sheet 'UT Readings')

59 % >= 60 % ? No, Detailed assessment required

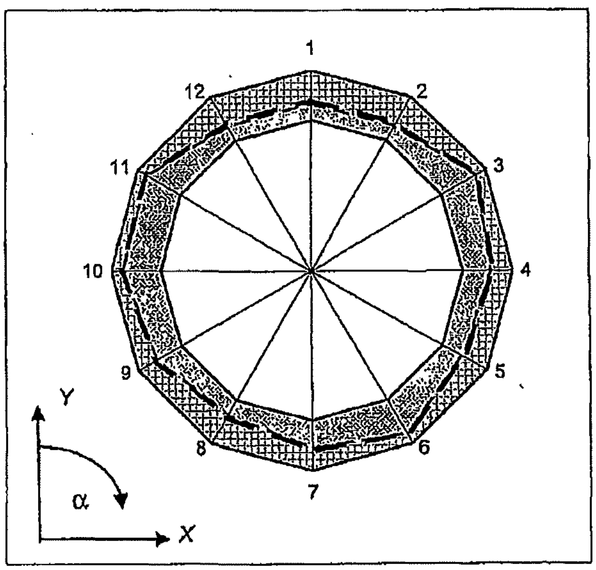
Part 2 Bond Data Summary (data from sheet 'Bond Calcs')

Offsets based on adjusted bond:

Dxx	-0.008	in
Dyy	-0.026	in
Doffset	0.027	in (5% of pipe radius)
Alpha	9.7	degrees - rotation angle of principal axes

Calculated effective bond data are in principal axes system, and are based on adjusted bond.

	Actual	Adjusted
Bxx	66%	62%
Byy	52%	47%
Bbend	52%	47%
Bpress	59%	55%



Note: Plot is figurative only, actual braze bond is cylindrical, not through-wall.

Braze Bond Structural Assessment Joint SWP95-FW37

Part 3 Calculated Bond Load Capability

D	1.05	in
tnom	0.154	in
Pipe Z	0.085	in^3
Linsert	0.344	in (from lookup table at right)
Smax(100%)	26,169	psi (from formula at right)

Lookup Tbl: L.insert per MilSpec

D.nom	D.od	Linsert
3/4	1.05	11/32
1	1.315	7/16
1.5	1.9	5/8
2	2.375	21/32
2.5	2.875	25/32
3	3.5	53/64

Load Capability (Allowable Nominal Pipe Stress)
(Based on bond levels from Part 2)

	Actual	Adjusted	
Sxx	17,213	16,218	psi
Syy	13,695	12,295	psi
Sallow	13,695	**12,295**	**psi**

stress based on shear allow. and percent bond

$$S_{max}(b_{adj}) = b_{adj} \cdot \left(\frac{\pi D^2 \cdot L_{insert}}{4 \cdot Z_{pipe}} \right) \cdot \tau_{max}$$

Part 4 Pipe Stress Data

(stress calc inputs)

Stress Calc	NP-SWP-95-V222
Rev / CCN	Rev. 2, CCN 0
Line No:	SWP-075-V222
Sys Function:	FT-43B upstrm instr tubing
Piping Iso:	CI-SWP-95 Sh 2
Joint:	SWP95-FW37

(data from Part 1)

Pipe Dia	1.05	in
Nom. Wall Thk	0.154	in
Pipe Mat'l	SB 466 CDA 706	
Fitting Mat'l	SB 61or 62	
A.pressure	0.825	in^2
Z.pipe	0.085	in^3

Inputs:

Stress Node	n/a
Alt. Stress Node	n/a
SIF Used	2.1
Primary SIF	1.575

$$S_{p\_offset} = D_{offset} \cdot \frac{P_{max} A_{press}}{Z_{pipe}}$$

$$S = \frac{S - S_{lp}}{psif} + S_{p\_offset} + S_{lp} \cdot \frac{B_{bend}}{B_{press}}$$

Inputs:

			Calculated Nominal Stresses	
Design Pressure	100 psig			
Max Op. Pressure	100 psig			
Slp	170 psi	Sp_offset	27	psi
Eq. 8 (P+DL)	2448 psi	Sust'd 8'	1619	psi
Eq. 9 (N/U)	5238 psi	N/U 9'	3391	psi
Eq. 9F (Design Basis0	6402 psi	Faulted 9F'	4130	psi
		Max Pipe Nominal Stress	**4130**	**psi**
		Apply Safety Factor of 1.5	**6195**	**psi**

Part 5 Structural Integrity Determination Joint SWP95-FW37

Joint Load Capability	12,295	psi	(from Part 3)
1.5*Design Basis Load	6,195	psi	(from Part 4)

Check: 6,195 < 12,295 ===> Braze is adequate for design basis loads
Monitor until repair/replacement

Braze Bond Measurements Joint SWP95-FW37

							R	Rmin
	Bond Adjustment		10%				1	0.75
Reading	Angle	Meas. Bond	Adj Bond	PlotValue	Adj Plot		Max	Min
1	0	40%	*33%*	0.850	0.833		1	0.75
2	30	40%	*33%*	0.850	0.833		1	0.75
3	60	80%	*78%*	0.950	0.944		1	0.75
4	90	60%	*56%*	0.900	0.889		1	0.75
5	120	50%	*44%*	0.875	0.861		1	0.75
6	150	80%	*78%*	0.950	0.944		1	0.75
7	180	60%	*56%*	0.900	0.889		1	0.75
8	210	40%	*33%*	0.850	0.833		1	0.75
9	240	60%	*56%*	0.900	0.889		1	0.75
10	270	80%	*78%*	0.950	0.944		1	0.75
11	300	80%	*78%*	0.950	0.944		1	0.75
12	330	40%	*33%*	0.850	0.833		1	0.75
13	360	0%	*0%*	0.750	0.750		1	0.75
14	390	0%	*0%*	0.750	0.750		1	0.75
15	420	0%	*0%*	0.750	0.750		1	0.75
16	450	0%	*0%*	0.750	0.750		1	0.75
17	480	0%	*0%*	0.750	0.750		1	0.75
18	510	0%	*0%*	0.750	0.750		1	0.75
19	540	0%	*0%*	0.750	0.750		1	0.75
20	570	0%	*0%*	0.750	0.750		1	0.75

Nreadings	12	**Ave**	59%	55%	G9:G21
dTheta	30	**Min**	40%	33%	
degrees		**Max**	80%	78%	

Braze Bond Calculations   Joint SWP95-FW37

Boffset 10%   Nreadings 12

D 1.05

Aoffset Input
0 degrees
0.000 rad

Equivalent bond based on measured bond readings, without adjustment

Angle	Meas. Bond	cos(theta)	db*cos	db*cos^2	db*sin*cos	sin(theta)	db*sin	db*sin^2
0	40%	1.000	0.400	0.400	0.000	0.000	0.000	0.000
30	40%	0.866	0.346	0.300	0.173	0.500	0.200	0.100
60	80%	0.500	0.400	0.200	0.346	0.866	0.693	0.600
90	60%	0.000	0.000	0.000	0.000	1.000	0.600	0.600
120	50%	-0.500	-0.250	0.125	-0.217	0.866	0.433	0.375
150	80%	-0.866	-0.693	0.600	-0.346	0.500	0.400	0.200
180	60%	-1.000	-0.600	0.600	0.000	0.000	0.000	0.000
210	40%	-0.866	-0.346	0.300	0.173	-0.500	-0.200	0.100
240	60%	-0.500	-0.300	0.150	0.260	-0.866	-0.520	0.450
270	80%	0.000	0.000	0.000	0.000	-1.000	-0.800	0.800
300	80%	0.500	0.400	0.200	-0.346	-0.866	-0.693	0.600
330	40%	0.866	0.346	0.300	-0.173	-0.500	-0.200	0.100
360	0%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
390	0%	0.866	0.000	0.000	0.000	0.500	0.000	0.000
420	0%	0.500	0.000	0.000	0.000	0.866	0.000	0.000
450	0%	0.000	0.000	0.000	0.000	1.000	0.000	0.000
480	0%	-0.500	0.000	0.000	0.000	0.866	0.000	0.000
510	0%	-0.866	0.000	0.000	0.000	0.500	0.000	0.000
540	0%	-1.000	0.000	0.000	0.000	0.000	0.000	0.000
570	0%	-0.866	0.000	0.000	0.000	-0.500	0.000	0.000
		0.000	-0.025	3.175	-0.130	0.000	-0.007	3.925
Bpress		check=0	ry	Bpyy	Bpxy	check=0	rx	Bpxx
59%			-0.042	0.265	-0.011	0.592	-0.012	0.327

