Consumers Power
POWERING MICHIGAN'S PROGRESS

PALISADES NUCLEAR PLANT
**ENGINEERING ANALYSIS COVER SHEET**

**EA**-SC-93-087-01

Total Number of Sheets 144

**Title** Justification of Weld Modifications to Pressurizer Temperature Nozzles for TE-0101 and TE-0102.

## INITIATION AND REVIEW

Calculation Status: Preliminary ☐ Pending ☒ Final ☐ Superseded ☐

| Rev # | Description | Initiated |  | Init Appd By | Review Method |  |  | Technically Reviewed |  | Revr Appd By | CPCo Appd |
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|  |  | By | Date |  | Alt Calc | Detail Review | Qual Test | By | Date |  |  |
| 0 | Original Issue | SSOverway | 10/19/93 | JCW for MDP |  | ✓ |  | James C Wong | 10-19-93 | JCW for MDP 10-19-93 |  |
| 1 | Editorial changes, clarify assumptions, add industry repairs, clarify hydro reqmts, add EDM effect justification | SSOverway | 10/23/93 | JSW |  | ✓ |  | J. C. Wong<br>JCWong | 10-23-93 | JSW |  |
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## 1.0 OBJECTIVE

The purpose of this Engineering Analysis is to document the justification for modifying the design of the Pressurizer Temperature Nozzles for TE-0101 and TE-0102 to include a weld built-up "pad" to stop Primary Coolant System (PCS) leakage caused by axial cracking of the nozzles interior to the exterior surface of the pressurizer. This EA will prove that the "pad" modification to stop this leakage is acceptable per the ASME Code for at least one fuel cycle.

## 2.0 ANALYSIS INPUT

### 2.1 Vendor Information - ABB/Combustion Engineering

a. "Nozzle Details for Consumers Power Pressurizer" - M1-L-A sh. 986 rev. 5
b. "Vessel Forming and Welding for Consumers Power Pressurizer" - M1-L-A sh. 982, rev. 9
c. "Top Head Forming and Welding for Consumers Power Pressurizer" - M1-L-A sh. 983, rev. 6
d. "Instruction Manual: Pressurizer; Consumers Power Company - Palisades Plant" - M1-L-A sh 862, rev. 1.

### 2.2 Codes and Standards

a. Initial Design - ASME Section III, 1965 with Winter 1966 addenda.
b. Modification Design - ASME Section III, 1965 with Winter 1966 addenda.
c. Modification Installation - ASME Section XI, 1983 with Summer 1983 addenda.
d. Weld Material Procurement - ASME Section III, 1986 (no addenda).

| | Reference/Comment | |
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| 2.3 Important Design Conditions | | |
| a. Press. - The modification must be able to function as the pressure boundary between the PCS and the Containment Atmosphere. Pressurizer Design Pressure - 2500 psia, Pressurizer Design Transients per CE Report Nos. CENC 1114 and CENC 1214. | EA-SC-93-087-03 | 1 |
| b. Temp. - The modification must take into account the differential temperature along the nozzle and through the pressurizer shell thickness during plant heatup and cooldown, as well as steady state conditions. Pressurizer Design Temperature - 700°F, Pressurizer Design Transients per CE Report Nos. CENC 1114 and CENC 1214.F | EA-SC-93-087-03 | 1 |
| c. Stress - The modification must account for the thermal expansion stresses that will be set up in the nozzle and pressurizer shell due to having dissimilar metals constrained to the same dimension by internal and external welds fixing both points of the nozzle to the pressurizer shell. The modification must also take into account the residual stresses in the nozzles and the pressurizer base metal caused by the welded "pad". This is a concern for reoccurrence of the cracking. Also orientation of residual stresses in the nozzles is a concern from the standpoint that excessive axial stress could lead to circumferential cracking of the nozzles and thus present a potential for a small Loss of Coolant Accident from the nozzle penetrations. | EA-SC-93-087-03<br>Ref 2.6.g, Att 9 | e<br>e |
| 2.4 Design Drawings | | |
| a. CPCo sketch, SK-SC-93-087 sh. 1, "TE-0101 Modification" and sh. 2, "TE-0102 Modification" | Attachment 1 | e |
| b. ABB/Combustion Engineering Drawing - "Pressurizer Head Temperature Nozzle Weld Repair" - D-9417-C093-019, rev. 02 | Attachment 12 | e |
| c. ABB/Combustion Engineering Drawing - "Pressurizer Shell Temperature Nozzle Weld Repair" - D-9417-C093-021, rev. 01 | Attachment 13 | e |
| 2.5 Existing Analyses | | |
| a. "Structural Analysis of Temperature Nozzle Weld Modifications for Consumers Power Palisades Pressurizer", EA-SC-93-087-03, Rev. 0. | | |
| b. "Half Bead Welding for Modifications to TE-0101 and TE-0102" - EA-SC-93-087-02, Rev. 0. | | |
| c. "Acceptability of Partial Severing of TE-0101 Nozzle", EA-SC-93-04, Rev. 0. | | 1 |

## 2.6 References

| | Reference/Comment |
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| a. ABB/Combustion Engineering Nuclear Services Welding Procedure Specification - SMA-3.43-937, rev. 1. | Attachment 3 |
| b. ABB/Combustion Engineering Nuclear Power letter, MCC-93-525, from J. F. Hall dated October 15, 1993 titled "Corrosion of Palisades Pressurizer Material." | Attachment 4 |
| c. ABB/Combustion Engineering Nuclear Services Traveler No. 2003067-001, rev. 2. | Attachment 5 |
| d. Consumers Power Company Internal Correspondence from PDFitton to KVCedarquist, PDF 91*019, dated May 22, 1991, "Palisades Plant Inconel 600 Primary Water Stress Corrosion Cracking Status Report." | Attachment 6 |
| e. ABB/Combustion Engineering Nuclear Services Welding Procedure Specification - GTA-8.8-910, rev. 10. | Attachment 7 |
| f. Consumers Power Company Internal Correspondence from JCNordby to SSOverway, JCN 93*029, dated October 18, 1993, "Effects of Half Bead Welding on Base Metals." | Attachment 8 |
| g. Consumers Power Company Internal Correspondence from RBJenkins to Design Package File, RBJ 93*064, dated October 18, 1993, "Nuclear Engineering and Construction Organization: Potential for Circumferential Cracks in Modified Pressurizer Instrumentation Nozzles." | Attachment 9 |
| h. "Engineering Specification for a Pressurizer Assembly", Specification No. 70P-001, Rev. 2 from Nuclear Power Systems, Combustion Engineering, Inc. | Attachment 10 |
| i. ABB/Combustion Engineering letter from Thomas U. Bipes to Scott Cedarquist, dated October 16, 1993, "Preliminary Results of Nozzle TE-0101 Eddy Current Exam." | Attachment 2 |
| j. ABB/Combustion Engineering letter - "Construction Code Reconciliation for Consumers Power Company - Palisades Pressurizer Upper and Lower Temperature Nozzle Repair/Modification." | Attachment 11 |
| k. ABB/Combustion Engineering Nuclear Services Traveler No. 2003067-002, Rev. 0. | Attachment 14 |
| l. ABB/Combustion Engineering Procedure of Electrical Discharge Machining (EDM) Pressurizer Nozzle Severing, STD-100-207, Rev. 0 | Attachment 15 |
| m. ASME Code Interpretation, IX-1-89-70 | Attachment 16 |

