Exelon Generation

200 Exelon Way
Kennett Square, PA 19348
www.exeloncorp.com

10 CFR 50.55a

July 29, 2015

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

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

Subject: Proposed Relief Request associated with the Common Emergency Service Water (ESW) System Piping

Attached for your review and approval is a proposed alternative in accordance with 10 CFR 50.55a(z)(2) concerning a through-wall leak identified in the common unit Emergency Service Water (ESW) system piping at the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3. This relief applies to the fourth 10-year Inservice Inspection (ISI) interval. The fourth interval for Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, began on November 5, 2008, and will conclude on November 4, 2018. The fourth 10-year ISI interval complies with the ASME Boiler and Pressure Vessel Code, Section XI, 2001 Edition through 2003 Addenda.

As noted in the attached relief request, on May 3, 2015, a through-wall leak was discovered in a segment of the ESW system that is common to Unit 2 and Unit 3. The next scheduled time at which a repair can be performed without a dual unit shutdown is during the PBAPS, Unit 2, refueling outage which is scheduled for October 2016. In order to prevent an unwarranted Unit 2 shutdown during the upcoming Unit 3 refueling outage, we are requesting your review and approval by September 21, 2015.

There are no regulatory commitments contained in this letter.

If you have any questions or require additional information, please contact Stephanie J. Hanson at (610) 765-5143.

Respectfully,

David P. Helker
Manager - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Attachment: Relief Request I4R-56

cc: USNRC Region I, Regional Administrator
USNRC Senior Resident Inspector, PBAPS
USNRC Project Manager, PBAPS
R. R. Janati, Pennsylvania Bureau of Radiation Protection
S. T. Gray, State of Maryland

ATTACHMENT

**PEACH BOTTOM ATOMIC POWER STATION
UNITS 2 AND 3**

PROPOSED RELIEF REQUEST ASSOCIATED WITH THE COMMON EMERGENCY SERVICE WATER (ESW) SYSTEM PIPING

<u>RELIEF REQUEST I4R-56</u>

1. ASME CODE COMPONENTS AFFECTED

Code Class:	3
Examination Category:	D-B
Item Number:	D2.10
Design Pressure and Temperature:	150 psig and 100°F
Maximum Operating Pressure:	58 psig
Maximum Operating Temperature:	92°F (governed by river temperature)
Piping Size:	12”
Piping thickness:	0.375”
Description:	This relief request is associated with the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, common Emergency Service Water (ESW) system piping adjacent to valve MO-2-33-2972 (see Enclosure 1).

2. APPLICABLE CODE EDITION AND ADDENDA

The current edition for the Inservice Inspection (ISI) interval is the ASME Section XI, 2001 Edition through 2003 Addenda. Code Case N-513-3 (“Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping Section XI, Division 1”) with the associated Regulatory Guide 1.147, Revision 17 condition has been applied to address acceptability of a through-wall leak in the affected piping.

3. APPLICABLE CODE REQUIREMENT

Code Case N-513-3 Section 2(h) states:

> “Repair or replacement shall be performed no later than when the predicted flaw size from either periodic inspection or by flaw growth analysis exceeds the acceptance criteria of 4, or the next scheduled outage, whichever occurs first.”

NRC Regulatory Guide 1.147, (“Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1”) dated August 2014, contains the following provision regarding Code Case N-513-3:

> “The repair or replacement activity temporarily deferred under the provisions of this Code Case shall be performed during the next scheduled outage.”

4. REASON FOR REQUEST

On May 3, 2015, during routine operator rounds, a pinhole leak was identified in a vertical run of 12" piping on the ESW system.

ESW is a safety-related support system which is common to PBAPS, Units 2 and 3 (see Enclosure 1). The system consists of two independent loops (A and B), with one 100% capacity pump per loop. Cooling water is pumped from the Conowingo Pond, which is the normal (primary) heat sink, and is discharged back to the pond subsequent to heat removal from essential components. Each ESW pump is capable of aligning supply and return flow paths to an emergency heat sink (Emergency Cooling Towers) during a Loss of Conowingo Pond special event.

Each ESW pump is also designed to supply cooling water to selected essential equipment during a design basis accident (DBA) or transient. Both pumps start upon receipt of a Loss of Offsite Power (LOOP), or whenever any diesel generator starts. In accordance with the acceptance criteria in the surveillance tests for the In-Service Testing program, during the most limiting conditions possible per Technical Specification (TS) 3.7.2 (i.e., 92 °F river temperature and 98.5' river level) the combined minimum accident flow rate required by components dependent upon the ESW cooling water is 3133 gpm. This flow rate is based on the worst-case accident scenario for each heat exchanger and is representative of ESW system balanced flow with 100% flow to the Unit 2 and Unit 3 Emergency Core Cooling System (ECCS) unit coolers and the diesel generator coolers. This flow is sufficient to mitigate the consequences of a design basis accident on one unit while bringing the other unit to a safe shutdown condition.

The piping pinhole leak is located very close to the ceiling of the Unit 2 Reactor Building Sump Room. This section of piping is part of the main ESW header that provides ESW flow to the Unit 2 ECCS room coolers. However, it is physically connected to common piping which also provides flow to the Unit 3 ECCS room coolers and to the common Emergency Diesel Generators (EDGs). The piping under review is line class 33HB-12", which is carbon steel, ASTM A106 Gr. B, 12", with a wall thickness of 0.375". The minimum allowable wall thickness for this piping was determined to be 0.063" (see Enclosure 2).

This location was evaluated for repair by branch connection, weld overlay, and pipe sleeve. It was determined that none of those options could be performed due to the proximity of the leak to the structural penetration. As shown in Enclosure 1, closing valves MO-2-33-2972, MO-3-33-3972, HV-0-33-507B, and HV-0-33-509 would isolate this location to allow pipe replacement. Removal of this section of piping results in loss of capability of the 'B' subsystem of ESW to supply cooling to these three heat loads (i.e., Unit 2 ECCS room coolers, Unit 3 ECCS room coolers, and EDGs) via the normal flow path. However, MO-2-33-2972 currently has through-valve leakage resulting in an inability to isolate the location and perform the repair. Additionally, it was determined that a freeze seal would not be effective for isolating this flaw location since the freeze seal location is not an adequate seismic boundary for a DBA seismic event. Also, the pipe temperature as a result of the freeze seal would be below the nil-ductility temperature and therefore, piping capability could not be assured if a DBA event were to occur. The MO-2-33-2972 valve is currently scheduled for replacement in the PBAPS Unit 2 refueling outage (P2R21) in 2016. In order to isolate the flaw with the MO-2-33-2972 valve leak-through, two additional valves (HV-2-33-502 and HV-2-33-517) would need to be closed. This results in an entry into a Unit 2 TS 3.7.2 shutdown statement due to the loss of both ESW subsystems to provide cooling to the Unit 2 ECCS room coolers. Per Code Case N-513-3 and Regulatory Guide 1.147, Revision 17, repair/replacement is required to be performed during the next scheduled outage. As this piping is considered to be common to both units, the next scheduled outage is the PBAPS Unit 3 outage scheduled to begin in September 2015. Isolating this location during the Unit 3 outage will result in a TS Required shutdown of Unit 2 in order to isolate the leak. With Unit 3 already shutdown for its refueling outage, this condition would result in a non-desirable dual unit shutdown of the PBAPS station. A dual unit shutdown is significant from a grid reliability viewpoint. In addition, a plant shutdown of Unit 2 would result in additional personnel radiological exposure and an unwarranted plant transient. Therefore, it is desirable to perform this repair during the next scheduled Unit 2 refueling outage in October 2016 to avoid an unscheduled Unit 2 outage during the September 2015 Unit 3 refueling outage.

There are no other known leaks in the ISI Class 3 segments of the ESW system.

5. PROPOSED ALTERNATIVE AND BASIS FOR USE

Exelon Generation Company, LLC (Exelon) is requesting approval to defer replacement of the leaking pipe spool until the Unit 2 outage in Fall 2016 in order to avoid an unwarranted shutdown of Unit 2. As discussed previously, a repair cannot be performed during the upcoming Unit 3 outage, scheduled for September 2015, without a dual unit shutdown. Shutdown of Unit 2 results in an unnecessary plant transient, additional personnel radiological exposure and a potential adverse effect on electrical grid stability. Therefore, Exelon proposes to repair the flaw by pipe replacement and to replace valve MO-2-33-2972 during the Unit 2 refueling outage currently scheduled for October 2016.

Leakage Analysis:

The leakage rate was originally identified as 18 ml/min, equivalent to 0.0048 gpm. Based on the leak rate and the known standby system pressure of 45 psig, the size of the pinhole orifice was computed to be approximately 0.0064". With an ESW system pump in operation, the maximum operating pressure in the system is 58 psig. Based on the computed orifice size, it is anticipated that the leak rate during operation of a pump would increase to 0.009 gpm, or 34 ml/min.

The flaw area has been re-inspected since performance of the original Ultrasonic Test (UT) and no changes have been identified in the degraded area. A review of the operator logs was performed for re-inspection of the leak as required by ASME Code Case N-513-3. The highest identified leakage through the flaw during re-inspections at both system standby and operating conditions was 44 ml/min. There have been no significant changes in leakage considering the standby mode (non-safety related service water) and the safety related ESW mode.

As discussed in Enclosure 2, the as-found condition of the pinhole leak does not adversely impact the ability of the piping to perform its intended safety function. Ample flow is available for the ESW system to meet the minimum safety related flow requirements for the EDGs and ECCS systems. Recent testing has shown that the ESW system flow rate was measured to be 3824 gpm from the 'A' ESW pump alone and 3851 gpm for the 'B' ESW pump alone. The ESW minimum required system flow rate at maximum river temperature of 92 °F, is 3133 gpm, which results in a 691 gpm flow margin when compared to the measured pump flow.