Roffset	Yoffset	Byy	Bxy	Byy+Bxx	Xoffset	Bxx
0.023	-0.022	0.264	-0.011	0.591	-0.006	0.327
BByy		53% Bave		59% BBxx		65%
Byy_p		0.262		Bxx_p		0.329
		52%				66%

Byy-Bxx=0	Bxy=0	tan 2alpha	cos 2alpha	sin 2alpha	tan check	alpha
-0.053	-0.011	0.351	0.944	0.331	0.351	0.169 rad
FALSE	FALSE					9.7 deg

Equivalent bond based on adjusted bond readings

$$b_{adj} = \frac{b - b_{offset}}{1 - b_{offset}}$$

$$B'_{yy} = \frac{1}{N}\cdot\sum b_i \cos(\theta_i)^2$$

$$B'_{xx} = \frac{1}{N}\cdot\sum b_i \sin(\theta_i)^2$$

$$B'_{xy} = \frac{1}{N}\cdot\sum b_i \sin(\theta_i)\cdot\cos(\theta_i)$$

$$B_{yy} = B'_{yy} - r_{yy}^2 \cdot b_{av}$$

$$B_{xx} = B'_{xx} - r_{xx}^2 \cdot b_{av}$$

$$B_{xy} = B'_{xy} - r_x r_y b_{av}$$

$$\tan(2\alpha) = \frac{2 B_{xy}}{(B_{yy} - B_{xx})}$$

$$\cos(2\alpha) = \frac{|B_{yy} - B_{xx}|}{\sqrt{(B_{yy} - B_{xx})^2 + 4 B_{xy}^2}}$$

$$\sin(2\alpha) = \frac{\mathrm{sgn}(\tan(2\alpha))\cdot|2 B_{xy}|}{\sqrt{(B_{yy} - B_{xx})^2 + 4 B_{xy}^2}}$$

$$\alpha = \frac{1}{2}\operatorname{asin}(\sin(2\alpha))$$

$$B_{p\_yy} = \frac{B_{yy} + B_{xx}}{2} + \frac{B_{yy} - B_{xx}}{2}\cdot\cos(2\alpha) + B_{xy}\sin(2\alpha)$$

$$B_{p\_xx} = \frac{B_{yy} + B_{xx}}{2} - \frac{B_{yy} - B_{xx}}{2}\cdot\cos(2\alpha) - B_{xy}\sin(2\alpha)$$

$$B_{p\_xy} = B_{xy}\cos(2\alpha) - \frac{B_{yy} - B_{xx}}{2}\cdot\sin(2\alpha)$$

Angle	Adj. Bond	cos(theta)	db*cos	db*cos^2	db*sin*cos	sin(theta)	db*sin	db*sin^2
0	33%	1.000	0.333	0.333	0.000	0.000	0.000	0.000
30	33%	0.866	0.289	0.250	0.144	0.500	0.167	0.083
60	78%	0.500	0.389	0.194	0.337	0.866	0.674	0.583
90	56%	0.000	0.000	0.000	0.000	1.000	0.556	0.556
120	44%	-0.500	-0.222	0.111	-0.192	0.866	0.385	0.333
150	78%	-0.866	-0.674	0.583	-0.337	0.500	0.389	0.194
180	56%	-1.000	-0.556	0.556	0.000	0.000	0.000	0.000
210	33%	-0.866	-0.289	0.250	0.144	-0.500	-0.167	0.083
240	56%	-0.500	-0.278	0.139	0.241	-0.866	-0.481	0.417
270	78%	0.000	0.000	0.000	0.000	-1.000	-0.778	0.778
300	78%	0.500	0.389	0.194	-0.337	-0.866	-0.674	0.583
330	33%	0.866	0.289	0.250	-0.144	-0.500	-0.167	0.083
360	0%	1.000	0.000	0.000	0.000	0.000	0.000	0.000
390	0%	0.866	0.000	0.000	0.000	0.500	0.000	0.000
420	0%	0.500	0.000	0.000	0.000	0.866	0.000	0.000
450	0%	0.000	0.000	0.000	0.000	1.000	0.000	0.000
480	0%	-0.500	0.000	0.000	0.000	0.866	0.000	0.000
510	0%	-0.866	0.000	0.000	0.000	0.500	0.000	0.000
540	0%	-1.000	0.000	0.000	0.000	0.000	0.000	0.000
570	0%	-0.866	0.000	0.000	0.000	-0.500	0.000	0.000
		0.000	-0.027	2.861	-0.144	0.000	-0.008	3.694
Bpress		check=0	ry	Bpyy	Bpxy	check=0	rx	Bpxx
55%			-0.050	0.238	-0.012	0.546	-0.016	0.306

Roffset	Yoffset	Byy	Bxy	Byy+Bxx	Xoffset	Bxx
0.027	-0.026	0.237	-0.012	0.545	-0.008	0.308
BByy		47% Bave		54% BBxx		62%
Byy_p		0.235		Bxx_p		0.310
		47%				62%

Byy-Bxx=0	Bxy=0	tan 2alpha	cos 2alpha	sin 2alpha	tan check	alpha
-0.071	-0.012	0.352	0.943	0.332	0.352	0.169 rad
FALSE	FALSE					9.7 deg

Measured Bonds

Bond values calculated at A_offset angle			
Yoffset	Byy	Xoffset	Bxx
-0.022	53%	-0.006	65%

Adjusted Bonds

Bond values calculated at A_offset angle			
Yoffset	Byy	Xoffset	Bxx
-0.026	47%	-0.008	62%

Independent Reviewer Comment and Resolution Sheet(s)

(ER/EV) No. M2-EV-08-0006 Rev. 0

Page 1 of 1

Independent Reviewer: Thomas Steahr Thomas G. Steahr Date 3/13/08

Comment No.	ER/EV Section	Comment
	All	Minor edits

INFORMATION ONLY

ATTACHMENT 1
ULTRASONIC CALIBRATION DATA SHEET

Plant: MILLSTONE Unit: 3

Purpose: ENGINEERING INFORMATION

Cal Block Number MTE-02015

DWG No. 25212-21001 SH. 21

Page 1 of 1

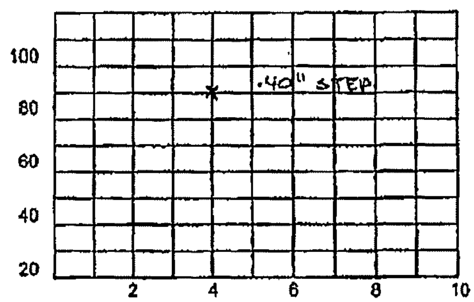
AWO Number: M3-08-04182

Cal Block Temp N/A

Thermometer S/N & Due Date N/A

Search Unit	
Manufacturer	KBA
Style or Type	GAMMA
Frequency	5.0 MHz
Size & Shape	.25"
Mode T or C	C
Search Unit Angle	0°
Measured Angle	N/A
Serial Number	003XNY
Cable Type, Length	RG-174/6' DUAL
No. of Connectors	0

Instrument & Settings	
Mfg. / Model	KB
Serial Number	00CLRY5
Range	1.0"
Material Velocity	.1960
Delay	-0.375
Pulser	DUAL
Reject	0%
Frequency	2-8
Damping	1000 OHM
Zero Value	4.146
Pulse Rep Rate	HIGH
Gain Setting	N/A