| | Reference/Comment |
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| **3.0 ASSUMPTIONS** | |
| 3.1 Major | |
| Cracks in the pressurizer temperature nozzle for TE-0102 can be characterized as axial and thus the cracks in both temperature nozzles are similar with respect to location and orientation to previous industry experience with Inconel 600 Pressurizer Penetrations experiencing Primary Water Stress Corrosion Cracking (PWSCC) i.e. the only cracks in the nozzles are axially oriented and are located in the vicinity of the partial penetration "J" weld. | Ref 2.6.d, Att 6 |
| 3.2 Minor | |
| a. Assume effects of borated primary coolant on the pressurizer base material is bounded by the results of the laboratory tests provided by ABB/Combustion Engineering. | Ref 2.6.b, Att 4 |
| b. Assume TE-0101 nozzle I.D. and O.D. are concentric. | |
| c. Assume measured TE-0101 nozzle I.D. and O.D. are representative of I.D. and O.D. of whole nozzle, i.e. that the I.D. and O.D. do not vary as a function of distance down the nozzle. | |

Reference/Comment

## 4.0 ANALYSIS

### 4.1 Background

a. On October 9, 1993 at approximately 0900 insulators working on the upper head of the pressurizer (T-72) re-installing insulation that had been removed to allow repair to the leaking PORV line observed water leaking from the upper head around the base of the TE-0101 temperature nozzle. (Operations department personnel were also scheduled to inspect the TE-0101 temperature nozzle prior to pressurizer insulation re-installation, but had not yet gotten to that location in their inspections.) At that time the pressurizer was filled solid with water, the PCS was cold and at 250 psia. Palisades Systems Engineering, Mechanical Maintenance, and Operations departments verified the leakage. Operations commenced reducing PCS pressure. ABB/Combustion Engineering (ABB/CE) was contracted to assist in correcting this problem, as were Systems Engineering and Nuclear Engineering and Construction Organization engineers. Event Report, E-PAL-93-032, was initiated to correct the problem.

b. A Project Team was established to evaluate the leakage, identify alternative solutions, and recommend a solution to management. On October 11, 1993 the alternative were presented to management and the option to modify the temperature nozzle design by welding a "pad" to the exterior surface of the pressurizer to re-establish the structural support and pressure boundary was chosen.

c. On October 12, 1993 a detailed inspection of the other pressurizer temperature nozzle (for TE-0102) was completed and leakage from around that nozzle was also noted. The modification scope was then expanded to include both pressurizer temperature nozzles.

d. A structural analysis of the modification was performed by ABB/CE. It determined that the upper nozzle must be severed between the new and old welds due to thermal stresses that develop during heatup and cooldown of the pressurizer. However, as the modification design continued to develop, it became apparent that complete severing of the nozzle had technical drawbacks. ABB/CE was then directed to determine the maximum amount of nozzle that could remain and still have the nozzle meet ASME Code requirements. ABB/CE developed a calculation showing a remaining "ligament" of the nozzle O.D. was acceptable. The modification design was then revised to incorporate this change.

EA-SC-93-087-04

### 4.2 Industry Experience

To date, the Nuclear Power Industry has experienced leakage from similarly designed nozzles, especially in high temperature environments like the pressurizer. In fact, a special Combustion Engineering Owner's Group (CEOG) Working Group was formed in November of 1989 to address the PWSCC of Inconel 600 that had been determined to be the cause of previous similar leaks. The results of a comparison of this working group's determinations indicated that the Palisades Pressurizer Temperature Nozzles were moderately susceptible to PWSCC. As a result inspections of the pressurizer temperature nozzles, using VT-2 methods with the insulation installed have been performed as part of the pre-startup inspections during each subsequent refueling. The industry in the United States has, so far, experienced cracking in instrument nozzles and heater sleeves in pressurizers. These leaking penetrations have all shared a common cause for the stress that sets up the conditions to promote PWSCC - they were all attached to the inner surface of the pressurizers with partial penetration welds. The Palisades temperature nozzles are attached with a partial penetration "J" weld. Permanent repairs at the other U.S. plants that have experienced penetration cracking have involved replacement of the nozzles which has involved some welding from the inside of the pressurizer. Due to time considerations in planning the most ALARA effective method of replacement, Palisades management decided to pursue a method that would allow operation of the plant for at least one fuel cycle while not being overly dose expensive to install. This approach would allow plant operation while the planning and engineering needed for the potentially high dose replacement of the nozzles occurs. The modification chosen to allow operation for at least one fuel cycle draws on ABB/CE's experience with other short term modifications at other U.S. nuclear plants for leaking Inconel 600 nozzles.

Ref 2.6.d, Att 6

Reference/Comment

4.3 Reason for Change

The existing temperature nozzles for TE-0101 (Pressurizer Vapor Phase Temperature Element) and TE-0102 (Pressurizer Water Space Temperature Element), located on the pressurizer upper head and lower shell respectively, are currently exhibiting leakage from between the Inconel 600 nozzle and the carbon steel base material of the pressurizer at the outer surface of the pressurizer. Eddy Current Testing has been used to characterize the cracks in the upper nozzle as axial. These cracks are similar to cracks found in Inconel nozzles at other Pressurized Water Reactors. The typical Inconel 600 cracks have been caused by PWSCC and are not considered to be a safety problem due to the fact that they occur axially rather than circumferentially (this implies they are not likely to fail catastrophically without leaking for a sufficient amount of time to be detected). The modification for these leaks, as proposed by the Nuclear Steam Supply System (NSSS) vender for Palisades, ABB/CE, is to replace the original pressure boundary weld on the interior surface of the pressurizer shell, called a "J" weld, with a new weld on the exterior surface of the shell, as indicated in the construction drawings. This exterior weld is intended to re-establish the pressure boundary downstream of the original "J" welds and replace the structural support that may have been weakened by the cracks, thereby bypassing the faulted (cracked) portion of the nozzles.