A leak rate limit of 5 gpm or 18,927 ml/min has been conservatively established. Given that the maximum safety-related leakage currently identified on the ESW system is 44 ml/min (0.0117 gpm), there is substantial margin remaining in the allowable leakage of the system.

An analysis was performed that supports that the pipe will continue to perform its safety function until the Unit 2 October 2016 outage. Based on a review of historical PBAPS-specific corrosion data, the corrosion rate for the leak was determined to be 12 mils per year (mpy) in each direction, or a total diameter growth of the flaw of 24 mpy. Based on the corrosion rate, the through-wall flaw is expected to increase by 34 mils before the start of the Unit 2 outage, for a final hole diameter of 0.0404", which will ensure that any postulated increases in leakage will remain well below the 5 gpm leakage limit.

Structural Integrity Analysis:

Code Case N-513-3 was used to evaluate continued operation without repair. This evaluation is provided in Enclosure 2. This evaluation provided in Enclosure 2 for the as-found flaw dimensions as well as the predicted flaw in October 2016 demonstrates that the piping will remain structurally sound and safe for continued operation through the proposed period of operation. As determined in Enclosure 2, the calculated stress intensity factors (SIFs) for normal/upset and emergency/faulted conditions were well below the allowable fracture toughness both at the time of discovery of the flaw on May 3, 2015 as well as what is projected to be the flaw in October 2016. Similarly, the calculated axial flaw SIF was also shown to be well below the allowable fracture toughness. The calculations performed in the evaluation utilized the maximum design pressure of the piping, 150 psi, as the anticipated load. This provides additional conservativism given that the maximum operating pressure expected is 58 psi.

Non-Destructive Examination (NDE) was performed in the vicinity of the pinhole and an area with a diameter of 0.75" surrounding the pinhole was identified to be below minimum allowable wall thickness (see Enclosure 2). Based on the flaw characterization, the failure mode appears to be under-deposit corrosion influenced by microbial activity. As required by ASME Code Case N-513-3, shear wave UT was performed around the area of the flaw and it was verified that there are no crack-like indications present. UT was also performed around the area surrounding the leak. From this inspection, it was identified that the size of the area surrounding the flaw that is below 87.5% of nominal wall thickness (i.e., 0.328") is 4.60" x 5.30". The surrounding band area was also inspected with 100% scanning coverage as required by ASME Code Case N-513-3. A total of 36 measurements were reported, the results of which showed that 35 of the 36 measurements were below 87.5% of nominal wall thickness, but only the leak area was identified below the minimum wall thickness. The NDE report from UT examination of the surrounding band area is included in Enclosure 2.

Enclosure 2 includes an ASME Code Case N-513-3 analysis using a flaw size of 0.75". As discussed above, the corrosion rate for the leak was determined to be 12 mpy in each direction, or a total diameter growth of the flaw of 24 mpy. Based on the corrosion rate, the area that is below minimum wall thickness is expected to grow by 34 mils before the start of the next Unit 2 refueling outage resulting in a flaw size of 0.784". Based on the geometry of the flaw characterization depicted in Enclosure 2, additional flaw growth that could occur until October 2016 was analyzed using a conservative, bounding flaw size of 1.5" in the axial and circumferential directions (i.e., double the current flaw size of 0.75"). Using a bounding flaw size of 1.5" in place of the 0.75" flaw size used in Enclosure 2 yields results that are well within the acceptance limits of ASME code requirements. Therefore, from a structural integrity perspective, there is reasonable assurance that the piping will remain operable and within all system limits until the proposed time for repair/replacement.

Corrosion analysis was also performed on surrounding and similar piping. Of the five areas inspected as extent of condition as required by ASME Code Case N-513-3, none have an expected life below nine years based on a low reading of 0.134".

Summary:

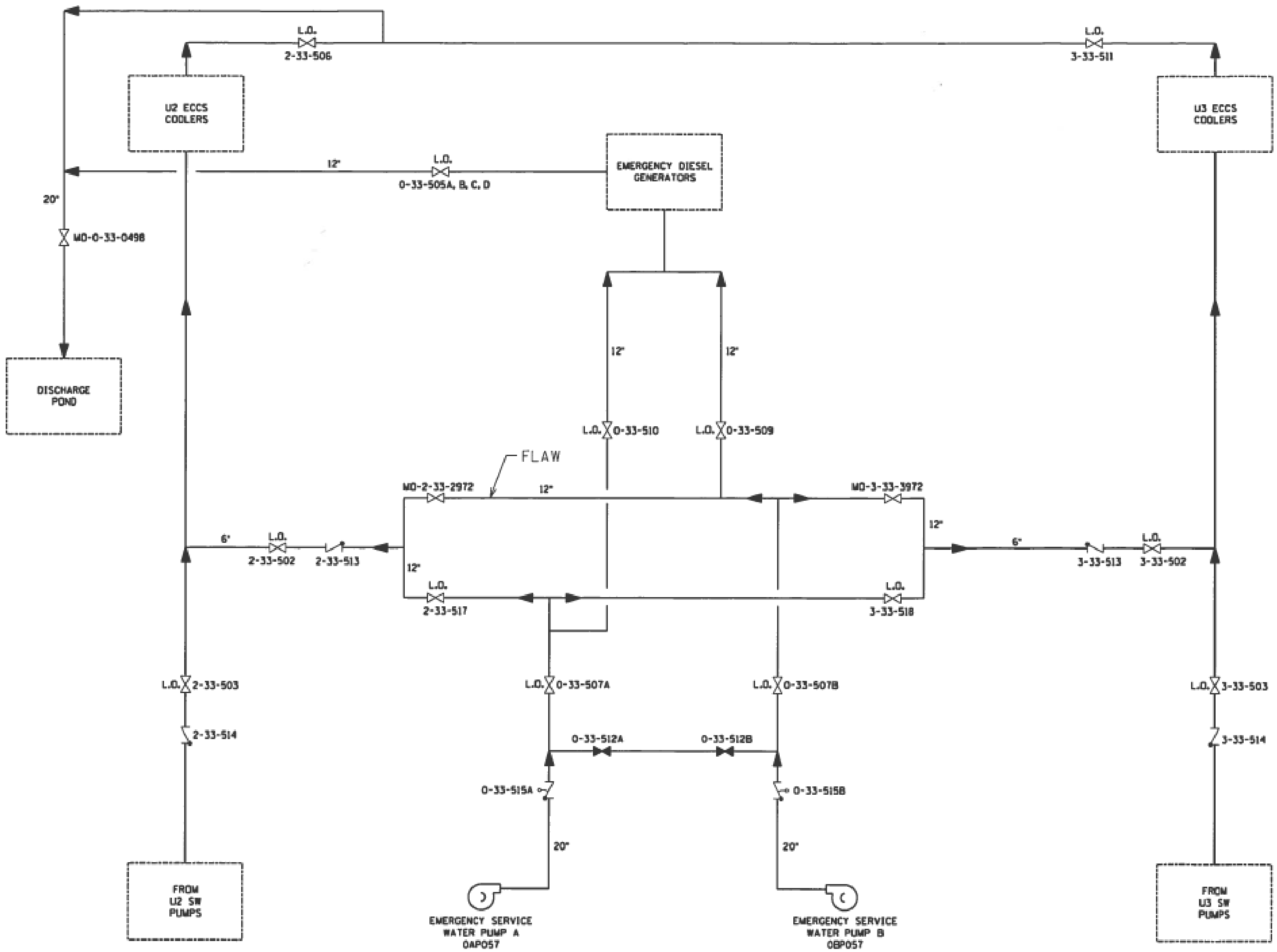
Exelon is requesting a proposed alternative in accordance with 10 CFR 50.55a(z)(2) on the basis that a shutdown of Unit 2 during the upcoming Unit 3 refueling outage would result in a hardship without a compensating increase in the level of quality or safety. Because the leak exists on piping that is considered as common to both Units 2 and 3, Code Case N-513-3 requires the leak to be repaired in the next refueling outage (which would be the upcoming Unit 3 refueling outage scheduled to begin in September 2015). However, by doing so, the isolation points to perform the work on this common piping would result in isolation of the Unit 2 ECCS unit coolers, which would result in a 12-hour TS-required Unit 2 shutdown. Since the clearance, tagging and maintenance evolutions would take significantly more time than the TS Required Action shutdown time of 12 hours, it is appropriate to seek relief to allow the leak repair to occur during the next scheduled Unit 2 refueling outage (October 2016). A Unit 2 shutdown during the Unit 3 refueling outage is unwarranted due to the hardship of an unnecessary Unit 2 plant transient, additional personnel radiological exposure and a potential adverse effect on electrical grid stability for no compensating increase in the level of quality or safety. The assurance of quality and safety in the extended period of time between September 2015 and October 2016 is based on: 1) the small size of the indication, 2) the results of the Code Case N-513-3 evaluation which demonstrates the structural integrity of the pipe, 3) the large capacity of the current flow margin, 4) the flaw growth analysis demonstrating that the flaw will not grow beyond any current acceptance criteria, and 5) Code Case N-513-3 required daily leak check and UT flaw examination every 30 days. Based on this, there is reasonable assurance that this leak will not exceed any system leakage limits, nor will the structural integrity of the piping be challenged prior to startup from the Unit 2 refueling outage in October 2016.

6. DURATION OF PROPOSED ALTERNATIVE

This relief request will be applied through the current PBAPS, Unit 2 operating cycle and refueling outage currently scheduled to begin October 2016. In addition, if system leakage exceeds 5 gpm, this relief request will no longer be applied.