Attachments (Check)	
Sketch Sheet	N/A
Supplements	✓

Calibrations	Time
Initial Calibration	1424
Final Calibration	N/A
Final Calibration	1436

CRT Setup	Inches
Metal Path	N/A
Depth	1.0"

Couplant Data	
Brand	SOUNDSAFE
Batch Number	06120A
SAP Batch Mgmt. No.	000075233

Component ID	Component Type	Comments
FW-38	BRAZED JOINT	FOLLOW-UP EXAM

Examiner (Print & Sign) TODD BOHNENKAMPER/ [signature] Level II Date 5/28/08

Examiner (Print & Sign) N/A Level N/A Date N/A

Reviewer (Signature) Michael Bulik Level II Date 5/28/08

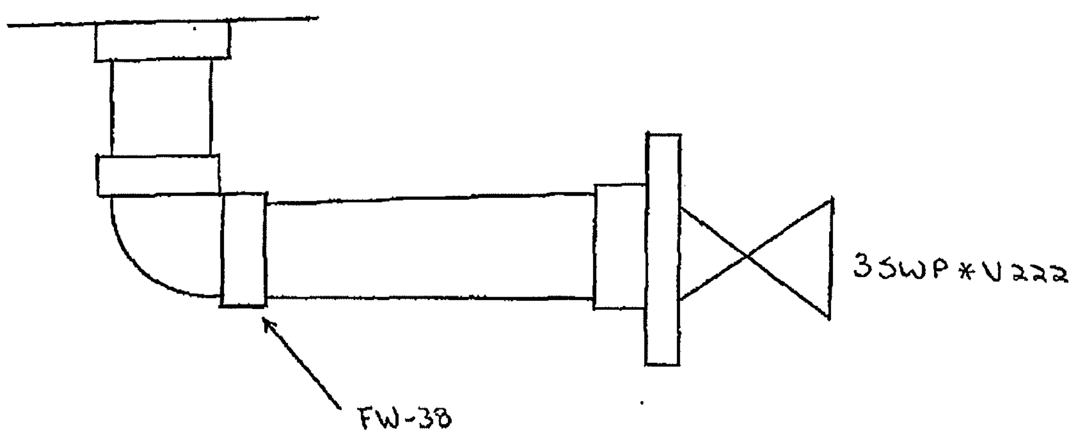
Level of Use
Reference

STOP THINK ACT REVIEW

INFORMATION ONLY

FW-38 AWO M3-08-04182

Point No.	1st Signal (no bond)	2nd Signal (bond)
1	60	40
2	60	40
3	70	30
4	65	35
5	60	40
6	70	30
7	70	30
8	65	35
9	60	40
10	60	40
11	70	30
12	70	30
Average	65 %	35 %



ATTACHMENT 1
ULTRASONIC CALIBRATION DATA SHEET

Plant: MILLSTONE Unit: 3

Purpose: ENGINEERING INFORMATION

Cal Block Number 98-7200

DWG No. 25212-21001 SH. 21

Page 1 of 2

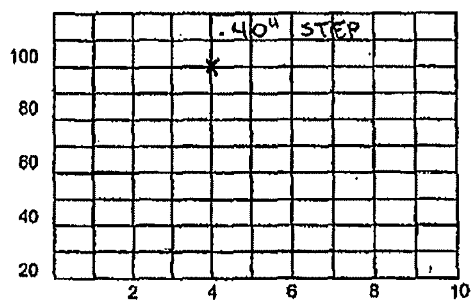
AWO Number: M3-08-04183

Cal Block Temp N/A

Thermometer S/N & Due Date N/A

Search Unit	
Manufacturer	KBA
Style or Type	GAMMA
Frequency	5.0 MHZ
Size & Shape	.25"
Mode T or C	C
Search Unit Angle	0°
Measured Angle	N/A
Serial Number	008XVY
Cable Type, Length	RG-174/6
No. of Connectors	0

Instrument & Settings	
Mfg. / Model	KB/USN52L
Serial Number	00CNF2
Range	1.00"
Material Velocity	1920
Delay	-.242
Pulser	DUAL
Reject	0%
Frequency	2-8
Damping	1000 OHM
Zero Value	4.008
Pulse Rep Rate	HIGH
Gain Setting	N/A



Attachments (Check)	
Sketch Sheet	N/A
Supplements	✓

Calibrations	Time
Initial Calibration	0938
Final Calibration	N/A
Final Calibration	1000

CRT Setup	Inches
Metal Path	N/A
Depth	1.0"

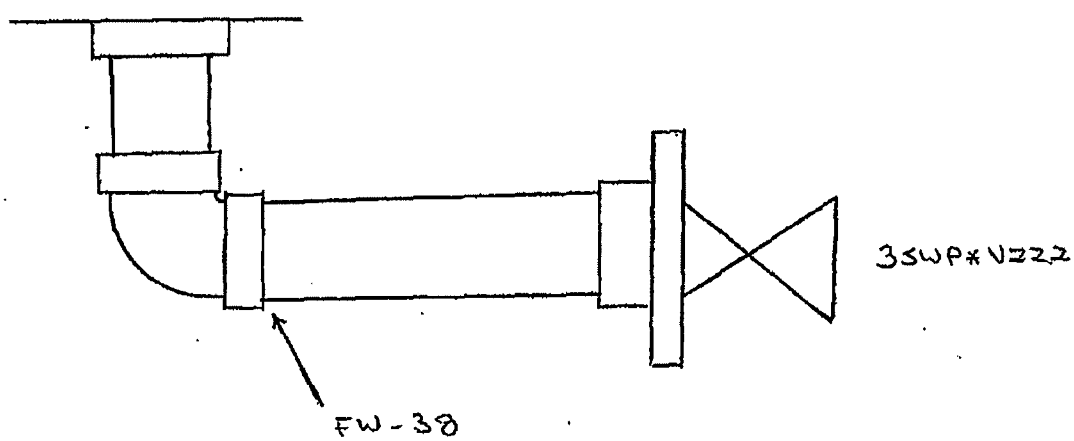
Couplant Data	
Brand	SOUNDSAFE
Batch Number	06120A
SAP Batch Mgmt. No.	0000075238

Component ID	Component Type	Comments
FW-38	BRAZED JOINT	FOLLOW-UP EXAM

Examiner (Print & Sign) TODD BOHNENKAMPER/ [signature] Level II Date 8/26/08
Examiner (Print & Sign) N/A Level N/A Date N/A
Reviewer (Signature) Michael Burke Level III Date 8/28/08

FW-38 AWO M3-08-04183

Point No.	1st Signal (no bond)	2nd Signal (bond)
1	60	40
2	60	40
3	70	30
4	65	35
5	65	35
6	65	35
7	70	30
8	60	40
9	70	30
10	65	35
11	65	35
12	70	30
Total	785	415
Average	65%	35%



ATTACHMENT 5

MECHANICAL TESTS

MILLSTONE POWER STATION UNIT 3
DOMINION ENERGY NUCLEAR CONNECTICUT, INC.

1.0 BACKGROUND

The correlation developed by the testing conservatively determines a required bond level for a given intensity of joint loading. The results of these tests support the use of the comparison shown in Figure 2 of Attachment 2, for the structural integrity analysis. It is noted that the evaluation of testing results was with respect to a braze shear capability of 5.0 ksi, which in the final methodology has been increased to 7.5 ksi, provided that piping loads have an FS of 1.5 applied. For consistency with testing as performed, the 5.0 ksi shear capability discussed is retained in this attachment.

2.0 TEST SAMPLE DESIGNS

The effort to empirically confirm required bond levels for varying intensities of joint loadings consisted of three separate series of mechanical tests:

a) specially fabricated joints with a controlled average bond level,
b) specially fabricated joints that had disbondment on a contiguous arc-segment of the joint, and
c) field sample piping joints, salvaged from piping removed from the plant.