Ref 2.6.i, Att 2
Ref 2.6.d, Att 6
Ref 2.4.b Att 12
Ref 2.4.c Att 13

4.4 Design Considerations

a. The weld modification design is governed by Section XI of the ASME Boiler and Pressure Vessel code, 1983 edition with the summer 1983 addenda, The Code. ABB/CE has provided a letter that details how the Code applies to this modification. The letter indicates that IWB-4000 will be used by the modification. By using IWB-4000 methods the modification avoids the difficulties encountered with welding to the pressurizer - post weld heat treatment of the entire pressurizer, since the methods specify a self-tempering weld process. The justification for choosing the specific processes of IWB-4000 as prescribed by the Traveler is presented in a letter from Consumers Power's Welding Codes and Materials Supervisor. The process is laid out in a qualified ABB/CE welding procedure.

Reference 2.2.c
Ref 2.6.j Att 11
Ref 2.6.c, Att 5
EA-SC-93-087-02
Ref 2.5.b, Att 3

Reference/Comment

b. The weld modifications will take the shape of a "pad" located around each nozzle on the outer surface of the pressurizer shell. The diameter of the pads, as specified, is designed to take into account the replacement of the nozzles in the future by allowing a large enough area to weld on without having to build-up additional pad area. At the same time it also provided a large area for the stresses on the weld pad to be spread over. The thickness of the pad is designed as part of the stress analysis of the modification. The pads establish the pressure boundary and structural support between the nozzles and the pressurizer shell. This modification will re-establish the leak-free condition that is the design condition for the nozzle/pressurizer shell interface.

Refs 2.4.b & c, Att 12 & 13

EA-SC-93-087-03

c. Welding the nozzles to the pressurizer shell at both the interior surface and the exterior surface, however, sets up the potential for high stresses in the nozzle due to the different thermal expansion experienced by the Inconel 600 nozzle and the ASTM A-533, Grade B, Class 1 steel plate pressurizer. This stress, caused by having the nozzle fixed at two locations to the pressurizer shell, is evaluated in the modification stress analysis. The conclusion of this calculation and its addendum is that the nozzle for TE-0101, located in the upper head of the pressurizer, needs to be partially severed within the thickness of the upper head to prevent the stresses caused by differences in thermal expansion during heatup and cooldown from exceeding the ASME code allowable stresses. The nozzle will be partially severed using the procedure laid out in a second traveler. By partially severing the nozzle, the thermally induced loads on the welded pressure boundary is bounded by the material's collapse loads in the thinned nozzle wall. The stress calculation addendum demonstrated that with a thinned wall thickness of 0.110 inches, the stress level in the pressure boundary will be within the Code allowables. The stress calculation also verifies that the nozzle for TE-0102, located in the lower section of the pressurizer shell, does not need to be severed since it does not experience as large a transient loading due to being in a liquid environment. The axial stresses developed on the lower nozzle due to accident transients are still within ASME code stress and fatigue allowables even with the nozzle constrained at the inner and outer surface of the pressurizer. The calculation also confirms that, since the modification design meets ASME code requirements for all stress and fatigue allowables, the modification will allow operation for at least one fuel cycle.

EA-SC-93-087-03

Ref 2.6.k Att 14

EA-SC-93-087-04

EA-SC-93-087-03

EA-SC-93-087-03

| | Reference/Comment |
|---|---|
| d. The existing crack locations in both nozzles leads to another potential problem. That problem is one of corrosion of the carbon steel pressurizer by the borated primary coolant that will come in direct contact with the steel. Due to the exterior weld build-up, the modification will allow the known axial cracks at the TE-0101 and TE-0102 temperature nozzles to potentially place borated primary coolant in contact with the carbon steel pressurizer. The NSSS vender indicates that, per an industry study, corrosion of low alloy steel relating to PWSCC failures in Inconel 600, the Palisades pressure boundary material can expect a conservative maximum corrosion rate of 3 mil/year. This corrosion rate would not significantly effect the integrity of the pressure boundary during one fuel cycle, thus this modification is acceptable for installation for at least one fuel cycle from a corrosion standpoint. Other proof that this intentional exposure of carbon steel to borated primary coolant is not a corrosion concern can be found from industry experience with pressurizer leaks from heater sleeves and temperature and pressure nozzles and from CEOG Task 637. Actual expected corrosion for the Palisades pressurizer base metal is probably undetectable due to the fact that the areas exposed to borated primary coolant will not experience any flow past them (and therefore no erosion effects) and thus will experience an even slower total rate of metal loss. | Ref 2.6.b, Att 4<br>Ref 2.6.d, Att 6 |

| | Reference/Comment |
|---|---|
| e. The partial sever cut will occur per the design drawing and the second traveler with the EDM procedure. The design is based on a desire to cut enough of the nozzle material to meet the Code allowables, as ABB/CE has shown in a supplement to the original design stress calculation, while ensuring that enough "ligament" is left of the nozzle wall thickness to prevent a through-wall penetration by the EDM process to the pressurizer shell. The reason for the concern with EDM cutting the pressurizer shell is that the EDM process has not been interpreted to be usable on low alloy carbon steels without post-removal surface smoothing by mechanical methods and, due to PCS foreign material exclusion concerns, that mechanical methods are not a prudent choice of method for this application. To design a ligament size, ABB/CE determined the maximum nozzle wall thickness that would meet ASME Code requirements. The dimension calculated was a maximum of 0.110 inches. To ensure that the nozzle would break at the cut notch in the unlikely event of an excessive transient loading and not somewhere else, the desired ligament size was chosen as 0.055 inches. This ligament size, taken along with the cutting accuracy of approximately ± 0.002 inches, the concentricity accuracy of the EDM wand versus the nozzle I.D. being approximately ± 0.005 inches (based of I.D. of nozzle, constriction at the modification weld, and O.D. of EDM wand), and nozzle I.D. and O.D as measured in the field, ensures that a sufficient amount of nozzle will be removed to control stress levels while still ensuring that the O.D. of nozzle will not be penetrated. Thus with this ligament size specified, no pressurizer base metal will be affected by the EDM process and this portion of the modification will also meet ASME Code. | Ref 2.4.b Att 12<br>Ref 2.6.k Att 14<br>Ref 2.6.l Att 15<br>EA-SC-93-087-04<br>EA-SC-93-087-04<br>Assumption 3.2.b<br>Assumption 3.2.c |