Enclosure 1

SIMPLIFIED ESW SYSTEM



Enclosure 2
N-513-3 Evaluation including the Nondestructive Examination Sheets

Title: Perform Code Case N-513 evaluation to support Operability.

ADMINISTRATIVE:

This evaluation was prepared in accordance with Exelon procedure CC-AA-309-101, revision 14, Engineering Technical Evaluations.

A technical task risk/rigor assessment was performed for this activity in accordance with HU-AA-1212, revision 6. Risk rank was determined to be '1' with a medium consequence (C.7, Safety System Loss), 1 human performance risk factor (H.10, Group Think), and 1 process risk factor (P.3, Fast Track). Therefore, per table 5.1 of attachment 5 to HU-AA-1212 existing process reviews are adequate.

This conclusion was discussed with Jeff Chizever, Manager PEDM on 05/05/2015.

An impact review per CC-AA-102, revision 28 was performed and it was concluded that procedure revisions are not required. However, the Raw Water Program is impacted by this evaluation. Assignments 2494904-04 and 2494904-05 have been created for the program manager to incorporate any changes into the Raw Water Program.

Safety Classification:

This evaluation is associated with safety-related equipment and therefore the evaluation is classified as safety-related. This technical evaluation will be submitted to Records Management for retention.

REASON FOR EVALUATION/SCOPE:

An Emergency Service Water (ESW) piping leak was discovered in the Unit 2 Reactor Building Sump room. The leak is directly below the Unit 2 Reactor Building Closed Cooling Water (RBCCW) room floor, upstream of MO-2-33-2972 which is located in the RBCCW room. The leakage was approximately 30 DPM at the time of discovery.

The presence of this leak warrants an evaluation in accordance with ASME Code Case N-513-3 (Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping, Mandatory Appendix I) in order to allow the associated piping to remain operable until a permanent ASME Section XI Code repair can be completed.

DETAILED EVALUATION;

Engineering has performed an analysis of the degraded areas in accordance with ASME Code Case N-513-3. This piping is 12-inch diameter, 0.375 inch wall thickness carbon steel piping, A-106 grade B as shown in Peach Bottom specification M-300 (Piping Materials) and P&ID M-315, sheets 4 and 5 for 33HB class pipe. The design pressure is 150 psig and the design temperature is 100°F. As shown on attached pages 13 and 14, the areas found to be less than the minimum wall thickness value of 0.063 inch are approximately 0.75 inch in the axial and circumferential directions.

In accordance with CC N-513-3, the pipe circumference at the location of the flaw was examined volumetrically to characterize the length and depth of all flaws in the pipe section. The results of the circumferential examination show that there are no other flaws in the area that are below the minimum wall thickness and need to be considered in this evaluation. Additionally, shear wave UT performed around the area of the flaw verified that there are no crack-like indications present. See the completion remarks for work-order activity C0257348-06 for documentation of this result.

Forces, moments, and stresses for the subject piping were extracted from reference 5 between node points 201 and 206. They are shown on pages 9 to 12 of the attachment.

The approach to the evaluation methodology included in CC N-513-3 is to compute a static fracture toughness factor, K1c for the circumferential and axial flaw evaluations. For this evaluation, as shown on attached page 2, the value of K1c is 37.111 ksi*in$^{0.5}$. The evaluation then computes the stress intensification factors, K1 for the circumferential and axial flaws for the various design modes (normal/upset and emergency/faulted) and then compares them to the previously calculated value for K1c. If K1 is less than or equal to K1c then the acceptability of the through wall flaw is demonstrated. The following is a summary of the results of the attached CC N-513-3 evaluation.

K1c = 37.111 ksi*in$^{0.5}$

K1 Circ. Normal/Upset = 5.036 ksi*in$^{0.5}$ < 37.111 ksi*in$^{0.5}$, therefore acceptable.

K1 Circ. Emer. /Fault = 4.426 ksi*in$^{0.5}$ < 37.111 ksi*in$^{0.5}$, therefore acceptable.

K1 Axial = 7.643 ksi*in$^{0.5}$ < 37.111 ksi*in$^{0.5}$, therefore acceptable.

For simplification, the maximum safety factor of 2.7 for Normal/Upset was used in the computation of all K1 Axial, and the maximum safety factors for either the membrane or bending stress was used for the Ki Circ. Normal/Upset and Emer. /Faulted computations.

Additionally the subject location was evaluated for the effect of thin wall on the normal piping stress and compared to the established design allowable stress for the piping. In this comparison, the allowable stress of 17,100 psi for the piping material (A-106, Grade B) was used. The results of this portion of the analysis, shown on attached pages 5 through 7, demonstrate that a uniform pipe wall thickness of 0.063 inch is acceptable to provide adequate structural integrity for the design basis loadings.

CONCLUSIONS/FINDINGS:

This evaluation of the discovered min-wall area indicates that the size of the flaw and the surrounding wall thickness is acceptable for continued operation of the associated ESW system piping within the requirements of ASME Code Case N-513-3.

REFERENCES:

1. ASME Code Case N-513-3, Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping
2. ASME B31.1, Power Piping, 1967
3. ASME Section XI, Rules for In-Service Inspection of Nuclear Power Plant Components, 2001 Edition plus addenda through and including 2003
4. Crane Technical Paper 410, Flow of Fluids
5. PBAPS Calculation 33-32, rev. 1B, Pipe Stress Analysis - ESW System Unit 2 RBCCW Room
6. Technical Evaluation A1998930-01, Request Min Wall
7. PBAPS Specification M-300, Piping Materials, Instrument Piping Standards & Valve Classifications
8. P&ID M-315, sh. 4 & 5, Emergency Service Water And High Pressure Service Water Systems

ATTACHMENTS:

Pages 1-8:	ASME Code Case N-513-3 Evaluation
Pages 9-12:	Excerpts from calculation 33-32
Pages 13-14:	NDE Report
Page 15:	Calc 33-32 page 19, Stress ISO

Prepared By:	Ken Hudson RAH	05/05/2015
Reviewed By:	Doug Lord DBL	05/05/2015

Reviewer Comments:

Performed independent review of this technical evaluation and concur that the piping system remains acceptable for continued operation with the identified flaw.

Approved By:	Jeff Chizever, Manager PEDM JSC	05/06/2015

Planar Flaw Evaluation in ferritic piping IAW Code Case N-513-3		
PBAPS ESW Min Wall "B" ESW (IR 2494904-03)		
Definitions:		
Flaw depth	a=	0.312 in
Pipe wall thickness	t=	0.375 in
Maximum assumed circumferential flaw length:	l=	0.750 in
Pipe outside diameter:	D=	12.75 in
Mean pipe radius: $R = \frac{D-t}{2}$	R=	6.19 in
Piping bending moment of inertia: $I = \frac{\pi[D^4-(D-2t)^4]}{64}$	I=	279.34 in^4
Flaw half-angle per Figure 1, N-513: $\theta = \frac{l}{2 \cdot R}$	θ=	0.061 rad
Unit definition for kips:		1 kip = 1000 lbf
Unit definition for psi:		1 ksi = 1000 psi
Piping Loads (Moments Increased by 25% for Uncertainties):		
Maximum operating pressure:	OP=	150.00 psi
Maximum operating pressure axial force: $P_{OP} = \pi\left(\frac{D}{2}-t\right)^2 \cdot OP$	P_{OP}=	16964.60 lbs
Axial load on pipe for Normal/Upset condition forces:	Pnu =	109.00 lbs
Axial load on pipe for Emergency/Faulted condition forces:	Pnf =	261.60 lbs
Total axial load on pipe, including pressure from piping analysis for normal/upset condition forces: $P_n = P_{OP}+P_{nu}$	Pn =	17073.60 lbs
Total axial load on pipe, including pressure from piping analysis for emergency/faulted condition forces: $P_f = P_{OP}+P_{nf}$	Pf =	17226.20 lbs
Applied bending moment on the pipe from piping analysis for normal/upset condition (SRSS(MA, MB, MC) for WT01+SEISOB)	Mn =	2206.25 ft-lbf
Applied bending moment on the pipe from piping analysis for emergency/faulted condition (SRSS(MA, MB, MC) for WT01+SEISSS)	Mf =	4328.02 ft-lbf
Pipe thermal expansion stress from piping analysis:	Pe =	0.000 ksi

Circumferential Flaw Evaluation Using N-513

Piping Material Properties (Ref. ASME B31.1):			
Young's Modulus:	E=	27850	ksi
Poisson's Ratio:	μ=	0.30	
$E' = (E/(1-\mu^2)$	E'=	30604.40	ksi
Material Properties for Flaws per H-4000:			
From ASME XI C-8322	J_{Ic} =	45	$in*lbf/in^2$
Allowable Fracture Toughness, KIc:	K_{Ic} =	37.111	$ksi*in^{0.5}$
$KIc = ((J_{Ic} * E') / (1000\ lbf/kip))^{0.5}$			
N-513 Appendix I Circumferential Flaw equations:			
Accurate between 5 and 20. Conservative over 20.	R/t=	16.500	Acceptable
$Am = -2.02917 + 1.67763*(R/t) - 0.07987*(R/t)^2 + 0.00176*(R/t)^3$			
	Am=	11.81	
$Bm = 7.09987 - 4.42394*(R/t) + 0.21036*(R/t)^2 - 0.00463*(R/t)^3$			
	Bm=	-29.42	
$Cm = 7.79661 + 5.16676*(R/t) - 0.24577*(R/t)^2 + 0.00541*(R/t)^3$			
	Cm=	50.44	
$Fm = 1.0 + Am*(\theta/\pi)^{1.5} + Bm*(\theta/\pi)^{2.5} + Cm*(\theta/\pi)^{3.5}$			
	Fm=	1.03	
$Ab = -3.26543 + 1.52784*(R/t) - 0.072698*(R/t)^2 + 0.0016011*(R/t)^3$			
	Ab=	9.34	
$Bb = 11.36322 - 3.91412*(R/t) + 0.18619*(R/t)^2 - 0.004099*(R/t)^3$			
	Bb=	-20.94	
$Cb = -3.18609 + 3.84763*(R/t) - 0.18304*(R/t)^2 + 0.00403*(R/t)^3$			
	Cb=	28.57	
$Fb = 1.0 + Ab*(\theta/\pi)^{1.5} + Bb*(\theta/\pi)^{2.5} + Cb*(\theta/\pi)^{3.5}$			
	Fb=	1.02	

Applied Stress Intensity Factor, KI, for Circumferential Flaw:

N-513 Appendix I requires that the flaw depth in the H-7300 stress intensity equations be changed to the flaw half-length, c:

Maximum assumed circumferential flaw length:	l=	0.75	in
Flaw half-length, c = l/2:	c=	0.38	in

Note: Units are converted automatically.