All joints were tested in three-point bending with the brazed fitting in the middle of the configuration.

2.1 Specially Fabricated Joints with a Controlled Average Bond Level

By a combination of machining and use of insert-groove type fittings, a series of test joints were fabricated with equivalent bond levels of 12, 30, 40 and 60 percent. The machining removed only about 30 mils of pipe thickness so that piping strength was not significantly affected. The samples were fabricated for two-inch and for three-inch joints. Three examples of each size and bond level were fabricated, for a total of 24 samples. (Of the 24 samples in this category, one of the 40 percent bond samples was subsequently found to have less than the fully intended bond and is excluded from the results.)

2.2 Specially Fabricated Joints that had Disbondment on a Contiguous Arc-Segment of the Joint:

These test items were intended to explore the effect of having a significantly non-uniform distribution of bond area around the circumference of the joint. Six samples were fabricated with disbondment segment angles of 36, 48, 72, 90, 108 and 126 degrees. The average bond levels for these samples, assuming perfect bond except in the disbonded segments, ranged from 90 percent down to 65 percent, respectively.

2.3 Field Sample Piping Joints:

These joints were salvaged from piping that was removed from the plant after about 20 years of service and screened by Ultrasonic Testing (UT). Piping joints with the lowest of measured bond were selected for testing.

The nine items selected for testing included the following:

Description	Quantity
Two-inch couplings	3
Three-inch couplings	2
Three-inch tee (run sides)	1
Three-inch flanges	3

The couplings and the tee included two brazed joints subjected to test loads. The test flanges were mated to full strength flanges not under test.

3.0 MECHANICAL TEST RESULTS

The results from testing on each of the series of tests are described in the balance of this section. The referenced figures are included in Attachment 2. A test report has been incorporated into the Millstone Power Station plant records.

3.1 Specially Fabricated Joints with a Controlled Average Bond Level:

For the intentionally disbonded joints, all joints with 30 percent or better true bond, achieved full piping collapse strength with no failure of the bond. Refer to Attachment 2, Figure 3. As testing of each joint continued above the piping collapse load, one of the 40 percent true bond joints had indications of bond failure. The 12 percent true bond joints all experienced bond failure before reaching piping collapse load but withstood a minimum of 37 percent of the piping collapse load(refer to Figure 4). All test items achieved their test collapse load at a load well above that which would be predicted for a 5 ksi braze shear strength.

3.2 Specially Fabricated Joints that had Disbondment on a Contiguous Arc-Segment of the Joint

From 36 through 72 degrees of segment disbondment, the test items all achieved full piping collapse load. The test items from 90 through 126 degrees disbondment exhibited progressively lower collapse load, as shown in Attachment 2, Figure 5. At 126 degrees disbondment, the test item achieved about 60 percent of the piping collapse load. The load deflection curves for these joints did not exhibit any indications of bond failure, however at the extremes of deflection (well above the level that would be acceptable for application of this methodology) the higher angle joints were significantly distorted. For such large levels of deflection, it was apparent that the close mechanical fit-up of the pipe in socket configuration contributed to joint bending strength. All test items achieved their test collapse load at a load well above that which would be predicted for a 5 ksi braze shear strength.

3.3 Field Sample Piping Joints

The field sample test items exhibited considerable variation in collapse load for roughly similar UT bond readings. The variations were expected for the field samples. Figures 6 and 7 show the displacement load curve for the tested field samples. Bond failure limited the collapse load in the two-inch Joints 37 and 39, and the three-inch Joints 3 and 9. The load curve for Joint 9 has a slight discontinuity at 11.9 ksi that is conservatively considered to indicate initial bond failure, even though the load continues above this point. The collapse load for other samples was limited by the piping collapse load, which is equivalent to about 21 ksi. Even with the low UT bond readings, the field samples developed at least 50 percent of the piping collapse load. The higher than expected collapse load for some of the three-inch joints is believed to be partly due to the thickness of filler metal present as a fillet at the face of some of the joints. All test items achieved their test collapse load at a load well above that which would be predicted for a 5 ksi braze shear strength and the adjusted percent bond used in this methodology.

The adequacy of the 5 ksi shear stress assumed in the methodology in Equation 3 of Figure 2, Attachment 2, for estimating joint strength is confirmed by the testing margins shown in the following table.

Table 1: Test Load vs. Bond Shear Capacity

Test Joint	Average UT %	Adjusted UT %	Test Collapse Load, ksi	Shear Capacity Load, ksi	Test / Shear Margin
36	65	61	22.8	15.8	1.44*
37	27	19	11.6	4.9	2.41
39	55	50	19.6	13.0	1.52
2	45	39	27.3	9.0	3.02*
3	47	41	22.6	9.6	2.38*
4A	15	5	27.3	1.3	23.59*
9	38	31	11.9	7.2	1.69
9J	48	42	28.6	9.8	2.95*
31A	21	12	32.0	2.8	11.61*

* Piping collapse load reached before bond failure or deflection run out.

The data in Table 1 is plotted in Figure 9 of Attachment 2. Of the joints that were limited by bond failure prior to reaching piping collapse load, the minimum margin factor was 1.52. This minimum margin appears in Joint 39, with a 50 percent adjusted average bond. Review of detailed bond readings around the circumference of Joint 39 gives an equivalent adjusted bond of 43 percent for the bending axis used during the test, corresponding to a margin factor of 1.74 for this test case.

ATTACHMENT 6

ULTRASONIC TEST PROCEDURE

MILLSTONE POWER STATION UNIT 3
DOMINION ENERGY NUCLEAR CONNECTICUT, INC.

Nuclear Fleet

Nondestructive Examination Procedure

Title: Ultrasonic Examination of Brazed Joints – Millstone Unit 3 Service Water Piping

Procedure Number	Revision Number	NPQR Number
ER-MP-NDE-UT-745	0	ER-MP-NDE-UT-745-NPQR, N/A

Approval signatures on file with approval documentation for this procedure revision.

R. C. Davies — 04/04/2016
Independent Level III Review

K. J. Hacker — 04/04/2016
Corporate Level III Approval

Level of Use: Reference

Record of Revision

Rev	Page	Paragraph #	Summary of Revision
0	All	All	New issue as a Millstone Site Specific NDE Procedure.

Table of Contents

1.0 Purpose

1.1 The purpose of this procedure is to define a process for the application of ultrasonic examination techniques for the examination of brazed pipe joints to establish the extent of braze bond. This procedure describes the equipment, material, and documentation requirements for ultrasonic (UT) examinations.

2.0 Scope

2.1 This procedure is applicable to the manual contact ultrasonic examination of Millstone Unit 3, ASME Code Class 3, service water piping with brazed joints to establish the extent of braze bond. This procedure is applicable to brazed joints in nominal pipe size (NPS) of 3 inches and smaller.

2.2 This procedure describes equipment and procedures that shall be used in the ultrasonic examination of brazed pipe joints. This procedure is written based on the techniques and methodology detailed in relief request IR-3-04, no additional qualification is required.

3.0 Reference Documents

3.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 2004 Edition with no Addenda.

3.2 ER-AA-NDE-120, "Dominion Written Practice for Certification of Nondestructive Examination Personnel."

3.3 ER-AA-NDE-121, "Dominion Written Practice for Certification of Nondestructive Examination Personnel in Accordance with ASME Section XI, Appendix VII Requirements."

3.4 ER-AA-NDE-130, "Storage and Control of Calibrated NDE Equipment, Calibration Standards, and Consumable NDE Materials."

3.5 ER-AA-NDE-140, "Processing of Dominion NDE Data."

3.6 Fabrication and Inspection of Brazed Piping Systems, NAVSEA 0900-LP-001-7000, Dated January 1, 1973.

3.7 Millstone Unit 3, Relief Request IR-3-04 "Alternative Brazed Joint Assessment Methodology", ML091310666 and ML092390141.