Reference/Comment

## 4.5 Design Basis Function

The design basis function of the pressurizer system is to control PCS pressure and volume through the use of a saturated steam bubble and stored water volume. Pressure control is performed by the saturated steam bubble. It controls PCS pressure reductions by expansion of the steam bubble and some of the stored water flashing to steam, thus reducing the pressure drop for a given PCS contraction. It controls PCS pressure increases by compressing the steam bubble and condensing some of the steam into water. (There is also a spray system to control rapid pressure increases.) The stored water volume also acts as a means of controlling the PCS water volume. The pressurizer water level is the controlling input to the Chemical and Volume Control System for letdown and charging. The pressurizer level is controlled automatically to maintain the appropriate PCS water volume. The design basis functions of the nozzles for TE-0101 and TE-0102 are to: (1) provide a pressure boundary from the pressurizer to the containment atmosphere and (2) provide structural support to the thermowells and temperature elements. The Temperature Elements (TEs) provide the plant operators with indication of the steam and water temperatures within the pressurizer to help control operation of the plant. The TEs, however, are not Q-Listed and do not provide any input into automated systems; they are just for indication. The nozzles for the TEs are provided to create the proper geometry and structural support for the mounting of the TEs to the pressurizer. The TEs actually mount inside a thermowell that provides the pressure boundary from the pressurizer to the TE. The thermowell is then welded to the safe end of the nozzle (the nozzle is welded to the safe end during nozzle fabrication, prior to installing the nozzle in the pressurizer shell). The nozzle is then welded, via the "J" weld to the pressurizer shell and the interior cladding of the pressurizer to provide the pressure boundary to atmosphere. The proposed modification will retain the original "J" weld inside the pressurizer but will not rely on it to prevent the nozzle (and thus thermowell and TE) from being ejected from the pressurizer. For TE-0101, since the nozzle is intentionally being partially severed outside of the "J" weld, the modification will assume both the design functions of pressure boundary and structural support. For TE-0102, even though the nozzle will remain intact, the "J" weld will not be relied on for any structural support. The modification will replace the pressure boundary and structural support aspects of the "J" weld with the "pad" on the exterior of the pressurizer. The modification, thus, moves the structural support point and the pressure boundary from the interior surface to the exterior surface of the pressurizer. Therefore the original design basis functions of the temperature nozzles are maintained.

Attachment 1

Reference/Comment

4.6 Impact on Affected System or Interfacing Systems

a. The proposed modification will not have any noticeable effect on the pressurizing system, PCS, or the pressurizer temperature indicating system.

b. Each pad's weight is less than 10 pounds which is insignificant compared to the dry weight of the pressurizer vessel which is 202,000 lb. (including heaters) and thus is not a weight concern.

c. The method by which the pads are deposited on the exterior of the pressurizer assures that they are not a residual stress concern for the vessel itself or the temperature nozzles. The modification will not adversely affect the pressurizer base metal due to any metallurgical changes caused by the weld process. This is the prime reason for the selection by the ASME Code for the weld procedures (Half Bead Technique) specified in paragraph IWB-4000 of the Code. The residual stresses created by this weld modification have been evaluated and determined that the residual stresses caused by the modification can be determined to be hoop stresses, just as was seen in the original design. The fact that the residual stresses are in the hoop direction, and not in the axial direction, implies that any cracking of the nozzle that might occur as a result of these stresses would again be axial and not circumferential. Also it is likely that the operational hoop stresses as a result of the modification will be substantially less than for the original "J" weld. This is due to the fact that nozzle exterior at the original "J" weld only saw only the tensile residual stresses caused by the shrinkage of the weld material, whereas the nozzle exterior at the pad weld will also see exterior pressure due to the cracks upstream on the nozzle pressurizing the bore of the pressurizer shell penetration. This exterior pressure is compressive and tends to lessen the total tensile stress on the nozzle. Operational axial stress is not a concern at the TE-0101 nozzle due to the fact that it is being partially severed. This allows any stresses due to the thermal expansion stresses caused by the difference in expansion between the inner and outer walls of the pressurizer and the nozzle material to plastically deform the nozzle in a known orientation and location. Operational axial stress is a potential concern in the TE-0102 nozzle, though, since it is remaining intact. This concern is mitigated by the fact that the corrosion mechanism that is producing the nozzle cracking is PWSCC and it is very time dependent. Since the modification is intended to only be installed one fuel cycle, it is highly unlikely that enough time would be available for PWSCC to produce a through-wall crack. The concern is also mitigated by the fact that the

Ref 2.6.g, Att 9

Ref 2.6.f, Att 8

Ref 2.6.g, Att 9

Ref 2.6.d, Att 6

Reference/Comment

axial stress in question is also self-limiting, due to its cause. The stress is highest during high differential temperatures between the interior and exterior walls of the pressurizer. This is a relatively uncommon occurrence, especially for the water space of the pressurizer, other than during plant heatup and cooldown. The intensity of the axial stress during steady state operation is likely to be much below the threshold stress required for the onset of PWSCC. Since the highest level of stress only occurs during major changes in plant state and the modification is only intended for installation during one fuel cycle, there will be little time spent with the nozzle at its maximum axial stress. Thus, there still is not a realistic threat of a circumferential crack that would lead to Loss of Coolant Accident. Another point to be considered with any cracking of the TE-0102 nozzle as a result of the high axial stress during heatup and cooldown is that any cracks that may occur due to the stress would occur between the "J" weld and the pad weld and thus would still be within the new pressure boundary. As regards new cracks in the nozzle wall beyond the new pressure boundary, it has been the industry experience that PWSCC requires significant time to develop into through wall cracks. Since the areas of the nozzles to be welded by the modification were not highly stressed prior to the modification, and currently have no eddy current detected indications within them; it can be expected that any PWSCC that will occur in the newly welded areas will be minimal and will not likely cause through wall cracks prior to the replacement of the nozzles. With no pre-existing flaws to accelerate the process, the time this modification is intended to be installed is insufficient to develop PWSCC. Because a Code authorized weld process was used to form the new pressure boundary and the stresses created in the lower nozzle are within Code allowables, the modification will not adversely affect the pressurizer or nozzle at the TE-0102 nozzle.