Normal/Upset Condition:

$K_{Im} = \left(\dfrac{2.7 \cdot P_n}{2 \cdot \pi \cdot R \cdot t}\right) \cdot (\pi \cdot c)^{0.5} \cdot F_m$	K_{Im} =	3.536	ksi-in$^{0.5}$
$K_{Ib} = \left(\dfrac{2.3 \cdot M_n}{\pi \cdot R^2 \cdot t} + P_e\right) \cdot (\pi \cdot c)^{0.5} \cdot F_b$	K_{Ib} =	1.501	ksi-in$^{0.5}$
$K_I = K_{Im} + K_{Ib}$	K_I =	5.036	ksi-in$^{0.5}$
	Therefore, K_I < KIc:	Acceptable	

Emergency/Faulted Condition:

$K_{Im} = \left(\dfrac{1.8 \cdot P_f}{2 \cdot \pi \cdot R \cdot t}\right) \cdot (\pi \cdot c)^{0.5} \cdot F_m$	K_{Im} =	2.378	ksi-in$^{0.5}$
$K_{Ib} = \left(\dfrac{1.6 \cdot M_f}{\pi \cdot R^2 \cdot t} + P_e\right) \cdot (\pi \cdot c)^{0.5} \cdot F_b$	K_{Ib} =	2.048	ksi-in$^{0.5}$
$K_I = K_{Im} + K_{Ib}$	K_I =	4.426	ksi-in$^{0.5}$
	Therefore, K_I < KIc:	Acceptable	

Axial Through-walll Flaw Evaluation Using N-513

Stress Intensity Factor, KI, for an axial flaw subject to the bounding condition:

Axial flaw length:	l=	0.75	in
Flaw half-length, c = l/2:	c=	0.375	in
Maximum operating pressure:	OP=	150	psi
Safety Factor for normal/upset conditions from C-2622:	SF=	2.7	
N-513 Appendix I assigned flaw shape parameter for a through-wall flaw:	Q=	1.00	
$\lambda = c/(R*t)^{0.5}$	λ=	0.246	
	Therefore, $0<\lambda<5$:	Acceptable	
Note: Units are converted automatically			
$F = 1.0 + 0.072449*\lambda + 0.64856*\lambda^2 - 0.2327*\lambda^3 + 0.038154*\lambda^4 - 0.0023487*\lambda^5$			
	F =	1.054	
$K_I = SF \cdot \frac{OP \cdot R}{t} \cdot \left(\frac{\pi \cdot c}{Q}\right)^{0.5} \cdot F$	K_I =	7.643	ksi-in$^{0.5}$
	Therefore, K_I < KIc:	Acceptable	

END OF ASME CODE CASE N-513-3 EVALUATION

Code Minimum Wall Requirement Based on ASME III, ND-3640:				
Joint efficiency factor:	E =	1.00		
Corrosion allowance used:	A =	0.00	in	
Maximum allowable stress for pipe material from Section II, Part D:	S =	17.10	ksi	
	y =	0.40		
Design Pressure:	PD =	150	psi	
Minimum ASME pipe wall thickness required, not including any corrosion allowance.				
$t_m = \frac{PD \cdot D}{2 \cdot (S \cdot E + PD \cdot y)} + A$	t_m =	0.056	in	

Minimum Wall Thickness Evaluation @ 0.063 inch Thickness				
Outside diameter of pipe:		D =	12.75	in
As analyzed pipe wall thickness:		t =	0.375	in
Allowable pipe wall thickness - Code minimum:		t1 =	0.063	in
(Use trial and error until satisfying modified stresses below)				
Design inside pipe diameter:	d = D-2*t	d =	12.00	in
New inside pipe diameter:	d1 = D-2*t1	d1 =	12.624	in
As analyzed Section Modulus:	$Z = 0.0982\,\frac{D^4 - d^4}{D}$	Z =	43.829	in^3
New Section Modulus:	$Z1 = 0.0982\,\frac{D^4 - d1^4}{D}$	Z1 =	7.927	in^3
Design Pressure:		Pd =	150	psig
Maximum Pressure:		Pm =	150	psig
ME101 Output Stress Summary - Input from Calculation 33-32, Revision 1B:				
Design Pressure Stress:		SPd =	1164	psi
Maximum Pressure Stress:		SPm =	1164	psi
Equation 11 Stress:		Eqn 11 =	1336	psi
Equation 12B Stress:		Eqn 12B =	1751	psi
Equation 12C Stress:		Eqn 12C =	0	psi
Equation 12D Stress:		Eqn 12D =	2262	psi
Equation 13 Stress:		Eqn 13 =	0	psi
Equation 14 Stress:		Eqn 14 =	1336	psi

ME101 Modified Stresses			
			Allowable Stress
Equation 11 Stress = $\left(\text{Eqn 11} - \text{SPd}\right)\cdot\frac{Z}{Z1} + \text{Pd}\cdot\frac{D}{(4*t1)} =$	8540	psi	17,100
Equation 12B Stress = $\left(\text{Eqn 12B} - \text{SPm}\right)\cdot\frac{Z}{Z1} + \text{Pm}\cdot\frac{D}{(4*t1)} =$	10835	psi	20520
Equation 12C Stress = $\left(\text{Eqn 12C} - \text{SPm}\right)\cdot\frac{Z}{Z1} + \text{Pm}\cdot\frac{D}{(4*t1)} =$	N/A	psi	N/A
Equation 12D Stress = $\left(\text{Eqn 12D} - \text{SPm}\right)\cdot\frac{Z}{Z1} + \text{Pm}\cdot\frac{D}{(4*t1)} =$	13660	psi	41040

Evaluation Input Data From Calculation 33-32 Rev 1B, Node Points 201-206								
	Fa	Fb	Fc	Ma	Mb	Mc	Mr	PSI s
Weight	848	255	56	70	346	424	551.72	
Thermal	0	0	0	0	0	0	0.00	
OBE	109	210	227	672	693	735	1213.28	
SSE	261	505	546	1613	1662	1763	2910.70	
		s	Allow s					
Pressure s		1164						
Equ. 11 s		1336	17,100					
Equ. 12b s		1751	20,520					
Equ. 12d s		2262	41,040					
Equ. 13 s		N/A						

ELEMENT FROM / TO	TYPE/TITLE	LOCAL FORCES (LB) FA	FB	FC	LOCAL MOMENTS (FT-LB) MA	MB	MC	STRESS (PSI) .75IM/Z	STRESS INT.FAC. (I)	FLEX. IN PLANE	FLEX. OUT PLANE	CODE AND CLASS
198	TNGT	-1055	-56	-56	70	459	-539	189.	1.000	1.000	1.000	B31S73
201		848	56	56	-70	-346	424	147.	1.000	1.000	1.000	
201	TNGT	-848	-56	-56	70	346	-424	147.	1.000	1.000	1.000	B31S73
206 B		424	56	56	-70	-115	190	62.	1.000	1.000	1.000	
206 B	BEND	-424	56	56	70	-115	190	133.	2.862	9.359	9.359	B31S73
206 M		175	-255	-56	7	72	21	43.	2.862	9.359	9.359	
206 M	BEND	-175	255	56	-7	-72	-21	43.	2.862	9.359	9.359	B31S73
206 E		-56	-184	-56	31	-13	301	173.	2.862	9.359	9.359	
206 E	TNGT	56	-184	-56	-31	-13	301	80.	1.000	1.000	1.000	B31S73
207		-56	-402	56	31	333	326	124.	1.000	1.000	1.000	
207	TNGT	402	-56	-56	-333	31	-326	181.	1.000	1.000	1.000	B31S73
208		-484	56	56	333	81	212	156.	1.000	1.000	1.000	
171	TNGT	-2459	-69	-72	90	-44	121	68.	2.172	1.000	1.000	B31S73
209		2807	69	72	-90	290	-358	125.	1.000	1.000	1.000	
209	TNGT	-2807	-72	69	90	358	290	125.	1.000	1.000	1.000	B31S73
211		3137	72	-69	-90	-582	-523	341.	2.172	1.000	1.000	
211	TNGT	-4054	-53	42	330	883	-605	486.	2.172	1.000	1.000	B31S73
216 B		4139	53	-42	-330	-918	560	299.	1.000	1.000	1.000	
216 B	BEND	4	42	53	330	-560	-918	643.	2.862	9.359	9.359	B31S73
216 M		53	-112	-53	139	573	995	661.	2.862	9.359	9.359	
216 M	BEND	-53	112	53	-139	-573	-995	661.	2.862	9.359	9.359	B31S73
216 E		-42	-236	-53	480	250	1204	754.	2.862	9.359	9.359	
216 E	TNGT	42	-236	-53	-480	250	1204	351.	1.000	1.000	1.000	B31S73
221		-42	253	53	480	-241	-1245	459.	1.696	1.000	1.000	
221	TNGT	42	-253	-53	-480	241	1245	459.	1.696	1.000	1.000	B31S73
223		-42	338	53	480	-197	-1491	420.	1.000	1.000	1.000	
223	TNGT	42	602	-53	-480	197	1491	420.	1.000	1.000	1.000	B31S73
226		-42	-449	53	480	-117	-704	229.	1.000	1.000	1.000	
226	TNGT	42	449	-98	-480	117	704	229.	1.000	1.000	1.000	B31S73
231 B		-42	-137	98	480	183	193	146.	1.000	1.000	1.000	
231 B	BEND	42	-27	166	-480	266	7	313.	2.862	9.359	9.359	B31S73
231 M		-70	-11	-81	91	-656	-12	378.	2.862	9.359	9.359	
231 M	BEND	70	11	81	-91	656	12	378.	2.862	9.359	9.359	B31S73
231 E		-142	42	4	-423	-567	-18	404.	2.862	9.359	9.359	