4.0 Definitions

4.1 **Face of Fitting** - The annulus surrounding the socket end.

4.2 **Insert Groove** - The groove in the fitting socket prepared to contain the brazing alloy ring.

4.3 **Land, Fitting -** That portion of the fitting on the side of the insert groove nearest the middle of the fitting.

4.4 **Land, Center** - That portion of the fitting between the grooves in a multiple insert fitting.

4.5 **Land, Pipe** - That portion of fitting on the side of the insert groove toward the end of the fitting.

5.0 Personnel Qualifications

5.1 The examiner shall be certified to a minimum of Level II in the ultrasonic method in accordance with ER-AA-NDE-120 or ER-AA-NDE-121. The examiner shall be responsible for and shall accept the results of the examination.

5.1.1 In addition, the examiner shall maintain a current endorsement for the ultrasonic examination of brazed piping joints in accordance with Appendix I of this procedure.

5.2 An assistant qualified to at least Trainee or Level I in the ultrasonic method may assist the examiner. The Trainee or Level I shall work under the direct supervision of the examiner and shall not evaluate or accept the examination results.

6.0 Equipment and Material Requirements

6.1 All equipment and materials used to implement this procedure shall comply with the requirements of ER-AA-NDE-130, "Storage and Control of Calibrated NDE Equipment, Calibration Standards, and Consumable NDE Materials".

6.2 Ultrasonic Instrument

6.2.1 A pulse-echo type of ultrasonic flaw detection instrument shall be used. The instrument shall be equipped with a stepped gain control calibrated in units of 1.0 dB or less.

6.2.2 The instrument shall be used at the rated frequency of the search unit.

6.2.3 The reject control shall be in the "off" position for all examinations.

6.3 Search Units

6.3.1 The search units shall be dual element, straight beam (longitudinal wave) with nominal frequencies of 5.0 MHz. The maximum nominal element dimension shall not exceed 0.250".

6.4 Cabling

6.4.1 Search unit cables shall be a maximum of 25' in length and may consist of RG-58, RG-174, or combination of RG-58 and RG-174 type cables with no more than 1 intermediate connector.

6.4.2 The same cables and intermediate connections used for the calibration shall be used for the examination.

6.5 Couplant

6.5.1 A suitable ultrasonic couplant shall be applied to the examination surface. The same couplant used for calibration shall be used for performing the examination.

6.6 Calibration Blocks

6.6.1 The material from which the blocks are fabricated shall be acoustically similar but need not be identical to the fitting being examined.

6.6.2 The calibration block used may be flat or of the same curvature as the component being examined with a surface finish representative of the scanning surface finish on the component to be examined.

7.0 Calibration

7.1 The screen height and amplitude control linearity of the ultrasonic instrument shall be verified before and after examining all components to be examined during an outage or periods of use not to exceed three months. The linearity checks shall be performed in accordance with ER-AA-NDE-130.

7.2 Time Base (Range) Calibration

7.2.1 A suitable linear screen range shall be established using a calibration block.

7.2.2 The nominal bond thickness (pipe back wall) should appear at no greater than 85% of full screen width, although data taken beyond that point, up to 100% of full screen width is valid.

7.3 Calibration Verification (Cal Check)

7.3.1 System calibration shall be checked on the calibration block.

7.3.2 The time base calibration shall be recorded for at least one point within the calibrated range of the system established during the initial calibration and:

7.3.3

7.3.3.1 At the finish of each examination or series of similar examinations;

7.3.3.2 At intervals not to exceed 4 hr during the examination;

7.3.3.3 When examination personnel are changed;

7.3.3.4 After any interruption in system continuity (e.g., power interruptions, search unit change-outs, activation of new examination setups, etc.);

7.3.3.5 After any instance of suspected system irregularity.

7.3.4 Any change in probes or UT instruments from that used during the initial calibration shall be cause for a new calibration. When replacing cables of the same size, type, length and number of intermediate connectors as used during the original calibration, it is acceptable to perform a calibration check only.

7.3.5 The system calibration shall be documented on the Brazed Joint Calibration Record, Attachment 1.

8.0 Examination

8.1 Surface Condition Requirements

8.1.1 The outer surface of the fitting socket shall be prepared sufficiently to obtain satisfactory sound transmission, shall not be rounded in the longitudinal direction, and should be relatively parallel to the pipe surface.

8.2 Examination Requirements

8.2.1 The surface of the brazed joint to be examined shall be laid out around the circumference in increments of ¼ inch. Markings shall be numbered clockwise as viewed facing the fitting from the pipe. These increments shall be measured on the outside diameter of the fitting.

8.2.2 Brazed joints shall be examined using a straight-beam (longitudinal wave) method as illustrated in Figure 1. Signals typically occur from the following sources; the insert groove (if present), the fitting inside diameter, areas of disbond (if present), the pipe inside diameter and possible multiple reflections.

8.2.3 To examine a joint, the search unit is placed over the area of the brazed joint intended to be bonded and moved around the circumference in ¼ inch increments (see paragraph 8.2.1) and in a number of axial increments determined by the number of lands, land or engagement area width and the search unit size. The percent of bond is determined for each circumferential increment.

8.2.4 A static examination technique shall be used. For the static examination technique, placement of the search unit shall be in accordance with paragraph 8.2.3 for each circumferential and axial increment. The instrument gain shall be adjusted so that the bond signal (pipe back wall) amplitude plus the no bond signal amplitude equals 100% for each increment.

8.2.5 For fittings containing insert grooves, as illustrated in Figure 2, place the search unit on each increment so that the search unit active area is over one land only. Note the first back reflection of the insert groove, inside diameter of the fitting (no bond) and the inside diameter of the pipe (bond) signal on the screen. If necessary, check the back reflections with an un-brazed fitting of the same size to ensure positive signal identification.

8.2.6 For fittings which contain no insert grooves, as illustrated in Figure 3, place the search unit on each increment so that the active area covers ½ of the land width of the fitting in the engagement area. Note the inside diameter of the fitting (no bond) and the inside diameter of the pipe (bond) signal on the screen. If necessary, check the back reflections with an un-brazed fitting of the same size to ensure positive signal identification.

8.2.7 Limitations or other conditions that prevent a complete examination of the required volume shall be documented on the examination data sheet.

9.0 Recording of Results

9.1 The "bond" and "no bond" signal amplitude values for all increments examined shall be recorded on the "Brazed Joint Examination Report", Attachment 2.

9.2 The increments for which no ultrasonic reading can be obtained shall be marked as follows:

"X"- increments which are inaccessible due to fitting configuration.

"NA"- Increments which are inaccessible due to piping configuration .

"NP"- Increments in which there is a lack of ultrasonic penetration.

9.3 The Increments of the above types shall be assigned percent bond values as follows:

"NA" = 0% bond

"NP" and "X" - Increments up to a total length not exceeding 20 percent of the circumference of the land shall be assigned a percentage bond value equal to that of the lowest readable increment adjacent to the "X" or "NP" increments or 60 percent whichever is the least. "X" or "NP" increments in excess of 20 percent of the circumference shall be assigned a bond value of 0 percent. The examiner may, at his discretion, shift the incremental scale so that the minimum number of increments that contain "X", "NP", of "NA" values. *

***NOTE** - Within the 20 percent limitation, two or more adjoining "X" and/or "NP" increments are considered a group of increments if the average of the remaining increments is 60 percent or more. The outermost two of any group, within the 20 percent maximum limitation, shall be rated on the basis of the adjacent readable increment. The inner increments of the group shall be assigned a zero value for calculation purposes.

9.4 The bond percentage for the joint shall be determined by a simple average of all the bond readings taken at each increment.

10.0 Data Recording

10.1 Calibration and examination data shall be recorded on data sheets and as a minimum shall include the following:

10.1.1 Calibration sheet identification.

10.1.2 Names and certification levels of examination personnel.

10.1.3 Examination procedure number and revision.

10.1.4 Calibration block identification.

10.1.5 Ultrasonic instrument serial number, manufacturer, and model identification.

10.1.6 Ultrasonic instrument essential instrument settings.

10.1.7 Search unit beam angle, mode of wave propagation in the material, nominal frequency, size, shape, and number of elements.