Ref 2.6.i, Att 2
Assumption 3.1

Assumption 3.1

Reference/Comment

d. Operational axial stress is not a concern with TE-0101 due to the fact the nozzle is being partially severed. This cutting operation is being performed by Electrical Discharge Machining (EDM). The EDM process is being used due to the fact that it produces only a residue that may be allowed to enter the PCS, thus simplifying the cutting operation by not requiring that the cutting be prevented from entering the PCS. The EDM process only produces residue in the consistency of talcum powder since it essentially vaporizes the metal it is being used to cut through. Since the EDM process is going to be used to cut Inconel 600, and Inconel 600 includes trace amounts of Cobalt, one of the concerns with releasing this residue to the PCS is the activation of the Co-60. The fact that the modification would introduce this Cobalt bearing powder to the PCS was brought to the attention of Palisades Reactor Engineering department. Allowing the EDM residue from Inconel 600 to enter the PCS was evaluated by Reactor Engineering as not being a concern to fuel integrity or PCS activation due to the fine consistency of the residue and the extremely small amounts of it being created. Another concern with EDM is that it produces a very thin Heat Affected Zone (HAZ). Per paragraph IWB-4212, if a thermal process is used to remove metal from a P-No. 43 material, 1/16" of material must be removed after the thermal removal process is complete. (Inconel 600 is grouped as a P-No. 43 material.) However, per ASME Code Interpretation XI-1-89-70, the requirements of paragraph IWB-4212 do not apply to the EDM process when used on P-No. 43 material. Thus no post-removal surface smoothing will be required after the EDM process is used to partially sever the TE-0101 nozzle. Yet another concern with using the EDM process is ensuring that only the nozzle be cut. This is because there is no Code interpretation for cutting the P-No. 3 base metal. Without the Code interpretation the modification would have to take into consideration the requirement to mechanically remove whatever little HAZ may be created by the EDM process operating on the base metal. However, due to the design, as indicated above in Section 4.4.e, the probability of contacting the base metal is minimized by leaving a 0.055 inch ligament of the nozzle behind. This ligament has been evaluated as acceptable per the ASME Code. Because the modification to the nozzle is being performed within the Code allowables, and because a Code authorized weld process was used to form the new pressure boundary, the modification will not adversely affect the pressurizer or the portion of the TE-0101 nozzle being relied on as a pressure retaining component.

Reference 2.2.c

Ref 2.6.m Att 16

EA-SC-93-087-04

| Reference/Comment |
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e. The modification will not adversely affect the PCS due to the entry of foreign materials. As discussed above, the only materials to enter the PCS are a small amount of EDM residue of powderized Inconel and the demineralized water used by the EDM process for cooling and dielectric. The residue has been evaluated by Reactor Engineering to not pose either a fuel damage risk or an activation problem. The demineralized water has been estimated at 120 gallons (6 gal/hr * 20 hrs) and has been evaluated as not being a boron dilution problem. Therefore the modification will not have an adverse effect on the PCS. 1

f. In addition, the weld modification will not affect the temperature elements because they are not affected by the location of the structural support or pressure boundary, as long as they are not exposed to PCS pressure. The leaks are not in an area that threatens to expose the TEs to PCS pressure, thus the modification will have no effect, in this regard, on the TEs. The TEs will be removed from the thermowells prior to the weld modification, thus the actual installation of the modification will not affect the TEs either. 2

g. Overall, the modification will not affect either the system it is installed on or any interfacing systems except to restore the structural support that may have been weakened by the cracks in the nozzles and to re-establish the pressure boundary that has been bypassed. 2

## 4.7 Critical Features

The critical features that the modification must meet are that it must re-establish the structural support and the pressure boundary between the pressurizer and the containment atmosphere while not detrimentally affecting the structural integrity of the pressurizer or the nozzle. The temperature elements and thermowells that are installed in the nozzles must continue to function normally. The original "J" weld had two critical physical functions - (1) to provide structural support for the thermowell and thus the temperature element, and (2) to provide a pressure boundary between the pressurizer and the containment atmosphere. The modification weld "pad" will function as the replacement structural support as determined the stress calculation and also function as the replacement pressure boundary due to its location. Because the temperature elements will be removed during the welding and because the thermowells will not be damaged during the modification, there will be no adverse effects on the temperature elements, so the TEs will continue to function normally.

EA-SC-93-087-03 2

Reference/Comment

4.8 Critical Feature Verification

a. The critical features of the weld will be verified by following the traveler, which calls for the use of non-destructive testing after the pad is installed by weld build-up on the pressurizer as required by section IWB-4344 of the Code.

Ref 2.6.c, Att 5

b. The critical features of the modification will be verified, as required by the Code, via a leak check and visual inspections at normal operating conditions. Per paragraph IWA-4500 (a) of the Code, an examination of the repaired area using the same technique as originally detected the flaw must be performed. For the temperature element nozzles, this means that a visual inspection for leakage, with the insulation off, must be performed at 250 psig. Per paragraph IWA-4400 (a) after repairs by welding on the pressure retaining boundary, a system hydrostatic test shall be performed per IWA-5000. IWA-5214 requires that the replacement component (in this case the pressure boundary) be pressure tested to comply with the system pressure test specified in IWB-5222. IWB-5222 (b) states that when a system hydrostatic test is conducted for a reactor vessel containing nuclear fuel and the vessel in within the system test boundary, the test pressure shall not exceed the limiting conditions specified in the plant Technical Specifications. Since the pressurizer is unisolable from the reactor vessel, and the reactor vessel will contain nuclear fuel during the performance of the hydrostatic test, this paragraph indicates that the test pressure shall not exceed the limiting conditions specified in the plant Technical Specifications. What this means is that the modification will have to be pressure tested to the maximum pressure allowed in the Technical Specifications, 2100 psia, and visually inspected at this pressure.

Palisades Technical Specs, Section 3.1.1

c. The critical function of normal indication observed on TE-0101 and TE-0102 will be verified by the plant operators during plant startup.

4.9 Weld Characteristics

Weld characteristics for the modification are indicated on the design drawings. The qualified weld procedure to be used for the creation of the weld build-up "pad" is found as Reference 2.6.a. The qualified weld procedure to reinstall the thermowell after the modification to the temperature nozzle attachment is found as Reference 2.6.e. Procedures for attachment of thermocouples for monitoring pre-weld and post-weld heat treatments and the procedure for the monitoring the heat treatments are called for in Reference 2.6.c.