Non Record Content

Attachment to:

ELEMENT FROM TO	TYPE/TITLE	LOCAL FORCES (LB) FA	FB	FC	LOCAL MOMENTS (FT-LB) MA	MB	MC	STRESS (PSI)	STRESS INT.FAC. (I)	FLEX. IN PLANE	FLEX. OUT PLANE	CODE AND CLASS
198	TNGT	109	168	104	469	841	1073	384.	1.000	1.000	1.000	B31S73
201		109	168	104	469	693	735	296.	1.000	1.000	1.000	
201	TNGT	108	210	106	469	693	735	296.	1.000	1.000	1.000	B31S73
206 B		56	94	147	546	427	122	187.	1.000	1.000	1.000	
206 B	BEND	56	98	184	546	427	122	402.	2.862	9.359	9.359	B31S73
206 M		109	31	184	672	284	194	431.	2.862	9.359	9.359	
206 M	BEND	109	31	184	672	284	194	431.	2.862	9.359	9.359	B31S73
206 E		98	56	184	607	356	176	414.	2.862	9.359	9.359	
206 E	TNGT	99	58	227	607	356	176	193.	1.000	1.000	1.000	B31S73
207		99	58	227	607	1190	158	358.	1.000	1.000	1.000	
207	TNGT	58	99	231	1190	607	158	522.	1.000	1.000	1.000	B31S73
208		58	99	231	1190	982	48	599.	1.000	1.000	1.000	
171	TNGT	508	155	165	541	781	581	483.	2.172	1.000	1.000	B31S73
209		508	155	165	541	1135	318	345.	1.000	1.000	1.000	
209	TNGT	508	151	140	541	318	1135	345.	1.000	1.000	1.000	B31S73
211		508	151	140	541	600	1433	713.	2.172	1.000	1.000	
211	TNGT	534	466	138	922	481	1045	639.	2.172	1.000	1.000	B31S73
216 B		534	466	138	922	468	667	327.	1.000	1.000	1.000	
216 B	BEND	237	120	492	922	667	468	703.	2.862	9.359	9.359	B31S73
216 M		231	135	492	565	572	474	533.	2.862	9.359	9.359	
216 M	BEND	231	135	492	565	572	474	533.	2.862	9.359	9.359	B31S73
216 E		120	237	492	236	554	560	470.	2.862	9.359	9.359	
216 E	TNGT	105	242	500	236	554	560	219.	1.000	1.000	1.000	B31S73
221		105	242	500	236	553	579	282.	1.696	1.000	1.000	
221	TNGT	100	244	504	236	553	579	282.	1.696	1.000	1.000	B31S73
223		100	244	504	236	695	692	269.	1.000	1.000	1.000	
223	TNGT	89	167	508	236	695	692	269.	1.000	1.000	1.000	B31S73
226		89	167	508	236	1324	446	377.	1.000	1.000	1.000	
226	TNGT	81	134	319	236	1324	446	377.	1.000	1.000	1.000	B31S73
231 B		212	104	369	211	879	348	258.	1.000	1.000	1.000	
231 B	BEND	277	318	212	211	390	861	553.	2.862	9.359	9.359	B31S73
231 M		400	131	212	379	386	991	645.	2.862	9.359	9.359	
231 M	BEND	400	131	212	379	386	991	645.	2.862	9.359	9.359	B31S73
231 E		318	277	212	589	230	817	590.	2.862	9.359	9.359	

Attachment to:

ELEMENT FROM TO	TYPE/TITLE	LOCAL FORCES (LB) FA	FB	FC	LOCAL MOMENTS (FT-LB) MA	MB	MC	STRESS (PSI)	STRESS INT.FAC. (I)	FLEX. IN PLANE	FLEX. OUT PLANE	CODE AND CLASS
198	TNGT	261	403	250	1126	2019	2575	921.	1.000	1.000	1.000	B31S73
201		261	403	250	1126	1662	1763	711.	1.000	1.000	1.000	
201	TNGT	260	505	254	1126	1662	1763	711.	1.000	1.000	1.000	B31S73
206 B		135	227	352	1311	1026	293	450.	1.000	1.000	1.000	
206 B	BEND	135	236	442	1311	1026	293	965.	2.862	9.359	9.359	B31S73
206 M		261	75	442	1613	681	465	1035.	2.862	9.359	9.359	
206 M	BEND	261	75	442	1613	681	465	1035.	2.862	9.359	9.359	B31S73
206 E		236	135	442	1456	855	423	994.	2.862	9.359	9.359	
206 E	TNGT	237	139	546	1456	855	423	463.	1.000	1.000	1.000	B31S73
207		237	139	546	1456	2855	379	859.	1.000	1.000	1.000	
207	TNGT	139	238	554	2855	1456	379	1253.	1.000	1.000	1.000	B31S73
208		139	238	554	2855	2357	115	1438.	1.000	1.000	1.000	
171	TNGT	1220	372	395	1299	1875	1395	1159.	2.172	1.000	1.000	B31S73
209		1220	372	395	1299	2724	763	828.	1.000	1.000	1.000	
209	TNGT	1220	362	337	1299	763	2724	828.	1.000	1.000	1.000	B31S73
211		1220	362	337	1299	1440	3440	1712.	2.172	1.000	1.000	
211	TNGT	1281	1118	330	2212	1155	2507	1533.	2.172	1.000	1.000	B31S73
216 B		1281	1118	330	2212	1122	1601	785.	1.000	1.000	1.000	
216 B	BEND	569	289	1180	2212	1601	1122	1686.	2.862	9.359	9.359	B31S73
216 M		553	323	1180	1355	1372	1137	1279.	2.862	9.359	9.359	
216 M	BEND	553	323	1180	1355	1372	1137	1279.	2.862	9.359	9.359	B31S73
216 E		289	569	1180	567	1329	1344	1127.	2.862	9.359	9.359	
216 E	TNGT	252	581	1201	567	1329	1344	525.	1.000	1.000	1.000	B31S73
221		252	581	1201	567	1326	1390	678.	1.696	1.000	1.000	
221	TNGT	239	586	1209	567	1326	1390	678.	1.696	1.000	1.000	B31S73
223		239	586	1209	567	1669	1662	644.	1.000	1.000	1.000	
223	TNGT	215	401	1219	567	1669	1662	644.	1.000	1.000	1.000	B31S73
226		215	401	1219	567	3178	1071	905.	1.000	1.000	1.000	
226	TNGT	195	321	765	567	3178	1071	905.	1.000	1.000	1.000	B31S73
231 B		510	249	886	507	2110	835	619.	1.000	1.000	1.000	
231 B	BEND	665	762	509	507	935	2067	1328.	2.862	9.359	9.359	B31S73
231 M		961	315	509	908	927	2378	1547.	2.862	9.359	9.359	
231 M	BEND	961	315	509	908	927	2378	1547.	2.862	9.359	9.359	B31S73
231 E		762	665	509	1414	553	1961	1416.	2.862	9.359	9.359	

Non Record Content

Attachment to:

CODE B31S73

ELEMENT FROM / TO	TYPE / TITLE	SUSTAINED LOAD EQN 11 PD/4T PSI	SUSTAINED LOAD EQN 11 CALC PSI	SUSTAINED LOAD EQN 11 ALLOW PSI	OCCASIONAL LOAD PD/4T PSI	LEVEL B EQN 12 CALC PSI	LEVEL B EQN 12 ALLOW PSI	LEVEL C EQN 12 CALC PSI	LEVEL C EQN 12 ALLOW PSI	LEVEL D EQN 12 CALC PSI	LEVEL D EQN 12 ALLOW PSI	THERMAL EXPANSION EQNS 13/14 CALC PSI	THERMAL EXPANSION EQNS 13/14 ALLOW PSI	NON-REPEATED ANCHOR MOV EQN *** CALC PSI	NON-REPEATED ANCHOR MOV EQN *** ALLOW PSI
141	BEND	776	1115	15000	776	2453	18000	0	0	4327	36000	0	0	0	0
151 M			1039	15000		2619	18000	0	0	4831	36000	0	0	0	0
151 M	BEND	776	1039	15000	776	2619	18000	0	0	4831	36000	0	0	0	0
156			922	15000		2725	18000	0	0	5248	36000	0	0	0	0
156	TNGT	335	382	15000	335	962	18000	0	0	1775	36000	0	0	0	0
161	CHK-2-33-513		529	15000		1257	18000	0	0	2276	36000	0	0	0	0
161	TNGT	776	1132	15000	776	2463	18000	0	0	4325	36000	0	0	0	0
171			1599	15000		3503	18000	0	0	6169	36000	0	0	0	0
171	TNGT	1164	1432	15000	1164	2115	18000	0	0	3071	36000	0	0	0	0
176			1317	15000		1737	18000	0	0	2326	36000	0	0	0	0
176	TNGT	527	609	15000	527	832	18000	0	0	1145	36000	0	0	0	0
181			604	15000		822	18000	0	0	1128	36000	0	0	0	0
181	CMPT	0	0	15000	0	0	18000	0	0	0	36000	0	0	0	0
186	MO-2972		0	15000		0	18000	0	0	0	36000	0	0	0	0
181	TNGT	527	641	15000	527	863	18000	0	0	1175	36000	0	0	0	0
191			632	15000		843	18000	0	0	1138	36000	0	0	0	0
191	TNGT	1164	1360	15000	1164	1757	18000	0	0	2313	36000	0	0	0	0
198			1353	15000		1736	18000	0	0	2274	36000	0	0	0	0
198	TNGT	1164	1353	15000	1164	1736	18000	0	0	2274	36000	0	0	0	0
201			1311	15000		1607	18000	0	0	2021	36000	0	0	0	0
201	TNGT	1164	1311	15000	1164	1607	18000	0	0	2021	36000	0	0	0	0
206 B			1226	15000		1413	18000	0	0	1675	36000	0	0	0	0
206 B	BEND	1164	1297	15000	1164	1699	18000	0	0	2262	36000	0	0	0	0
206 M			1207	15000		1638	18000	0	0	2241	36000	0	0	0	0
206 M	BEND	1164	1207	15000	1164	1638	18000	0	0	2241	36000	0	0	0	0
206 E			1336	15000		1751	18000	0	0	2331	36000	0	0	0	0
206 E	TNGT	1164	1244	15000	1164	1437	18000	0	0	1707	36000	0	0	0	0
207			1288	15000		1646	18000	0	0	2147	36000	0	0	0	0
207	TNGT	993	1174	15000	993	1696	18000	0	0	2427	36000	0	0	0	0
208			1150	15000		1749	18000	0	0	2587	36000	0	0	0	0

* EXCEEDED ALLOWABLE IN EQUATION 13, EQUATION 14 USED
** EXCEEDED ALLOWABLE

Non Record Content

Attachment to:

Exelon Generation.

RAW WATER CORROSION
ULTRASONIC EXAMINATION REPORT FORM

WORK ORDER # C0257348-06

RT GROUP

STATION / UNIT	PBAPS UNIT 2	**EXAM AREA**	WELD	STRAIGHT
EXAM LOCATION ID#	ISO-2-33-17	(X - ONE)	[ ]	[X]
PIPE NOMINAL WALL	.375"	EXAM POSITION	HORIZ	VERT
PIPE MINIMUM WALL	.063"	(X - ONE)	[X]	[ ]
PIPE DIA. 12"			**ROOM**	Sump Room

INSTRUMENT: Mfgr: Olympus Model: 38DL Plus Serial: 140875705

SPECIAL GRIDING: N/A

SEARCH UNIT: Mfgr: Panametrics S/N: 810220 Make: D799

Size: .434" Frequency: 5 Mhz

Couplant: Humex / 04165 Reference Block: 0002812581

CALIBRATION TIMES: Initial: 10:30 Final: 14:30 Other: N/A

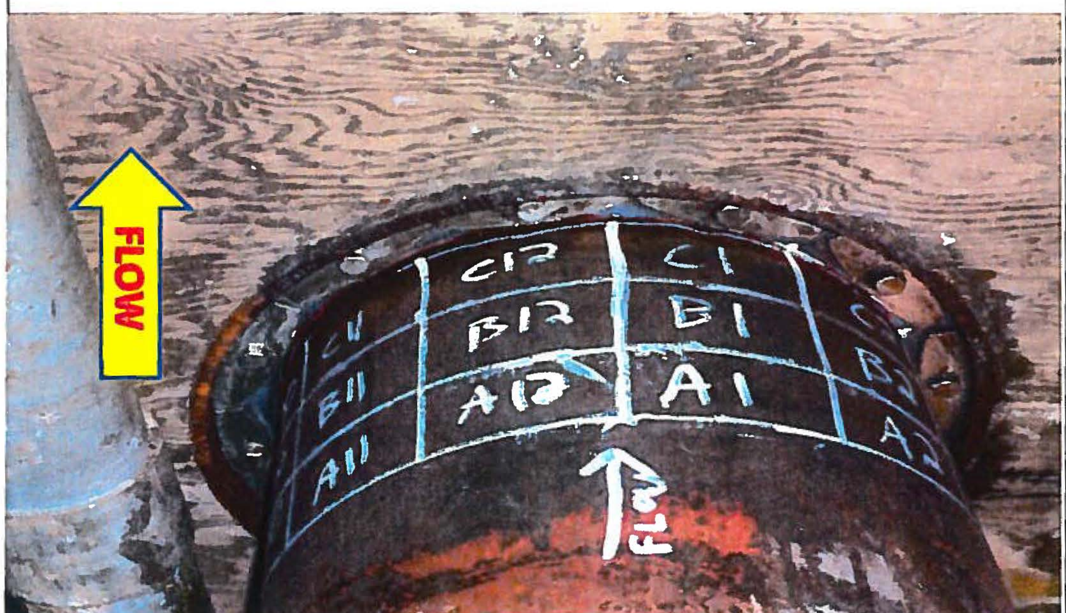
THERMOMETER: 0002834215 Due 6/5/15 CAL TEMP 80° COMP TEMP 70°

MEASUREMENT / RESULTS

Grid	BAND A		BAND B		BAND C	
1	0.268	"	0.353	"	0.270	"
2	0.327	"	0.307	"	0.264	"
3	0.249	"	0.276	"	0.206	"
4	0.247	"	0.136	"	0.180	"
5	0.275	"	0.105	"	*0.034	"
6	0.168	"	0.254	"	0.289	"
7	0.256	"	0.248	"	0.300	"
8	0.288	"	0.151	"	0.255	"
9	0.303	"	0.266	"	0.124	"
10	0.280	"	0.248	"	0.300	"
11	0.294	"	0.245	"	0.297	"
12	0.305	"	0.245	"	0.273	"

DRAWING (If Applicable)

IS0-2-33-17 Leak Upstream of MO-2972



*A thru wall leak was identified on IS0-2-33-17 upstream of MO-2972. Mapping was performed as per ASME Code Case N-513-3. Although the low in C5 is a thru wall leak, the lowest recordable reading of the leak was found to be .034" for continuous monitoring purposes.

See Attached Page For ISO Bar.

COMMENTS:

Grid location C5 was identified as below Engineering Min. Wall criteria. See attached Iso bar.

Material: A-106 GR. B Carbon Steel.

Examination Perormed in Accordance with ER-AA-335-004 REV. 7

Reference Min Wall Acceptance Criteria per A1998930-E01

Surface Condition = Prepped, Paint Removed.

Calibration

Actual	**Meas.**
.500"	**.500"**
.300"	**.300"**
.200"	**.200"**
.100"	**.100"**

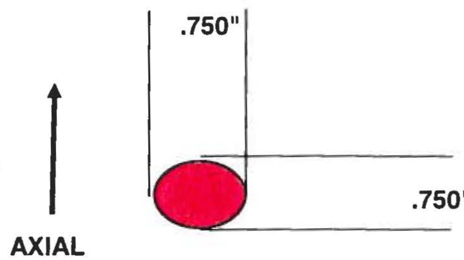
James Martin / III [signature] / 5/4/15 — NAME / LEVEL — DATE

n/a / n/a — NAME / LEVEL — DATE

ExelonGeneration.	ULTRASONIC EXAMINATION PHOTO SHEET	GROUP

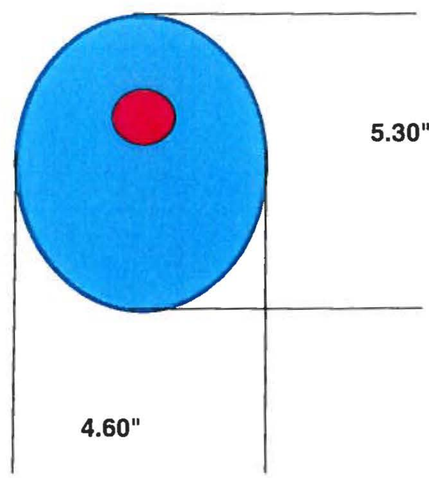
IS0-2-33-17 Leak Upstream of MO-2972

Engineering Minimum
Wall Thickness = .063"



Lm(a)= .750"
Lm(c)= .750"

Isobar out .328"