10.1.8 Search unit manufacturer, model, and manufacturer's serial number.

10.1.9 Search unit cable type, length, and number of intermediate connectors.

10.1.10 Times and dates of initial calibration and subsequent calibration checks.

10.1.11 Signal response amplitudes and sweep positions obtained from the calibration reflectors.

10.1.12 Couplant type and batch number.

10.1.13 Data sheet identification and date and time period of examination.

10.1.14 Identification and location of the braze joint examined.

10.1.15 A sketch of the component examined.

10.1.16 Examination results including any limitations.

10.2 All data records shall be reviewed and processed in accordance with ER-AA-NDE-140, "Processing of Dominion NDE Data".

10.3 All results shall be turned over to Engineering for final evaluation of joint integrity.

Brazed Joint Calibration Report

Dominion

Site: ______________ Procedure Rev.: ______________

Procedure: ______________ Cal. Report No.: ______________

Instrument Type: ______________ Serial No.: ______________ Search Unit Mfg.: ______________ Serial No.: ______________

Temp. Tool Mfg.: ______________ Serial No.: ______________ Search Unit Size: ______________ Frequency: ______________

Couplant: ______________ Batch No.: ______________ Search Unit Nom. Angle: ______ ° Meas. Angle: ______

Calibration Block Serial No.: ______________ Search Unit Cable Length: ______________ Cable Type: ______________

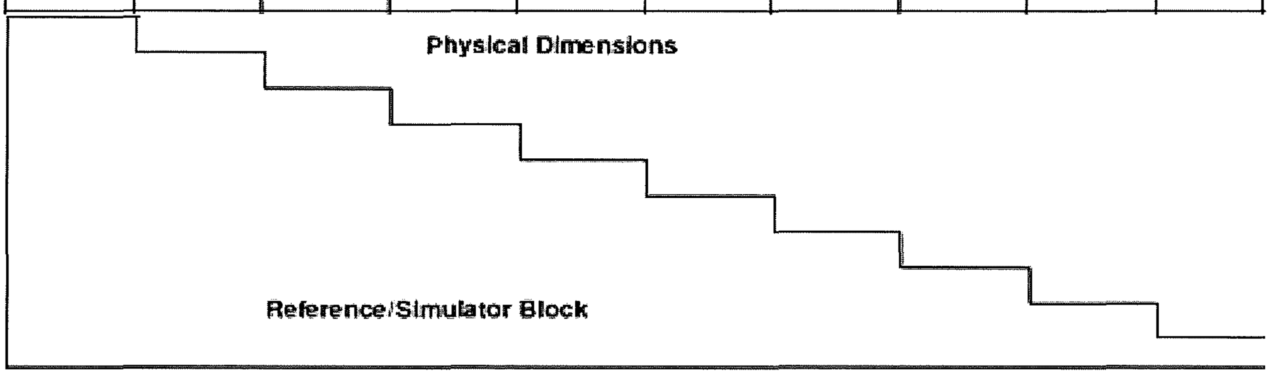
Reference/Simulator Block Type: ______________ Serial No.: ______________ Calibration Block Temperature: ______ °F

Instrument Settings	
Gain	
Range	
Delay	
Velocity/Mat. Cal.	
Frequency	
Rep. Rate	
Damping	
Display/Video/Rectif.	
Reject	

	Time	Initials
Initial Calibration		
Cal. Verification		
Cal. Verification		
Cal. Verification		
Cal. Verification		
Cal. Verification		
Final Calibration		

______ Screen Divisions = ______ in. of Sound Path

UT Measurements



Comments:

Summary No.(s):

Examiner	Level	Signature	Date	Reviewer	Signature	Date
Examiner	Level	Signature	Date	Site Review	Signature	Date
Other	Level	Signature	Date	ANII Review	Signature	Date

Attachment 1 – Typical Brazed Joint Calibration Report

Dominion

Brazed Joint Examination Report

Site/Unit: ______ Procedure: ______ Outage No.: ______
Summary No.: ______ Procedure Rev.: ______ Report No.: ______
Workscope: ______ Work Order No.: ______ Page: ____ of ____

Code: ______ Cat./Item: ______ Location: ______
Drawing No.: ______ Description: ______
System ID: ______
Component ID: ______ Size Length: ______ Thickness Diameter: ______
Limitations: ______ Component File No.: ______ Start Time: ______ Finish Time: ______

Increment	No Bond %	Bond %
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
Total		
Average		

Sketch

Comments

Examiner	Level	Signature	Date	Reviewer	Signature	Date
Examiner	Level	Signature	Date	Site Review	Signature	Date
Other	Level	Signature	Date	ANII Review	Signature	Date