Ref 2.4.b & c, Attach. 12 & 13

Attachment 3

Attachment 7

Attachment 5

Reference/Comment

### 4.10 Code Reconciliation

The ASME Boiler and Pressure Vessel Code (B & PV) for the construction design of the pressurizer was Section III of the 1965 edition with the winter 1966 addenda. Per the Palisades Nuclear Plant Final Safety Analysis Report, Section 4.3.7, the pressurizer was built to ASME Section III 1965 edition with winter 1965 addenda. The original engineering specification for the pressurizer, on pages 2 and 3, states that the winter 1966 addenda is approved for the Palisades pressurizer. Based on this fact an FSAR Update will be submitted to correct this error. The design of the modified connection for the temperature nozzles is to the Section III of the ASME B & PV Code, 1965 edition with the winter 1966 addenda. Since the design of the pressurizer and the design of the modification are to the same edition and addenda of the Code, no reconciliation is required. The modification installation is to the ASME B & PV Code, 1983 edition with the summer 1983 addenda. This particular edition and addenda of the Code has been approved as Palisades' Inservice Inspection (ISI) Code, and thus all welding to Section XI components at Palisades is done to this edition and addenda without the need for reconciliation to the Construction Code - the reconciliation was performed when this edition and addenda were approved as the ISI code. (See Reference 2.6.j for a more detailed code reconciliation.) Thus the modification design and installation are properly reconciled to the Construction Code.

Ref 2.6.h Att 10 | e

Ref 2.6.h Att 10 | e

EA-SC-93-087-03 | e

Attachment 11 | e

## 5.0 CONCLUSION

The modification as specified in design drawings and installed per the Travelers is an acceptable modification to the Palisades Pressurizer Temperature Nozzles per the ASME Boiler and Pressure Vessel Code, Section XI. The modification is being performed per the Code and thus will provide adequate structural support and a sufficient pressure boundary to continue operation of the Palisades Nuclear Plant for at least one full fuel cycle.

Ref 2.4.b & c,
Attach. 12 & 13,
Ref 2.6.c & k,
Attach. 5 & 14 | e

Consumers Power
POWERING MICHIGAN'S PROGRESS

# NUCLEAR OPERATIONS DEPARTMENT
## Document Review Sheet

Document Title: Justification of Weld Mod to PZR Temp Nozzles TE-0102 TE-0101

Document Number: EA-SC-93-087-01

Revision Number: 1

Page 1 of 1

| Item Number | Page and/or Section Number | Comments | Response or Resolution |
|---|---|---|---|
| | | None | |
| | | | |
| | | | |
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| | | | |

| Reviewer | Organization | Date | Review Coordinator | Date | Document Sponsor | Date |
|---|---|---|---|---|---|---|
| J.C. Wong | NECO | 10-23-93 | | | | |

Form 3110 10 91

Proc No 9.11
Attachment 5
Revision 5
Page 1 of 1

## TECHNICAL REVIEW CHECKLIST

EA - SC-93-087-01 REV. 1

This checklist provides guidance for the review of engineering analyses. Answer questions Yes or No, or N/A if they do not apply. Document all comments on a 3110 Form. Satisfactory resolution of comments and completion of this checklist is noted by the Technically Reviewed signature on the Initiation and Review record block of Form 3619.

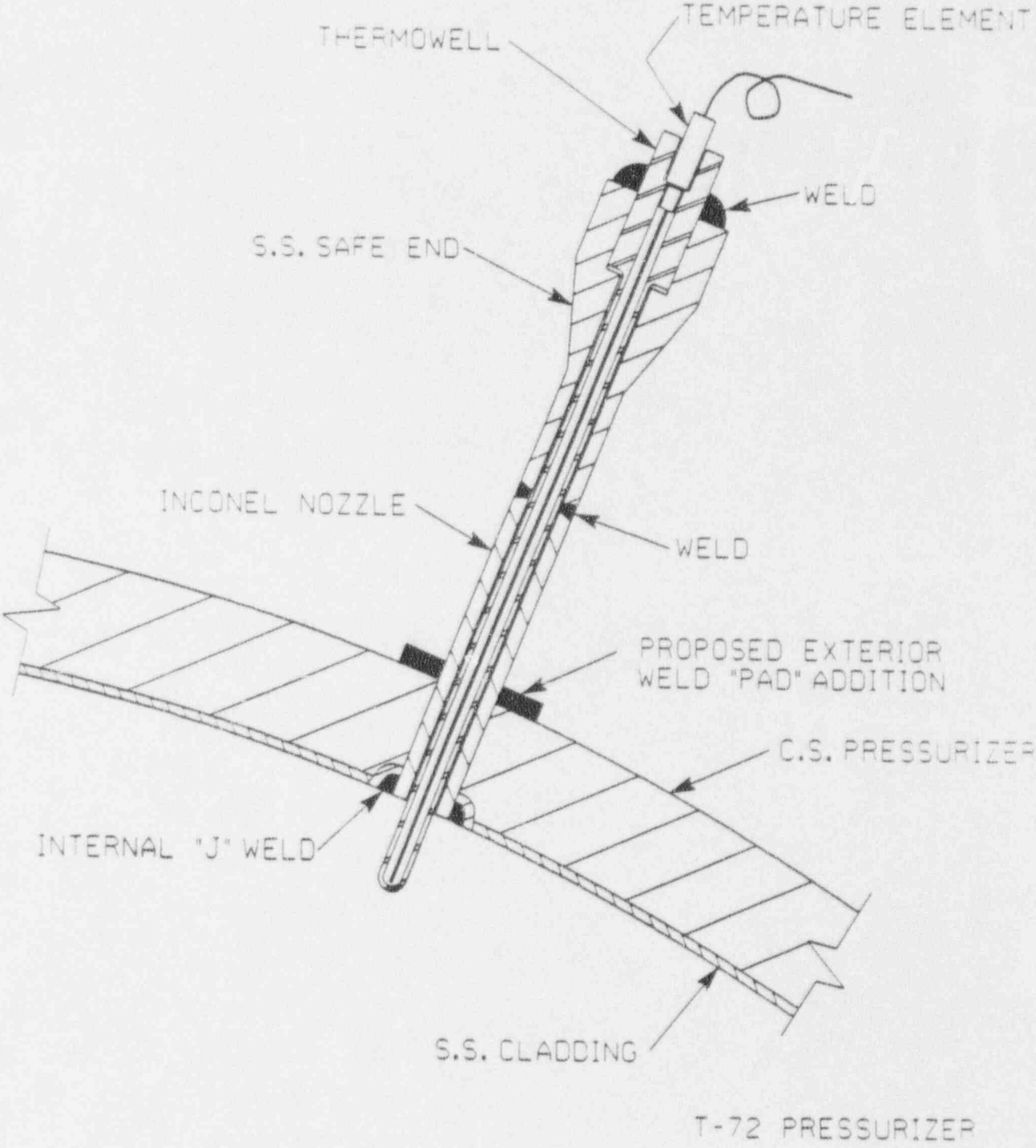
| | ([✓ Y], N, N/A) |
|---|---|
| 1. Have the proper input codes, standards and design principles been specified? | |
| 2. Have the input codes, standards and design principles been properly applied? | Y |
| 3. Are all inputs and assumptions valid and the basis for their use documented? | Y |
| 4. Is Vendor information used as input addressed correctly in the analysis? | Y |
| 5. If the analysis argument departs from Vendor Information/Recommendations, is the departure justification documented? | n/a |
| 6. Are assumptions accurately described and reasonable? | Y |
| 7. Has the use of engineering judgement been documented and justified? | Y |
| 8. Are all constants, variables and formulas correct and properly applied? | Y |
| 9. Have any minor (insignificant) errors been identified? If yes; Identify on the 3110 Form and justify their insignificance. | N |
| 10. Does analysis involve welding? If Yes; verify the following information is accurately represented on the analysis drawing (Output document).<br>• Type of Weld<br>• Size of Weld<br>• Material Being Joined<br>• Thickness of Material Being Joined<br>• Location of Weld(s)<br>• Appropriate Weld Symbology | Y |
| 11. Has the objective of the analysis been met? | Y |
| 12. Have administrative requirements such as numbering and format been satisfied? | Y |