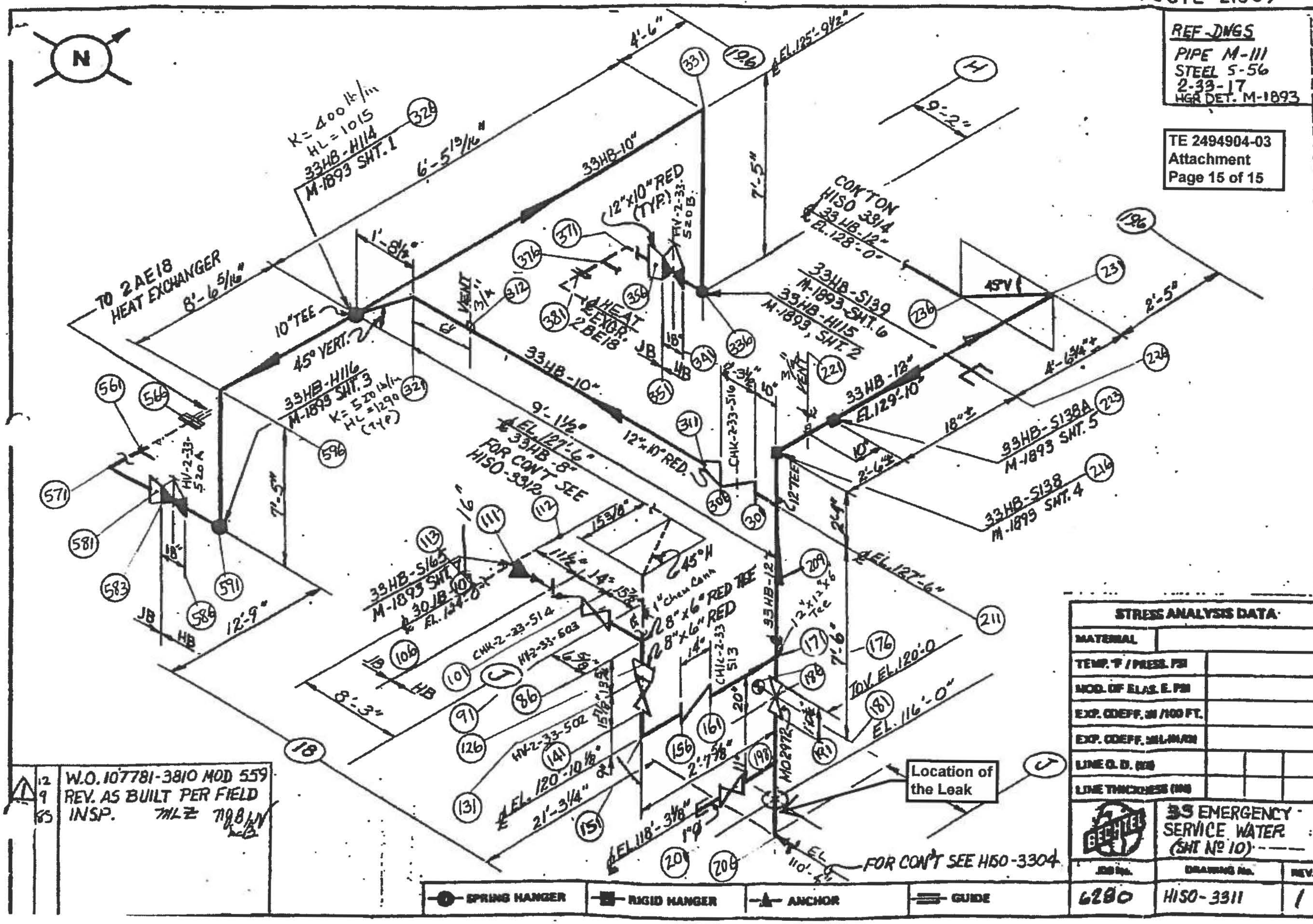
COMMENTS: Area below Engineering Minimum Wall Thickness is .750" rounded, with the area below .328" approximately 4.6" x 5.30".

James Martin / III	5/4/15	n/a	n/a
NAME / LEVEL	DATE	NAME / LEVEL	DATE

M-100

ROUTE 21059

Attach. to Calc. 33-32 R. 16 page 45



ATTACHMENT NO. ______
CALC. NO. 33-32 REV. 0 1
SHEET NO. 18 19 OF ______

ENCLOSURE 2
1.5 inch Through Wall
Flaw Evaluation

Planar Flaw Evaluation in ferritic piping IAW Code Case N-513-3			
PBAPS ESW Min Wall "B" ESW (IR 2494904-03)			
Definitions:			
Flaw depth		a=	0.312 in
Pipe wall thickness		t=	0.375 in
Maximum assumed circumferential flaw length:		l=	1.500 in
Pipe outside diameter:		D=	12.75 in
Mean pipe radius:	$R = \frac{D-t}{2}$	R=	6.19 in
Piping bending moment of inertia:	$I = \frac{\pi[D^4-(D-2t)^4]}{64}$	I=	279.34 in^4
Flaw half-angle per Figure 1, N-513:	$\theta = \frac{1}{2 \cdot R}$	θ=	0.121 rad
Unit definition for kips:			1 kip = 1000 lbf
Unit definition for psi:			1 ksi = 1000 psi
Piping Loads (Moments Increased by 25% for Uncertainties):			
Maximum operating pressure:		OP=	150.00 psi
Maximum operating pressure axial force:	$P_{OP} = \pi\left(\frac{D}{2}-t\right)^2 \cdot OP$	P_{OP}=	16964.60 lbs
Axial load on pipe for Normal/Upset condition forces:		Pnu =	109.00 lbs
Axial load on pipe for Emergency/Faulted condition forces:		Pnf =	261.60 lbs
Total axial load on pipe, including pressure from piping analysis for normal/upset condition forces:	$P_n = P_{OP}+P_{nu}$	Pn =	17073.60 lbs
Total axial load on pipe, including pressure from piping analysis for emergency/faulted condition forces:	$P_f = P_{OP}+P_{nf}$	Pf =	17226.20 lbs
Applied bending moment on the pipe from piping analysis for normal/upset condition (SRSS(MA, MB, MC) for WT01+SEISOB)		Mn =	2206.25 ft-lbf
Applied bending moment on the pipe from piping analysis for emergency/faulted condition (SRSS(MA, MB, MC) for WT01+SEISSS)		Mf =	4328.02 ft-lbf
Pipe thermal expansion stress from piping analysis:		Pe =	0.000 ksi

1.5 inch Through Wall Flaw Evaluation

Circumferential Flaw Evaluation Using N-513			
Piping Material Properties (Ref. ASME B31.1):			
Young's Modulus:	E=	27850	ksi
Poisson's Ratio:	μ=	0.30	
$E' = (E/(1-\mu^2)$	E'=	30604.40	ksi
Material Properties for Flaws per H-4000:			
From ASME XI C-8322	J_{Ic} =	45	$in*lbf/in^2$
Allowable Fracture Toughness, KIc:	K_{Ic} =	37.111	$ksi*in^{0.5}$
$KIc = ((J_{Ic} * E') / (1000\ lbf/kip))^{0.5}$			
N-513 Appendix I Circumferential Flaw equations:			
Accurate between 5 and 20. Conservative over 20.	R/t=	16.500	Acceptable
$Am = -2.02917 + 1.67763*(R/t) - 0.07987*(R/t)^2 + 0.00176*(R/t)^3$			
	Am=	11.81	
$Bm = 7.09987 - 4.42394*(R/t) + 0.21036*(R/t)^2 - 0.00463*(R/t)^3$			
	Bm=	-29.42	
$Cm = 7.79661 + 5.16676*(R/t) - 0.24577*(R/t)^2 + 0.00541*(R/t)^3$			
	Cm=	50.44	
$Fm = 1.0 + Am*(\theta/\pi)^{1.5} + Bm*(\theta/\pi)^{2.5} + Cm*(\theta/\pi)^{3.5}$			
	Fm=	1.08	
$Ab = -3.26543 + 1.52784*(R/t) - 0.072698*(R/t)^2 + 0.0016011*(R/t)^3$			
	Ab=	9.34	
$Bb = 11.36322 - 3.91412*(R/t) + 0.18619*(R/t)^2 - 0.004099*(R/t)^3$			
	Bb=	-20.94	
$Cb = -3.18609 + 3.84763*(R/t) - 0.18304*(R/t)^2 + 0.00403*(R/t)^3$			
	Cb=	28.57	
$Fb = 1.0 + Ab*(\theta/\pi)^{1.5} + Bb*(\theta/\pi)^{2.5} + Cb*(\theta/\pi)^{3.5}$			
	Fb=	1.07	

Applied Stress Intensity Factor, KI, for Circumferential Flaw:

N-513 Appendix I requires that the flaw depth in the H-7300 stress intensity equations be changed to the flaw half-length, c:

Maximum assumed circumferential flaw length:	l=	1.50	in
Flaw half-length, c = l/2:	c=	0.75	in

Note: Units are converted automatically.