Attachment 2 – Typical Brazed Joint Examination Record

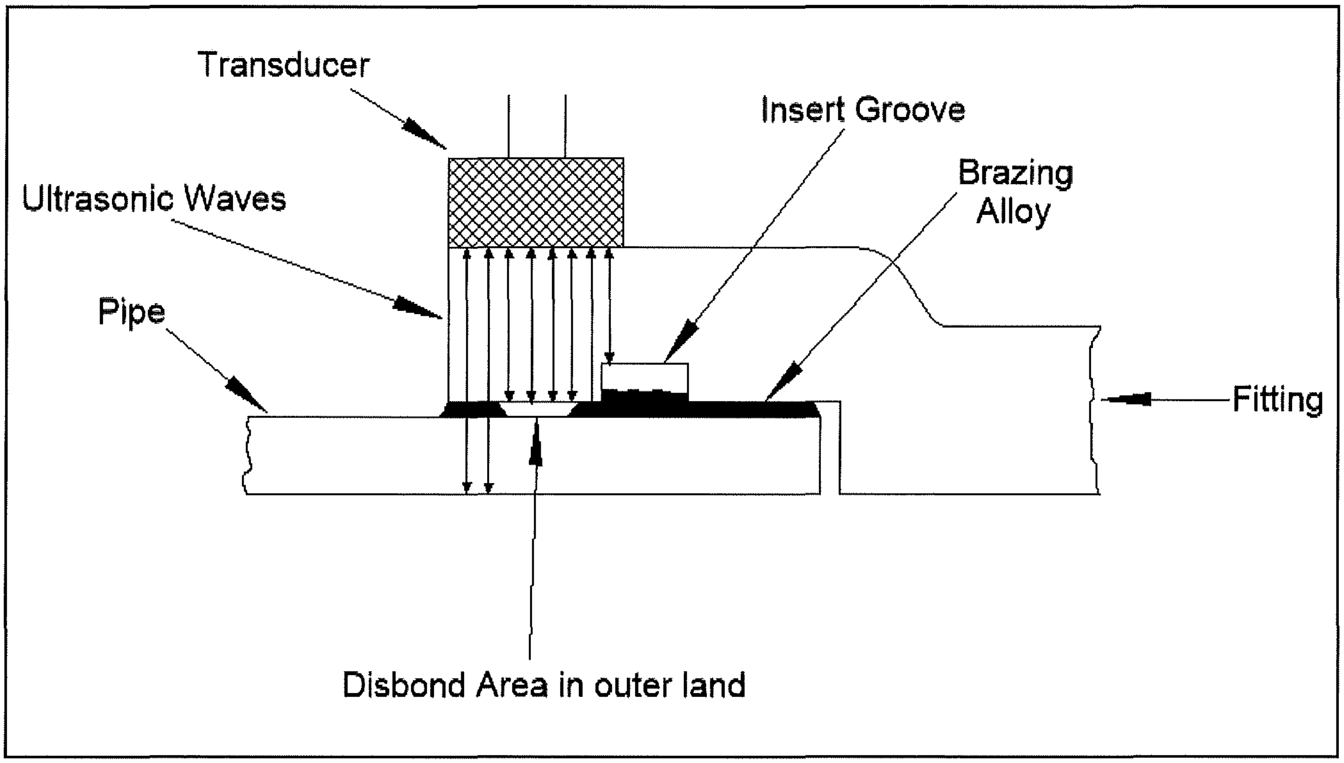


Figure 1 – Brazed Joint Examination Illustration

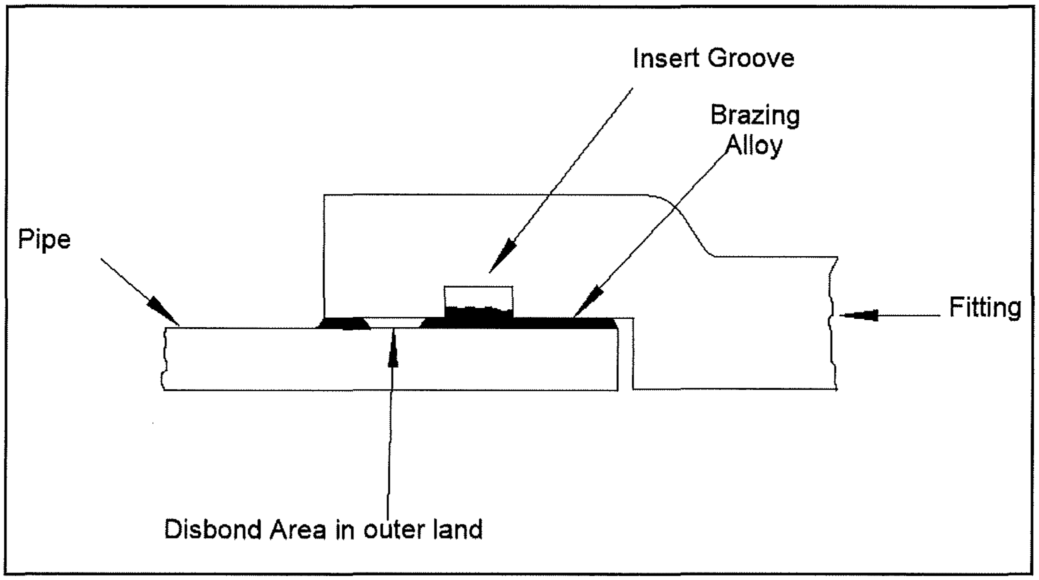


Figure 2 – Illustration of Braze Joint with Insert Groove

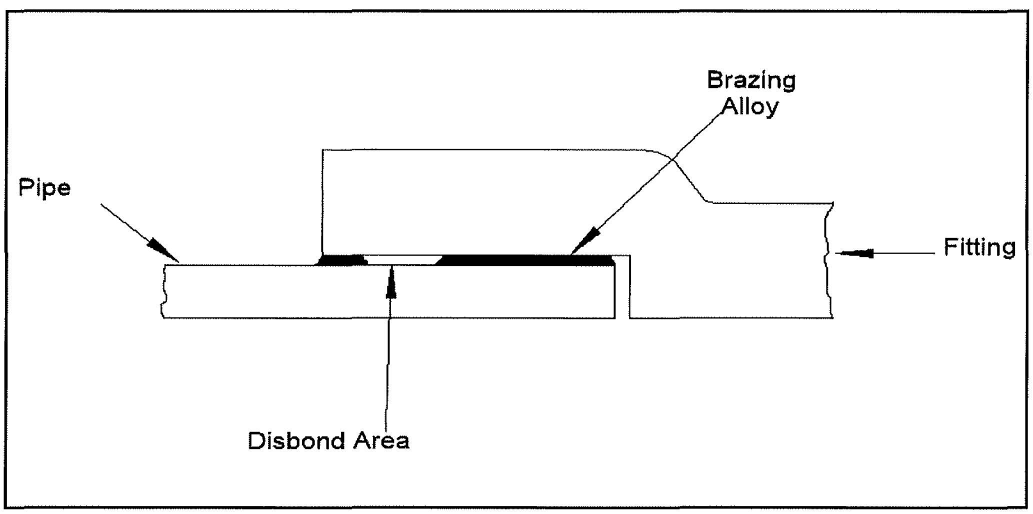


Figure 3 – Illustration of Braze Joint with no Insert Groove (Face Fed)

Appendix I – Qualification Requirements for Brazed Joint Examination

1.0 Purpose

1.1 The purpose of this Appendix is to provide the additional requirements for the qualification of UT examiners for the ultrasonic examination of brazed piping joints.

2.0 Prerequisites

2.1 Personnel who perform ultrasonic examinations of brazed joints shall also be trained, qualified, and certified as a Level II or Level III in the ultrasonic method in accordance with Dominion procedures ER-AA-NDE-120 or ER-AA-NDE-121.

2.2 This Appendix defines the additional requirements for the UT Level II or III examiner to successfully obtain a qualification endorsement for brazed joint UT examination.

3.0 Examinations

3.1 Required examinations for the brazed joint UT endorsement include written and practical examinations. These examinations shall be administered and graded in accordance with the ER-AA-NDE-121. The additional brazed joint UT endorsement qualification testing requirements are defined by 3.2 and 3.3 of this Appendix.

3.2 The written examination shall consist of at least 17 questions covering the ultrasonic testing procedure for brazed pipe joint examination.

3.2.1 The examination shall contain at least 10 questions on the operation of the ultrasonic equipment;

3.2.2 At least 5 additional questions on the ultrasonic procedure concerning the inspection of joints which fall into abnormal categories of a physical or administrative nature;

3.2.3 At least 2 additional questions concerning the recording of readings which the examiner makes.

3.2.4 The minimum-passing grade for the written examination is 80%.

3.3 The practical examination shall demonstrate the examiners ability to determine ultrasonically the bond of brazed joints. In addition the practical examination shall demonstrate the ability to recognize such technical deficiencies as insufficient beam penetration, poor transducer contact and interfering contact surface roughness from patterns displayed on the ultrasonic instrument screen.

3.3.1 The candidate shall demonstrate ability to determine ultrasonically the bond in at least six brazed joins consisting of three different pipe sizes, with two brazed joints for each size.

3.3.2 The joints shall exhibit from 40 to 80 percent bond with varying degrees of bonding in each.

3.3.3 The percent bond readings obtained by the examiner shall be compared with the true bond. The true bond is considered to be the average percent bond readings obtained by at least three qualified examiners, using the same joints. In the absence of three qualified examiners, the true bond shall be established from reading obtained by the Level III testing examiner.

3.3.4 Acceptance of the practical demonstration is based upon the arithmetic average of the six deviations from the true bond shall not vary by more than 8% from the true bond of any of the test joint specimens and no single joint deviation shall exceed 15%.

3.4 Maintaining Proficiency

3.4.1 In order to maintain examiner proficiency for the brazed joint UT endorsement:

3.4.1.1 The examiner shall either have performed a brazed joint UT examination, within the last six months, or;

3.4.1.2 Performed an examination of at least three brazed joint demonstration specimens, in accordance with the requirements of 3.3 above, within the last six months.

3.5 Requalification

3.5.1 A qualified brazed joint UT examiner shall be requalified in accordance with the requirements of 3.2 and 3.3 above, prior to performing examinations:

3.5.1.1 If the individual has not maintained proficiency for the brazed joint UT endorsement;

3.5.1.2 If the individual's performance is determined to be deficient;

3.5.1.3 At the end of three years from the endorsement qualification date.

4.0 Qualification Records

4.1 Dominion shall document the ultrasonic examination personnel endorsement for brazed piping joint UT examination on the individuals' certification record.

ATTACHMENT 7

ADDITIONAL BASIS FOR BRAZE SHEAR STRESS

MILLSTONE POWER STATION UNIT 3
DOMINION ENERGY NUCLEAR CONNECTICUT, INC.