# EA-SC-93-087-01

# ATTACHMENT 1

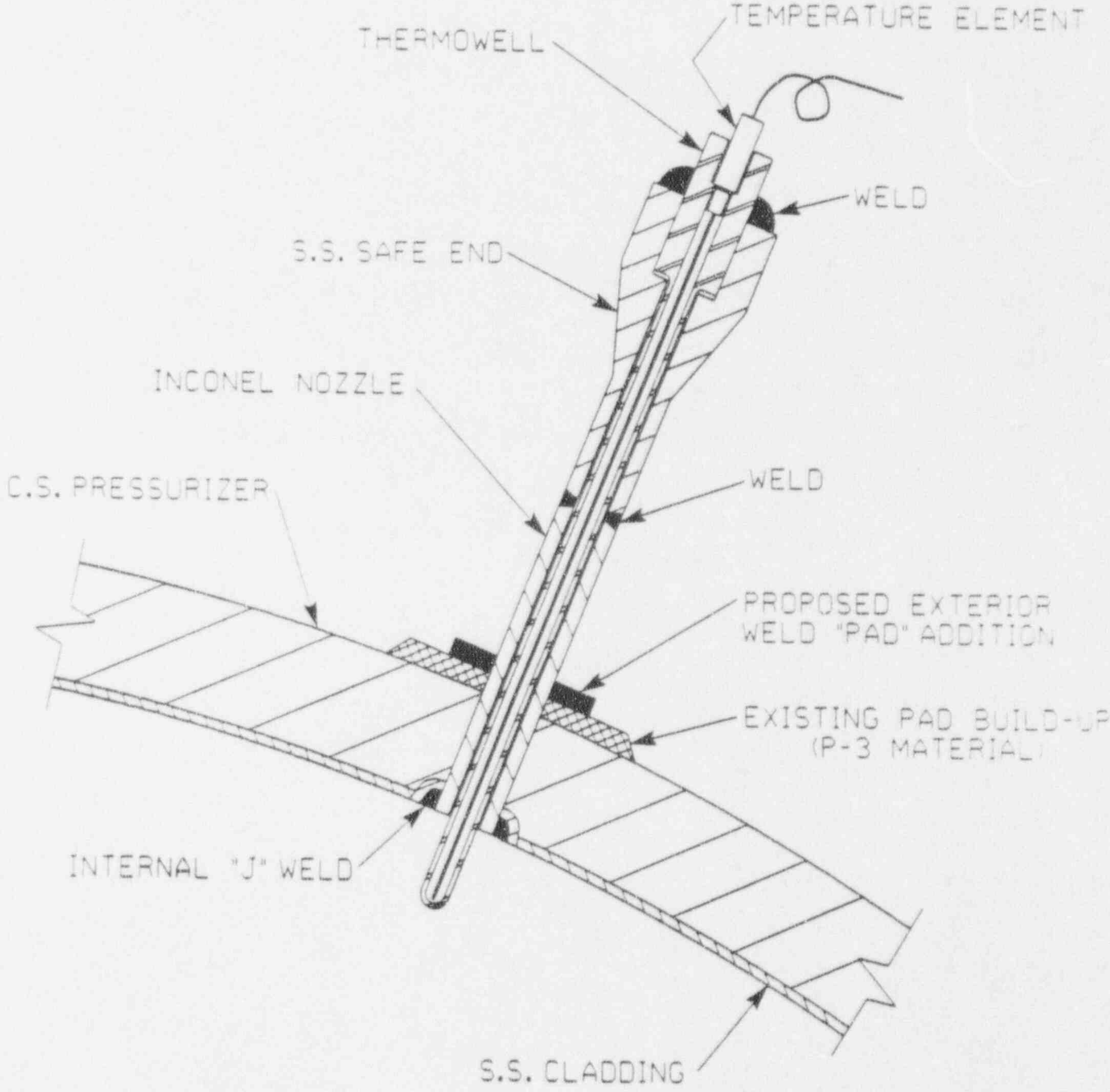
## CPCo Sketches

# TE-0101 MODIFICATION



T-72 PRESSURIZER

# TE-0102 MODIFICATION



T-72 PRESSURIZER

SK-SC-93-087 Sheet 2

# EA-SC-93-087-01

# ATTACHMENT 2

# Eddy Current Exam Results

ABB

October 16, 1993

Scott Cedarquist
Consumers Power Co.

Subject: Preliminary results of Nozzle TE-0101 Eddy Current Exam

On October 16 1993, ABB/Combustion Engineering performed an eddy current examination of Nozzle TE-0101 located on the top of the pressurizer at Palisades Unit 1 Nuclear Plant. The inspection utilized the rotating 3-coil eddy current probe to aid in distinguishing an axial or circumferential orientated indication.

The results of the examination indicated four axial crack indications emanating from the inside of the pressurizer with a length of approximately one half inch. The examination was performed utilizing a calibration standard with axial and circumferential indications of various sizes located on the ID of the standard.