Normal/Upset Condition:

$K_{Im} = \left(\frac{2.7 \cdot P_n}{2 \cdot \pi \cdot R \cdot t} \right) \cdot (\pi \cdot c)^{0.5} \cdot F_m$	K_{Im} =	5.249	ksi-in$^{0.5}$
$K_{Ib} = \left(\frac{2.3 \cdot M_n}{\pi \cdot R^2 \cdot t} + P_e \right) \cdot (\pi \cdot c)^{0.5} \cdot F_b$	K_{Ib} =	2.207	ksi-in$^{0.5}$
$K_I = K_{Im} + K_{Ib}$	K_I =	7.456	ksi-in$^{0.5}$
	Therefore, K_I < KIc:	Acceptable	

Emergency/Faulted Condition:

$K_{Im} = \left(\frac{1.8 \cdot P_f}{2 \cdot \pi \cdot R \cdot t} \right) \cdot (\pi \cdot c)^{0.5} \cdot F_m$	K_{Im} =	3.531	ksi-in$^{0.5}$
$K_{Ib} = \left(\frac{1.6 \cdot M_f}{\pi \cdot R^2 \cdot t} + P_e \right) \cdot (\pi \cdot c)^{0.5} \cdot F_b$	K_{Ib} =	3.012	ksi-in$^{0.5}$
$K_I = K_{Im} + K_{Ib}$	K_I =	6.543	ksi-in$^{0.5}$
	Therefore, K_I < KIc:	Acceptable	

ENCLOSURE 2
1.5 inch Through Wall
Flaw Evaluation

Axial Through-walll Flaw Evaluation Using N-513

Stress Intensity Factor, KI, for an axial flaw subject to the bounding condition:

Axial flaw length:	l=	1.50	in
Flaw half-length, c = l/2:	c=	0.75	in
Maximum operating pressure:	OP=	150	psi
Safety Factor for normal/upset conditions from C-2622:	SF=	2.7	
N-513 Appendix I assigned flaw shape parameter for a through-wall flaw:	Q=	1.00	
$\lambda = c/(R*t)^{0.5}$	λ=	0.492	
	Therefore, $0<\lambda<5$:	Acceptable	
Note: Units are converted automatically			
$F = 1.0 + 0.072449*\lambda + 0.64856*\lambda^2 - 0.2327*\lambda^3 + 0.038154*\lambda^4 - 0.0023487*\lambda^5$			
	F =	1.167	
$K_I = SF \cdot \frac{OP \cdot R}{t} \cdot \left(\frac{\pi \cdot c}{Q}\right)^{0.5} \cdot F$	K_I =	11.974	ksi-in$^{0.5}$
	Therefore, $K_I <$ KIc:	Acceptable	

END OF ASME CODE CASE N-513-3 EVALUATION

ENCLOSURE 2
1.5 inch Through Wall
Flaw Evaluation

Code Minimum Wall Requirement Based on ASME III, ND-3640:

Joint efficiency factor:	E =	1.00	
Corrosion allowance used:	A =	0.00	in
Maximum allowable stress for pipe material from Section II, Part D:	S =	15.00	ksi
	y =	0.40	
Design Pressure:	PD =	150	psi
Minimum ASME pipe wall thickness required, not including any corrosion allowance.			
$t_m = \frac{PD}{2\cdot(S\cdot E + P\cdot y)} + A$	t_m =	0.063	in

ENCLOSURE 2
1.5 inch Through Wall
Flaw Evaluation

Minimum Wall Thickness Evaluation @ 0.063 inch Thickness				
Outside diameter of pipe:		D =	12.75	in
As analyzed pipe wall thickness:		t =	0.375	in
Allowable pipe wall thickness - Code minimum:		t1 =	0.063	in
(Use trial and error until satisfying modified stresses below)				
Design inside pipe diameter:	d = D-2*t	d =	12.00	in
New inside pipe diameter:	d1 = D-2*t1	d1 =	12.624	in
As analyzed Section Modulus:	$Z = 0.0982 \dfrac{D^4 - d^4}{D}$	Z =	43.829	in^3
New Section Modulus:	$Z1 = 0.0982 \dfrac{D^4 - d1^4}{D}$	Z1 =	7.927	in^3
Design Pressure:		Pd =	150	psig
Maximum Pressure:		Pm =	150	psig
ME101 Output Stress Summary - Input from Calculation 33-32, Revision 1B:				
Design Pressure Stress:		SPd =	1164	psi
Maximum Pressure Stress:		SPm =	1164	psi
Equation 11 Stress:		Eqn 11 =	1336	psi
Equation 12B Stress:		Eqn 12B =	1751	psi
Equation 12C Stress:		Eqn 12C =	0	psi
Equation 12D Stress:		Eqn 12D =	2262	psi
Equation 13 Stress:		Eqn 13 =	0	psi
Equation 14 Stress:		Eqn 14 =	1336	psi

ENCLOSURE 2
1.5 inch Through Wall
Flaw Evaluation

ME101 Modified Stresses			
			Allowable Stress
Equation 11 Stress = $(\mathrm{Eqn\ 11} - \mathrm{SPd}) \cdot \frac{Z}{Z1} + \mathrm{Pd} \cdot \frac{D}{(4*t1)} =$	8540	psi	17,100
Equation 12B Stress = $(\mathrm{Eqn\ 12B} - \mathrm{SPm}) \cdot \frac{Z}{Z1} + \mathrm{Pm} \cdot \frac{D}{(4*t1)} =$	10835	psi	20520
Equation 12C Stress = $(\mathrm{Eqn\ 12C} - \mathrm{SPm}) \cdot \frac{Z}{Z1} + \mathrm{Pm} \cdot \frac{D}{(4*t1)} =$	N/A	psi	N/A
Equation 12D Stress = $(\mathrm{Eqn\ 12D} - \mathrm{SPm}) \cdot \frac{Z}{Z1} + \mathrm{Pm} \cdot \frac{D}{(4*t1)} =$	13660	psi	41040

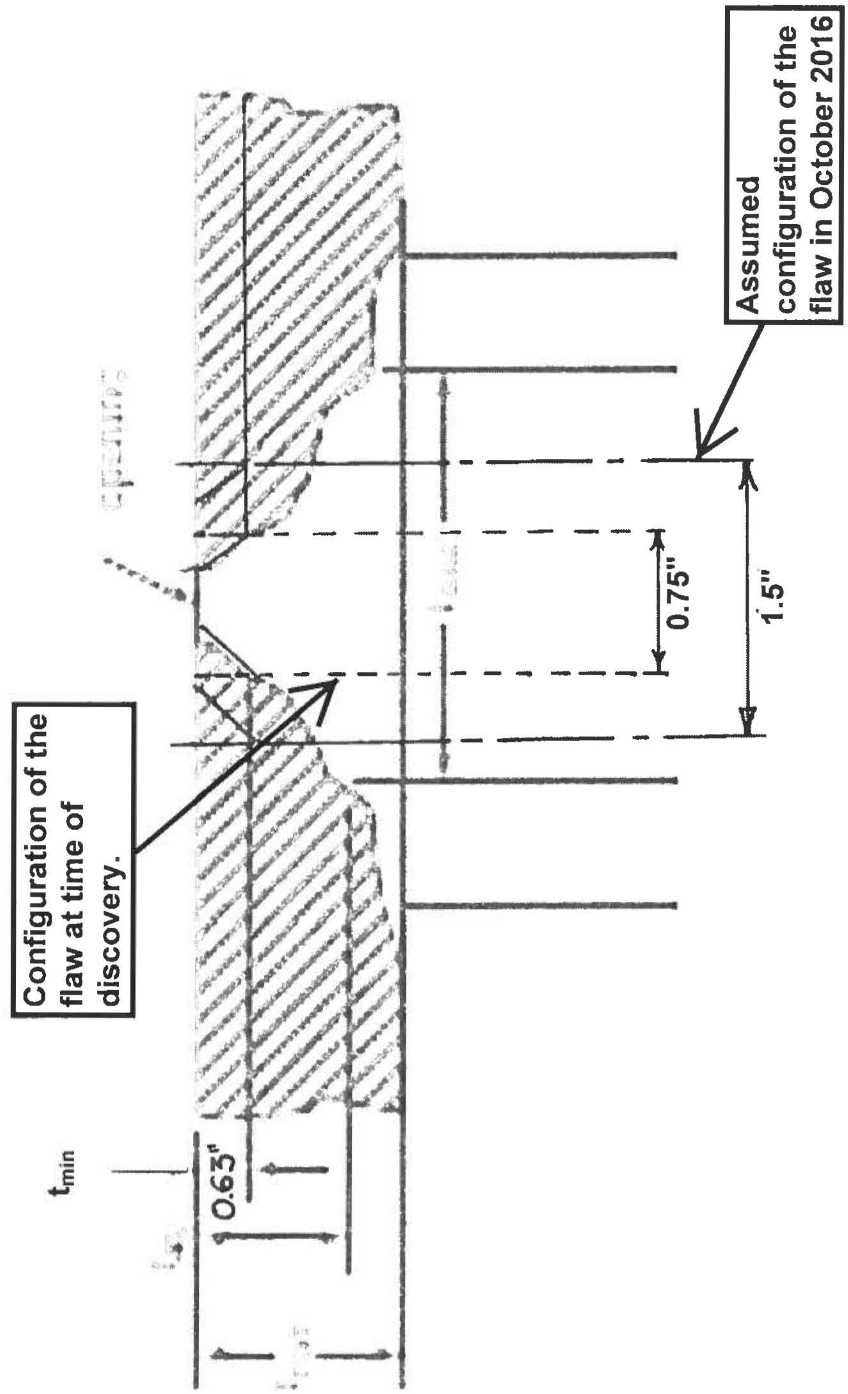
ENCLOSURE 2
1.5 inch Through Wall
Flaw Evaluation

Evaluation Input Data From Calculation 33-32 Rev 1B, Node Points 201-206								
	Fa	Fb	Fc	Ma	Mb	Mc	Mr	PSI s
Weight	848	255	56	70	346	424	551.72	
Thermal	0	0	0	0	0	0	0.00	
OBE	109	210	227	672	693	735	1213.28	
SSE	261	505	546	1613	1662	1763	2910.70	
		s	Allow s					
Pressure s		1164						
Equ. 11 s		1336	17,100					
Equ. 12b s		1751	20,520					
Equ. 12d s		2262	41,040					
Equ. 13 s		N/A						

Prepared By: Ken Hudson (signature) — **Ken Hudson** — 07-23-2015 — **Date**

Reviewed By: Douglas B. Lord (signature) — **Doug Lord** — 7/23/2015 — **Date**

ENCLOSURE 2



Assumed configuration of the flaw in October 2016
Configuration of the flaw at time of discovery.
0.75"
1.5"
0.63"
t_min