This attachment provides the following two items:

- Additional minimum brazed joint shear stress experimental values
- Further justification for the proposed use of brazed joint shear strength and safety factor

1. Minimum Brazed Joint Shear Stress Experimental Values

The test data in Table 1 supports the proposed methodology in Request IR-4-09 for evaluating the structural integrity of brazed joints. Table 1 was derived from existing ASME Brazing Procedure Qualification Records of qualification tests performed in accordance with the ASME Boiler and Pressure Vessel Code, Section IX. Each test includes a set of either reduced or full section tensile tests. In order to pass these tests, the brazed joint must be at least as strong as the specified minimum tensile strength of the weaker of the two base metals joined. Figure 1 shows a simple schematic of a tensile test specimen. The tensile test specimen loads the braze bond in shear. The shear stress data in Table 1 was calculated by dividing the ultimate load by the theoretical shear area of each braze joint instead of the cross-sectional area of the pipe. Where failure occurred in the base metal (as was the case in all but two of the reported tests) the ultimate shear strength of the brazed joint was not measured but must be greater than the reported values.

TABLE 1: MINIMUM BRAZE JOINT SHEAR STRESS

Specimen	Pipe O.D.(1) (in)	Lap Length (in)	Shear Area (in^2)	Load (lbs)	Shear Stress (psi)	Type and Location of failure
				BPQR 112: three-inch P-110 Pipe to P-107 Fitting with Pre-placed BAg-1a Insert Ring Reduced Section tensile test data		
V-T1	0.750 (1)	0.570	0.428	5,600	13,100	Ductile - Fitting
V-T2	0.752 (1)	0.570	0.429	4,800	11,200	Ductile - Fitting
H-T1	0.753 (1)	0.570	0.429	4,300	10,000	Ductile - Fitting
H-T2	0.753 (1)	0.570	0.429	4,800	11,200	Ductile - Fitting
BPQR 113: 3/4-inch P-107 Pipe to P-110 Fitting with Pre-placed Bag-7 Insert Ring Full Section tensile test data						
V-1	1.050	0.305	1.006	14,100	14,000	Ductile - Pipe
V-2	1.050	0.305	1.006	14,800	14,700	Ductile - Pipe
H-1	1.050	0.305	1.006	14,900	14,800	Ductile - Pipe
H-2	1.050	0.305	1.006	15,100	15,000	Ductile - Pipe
BPQR 113: 3/4-inch P-107 Pipe to P-101 Fitting Face Fed Bag-7 filler metal Full Section tensile test data						
V-1	1.040	0.250	0.817	12,900	**15,800**	Ductile - Braze
V-2	1.040	0.250	0.817	14,700	18,000	Ductile - Pipe
H-1	1.040	0.250	0.817	14,500	17,700	Ductile - Pipe
H-2	1.040	0.250	0.817	12,900	**15,800**	Ductile - Braze
NOTE: (1). A pipe O.D. is used unless the value given is annotated with this note. This note denotes the value shown is a dimension of width.						

In all but two of the reported tensile tests, the specimens failed in the base material and therefore do not provide an ultimate shear strength for the brazed joint. With a failure in the base material, the reported values demonstrate that the brazed joint was capable of carrying at least the reported shear stress without failure. Therefore, ultimate shear stress for brazed joints in specimens that failed in base material was higher than the reported values.

In the two joints where failure occurred in the braze, the ultimate shear strength of the braze was 15,800 psi. Values of the other 10 specimens range from 10,000 to 18,000 psi. These values do not take into account any loss of shear area due to voids, inclusions or other flaws, which typically exceed 10 percent and may include up to 25 percent of the braze area and are still acceptable to ASME IX criteria.

Considering the data from failures in either pipe of fitting base materials and the ideal assumptions of shear area that are used to derive shear stress of Table 1, the data reasonably supports a conclusion that the ultimate shear strength of these brazed joints is much greater than where failure occurred in pipe of fitting base materials.

The indicated ultimate shear strength from the actual brazed joint failures is shown to be greater than 15,000 psi. As a conservative measure, a '2 times' margin has been used. This will result in a usable allowable shear stress value of 7,500 psi as input to the evaluation of the structural integrity of the braze joints using the methodology described in DENC request IR-4-09.

2. Brazed Joint Shear Strength and Safety Factor Use in Evaluation

DENC will revise the brazed joint evaluation procedure previously described in Request IR-4-09 in the following manner:

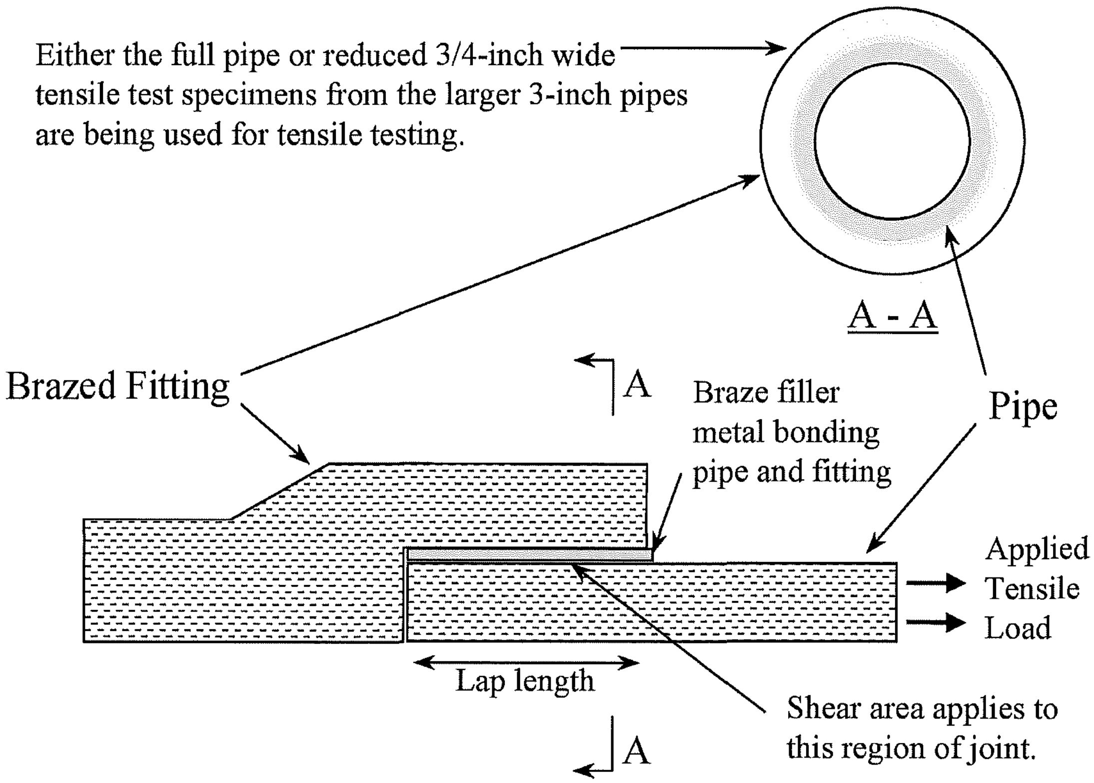
(a) The braze joint shear strength assumed for evaluation purposes will be changed to 7,500 psi, as justified above. Thus, in Attachment 2, Figure 2 of the original submittal, the parameter τ_{max} in Equation 3 is 7,500 psi.

(b) The piping analysis loads and equivalent stresses used to evaluate the braze joint will be multiplied by a safety factor of 1.5, which is conservative to factors required by ASME III Code Case N-513-4. Thus, in Attachment 2, Figure 2 of the Equation (1) reads:

$$1.5\ Seq < Smax(badj)$$

(c) Corresponding changes will be made to the "Braze Bond Structural Assessment", shown by example in the original submittal, to implement (a) and (b) above.

FIGURE 1: TENSILE TEST SPECIMEN SCHEMATIC



NOTE: This schematic shows how the tensile test specimens that are described in Table 1 load the braze bond in shear.