To indicate the approximate size of the crack indications, a voltage setting of five volts was established on the 0.018" deep I.D. axial notch in the calibration standard. The size of the largest axial indication in the nozzle was approximately nineteen volts. This indicates the axial indications are larger than the calibration standard notches.

Details of this inspection will be included in the final report to be issued at a later date. Graphic presentations and other documentation will be included in the final report.

Sincerely,

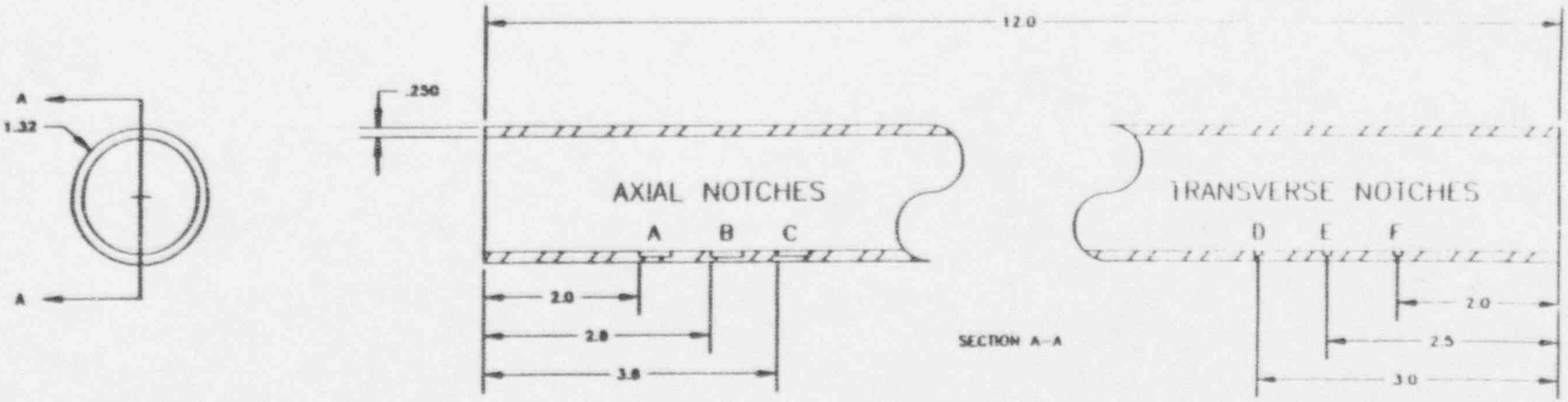
ABB/Combustion Engineering

Thomas U. Bipes
ABB/CE Eddy Current Level III

Combustion Engineering Nuclear Services

Combustion Engineering, Inc.
P.O. Box 500
1000 Prospect Hill Road
Windsor, Connecticut 06095-0500
Telephone 203-285-9519
Fax 203-285-9530

**REVISIONS:**



| NOTCH | DEPTH | WIDTH | LENGTH |
|---|---|---|---|
| A | 0.005 | 0.007 | 0.370 |
| B | 0.010 | 0.007 | 0.370 |
| C | 0.018 | 0.007 | 0.370 |
| D | 0.022 | 0.007 | 0.378 |
| E | 0.015 | 0.007 | 0.376 |
| F | 0.006 | 0.007 | 0.376 |

**J & K PERFORMANCE**

ECT STANDARD
S/N PAL-410-004-01.
ECT-93

DATE OCTOBER 15, 1993
DRAWN BY W M RAMEY
APPROVED BY J W HALES
MATERIAL INC 600

CONTRACT NO
9311098
SCALE NONE

TOLERANCES UNLESS SPECIFIED

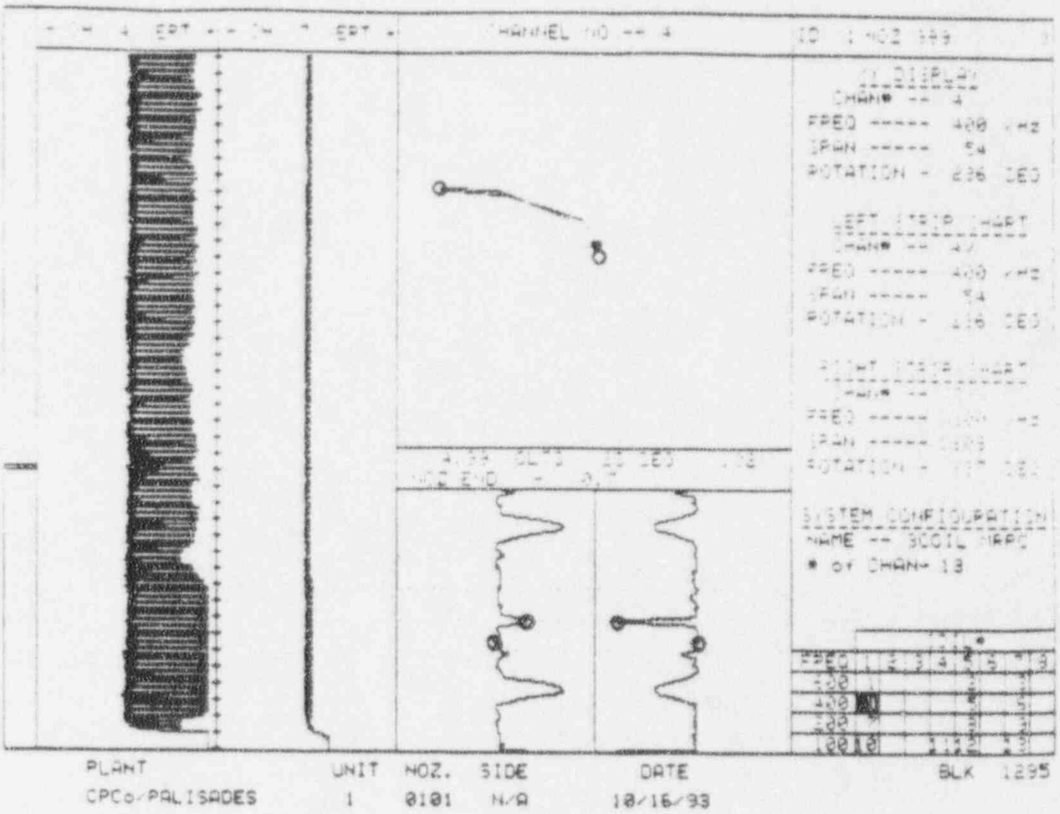
| X | X | XX | XXX |
|---|---|---|---|
| 25 | 12 | 08 | 010 |

DRAWING NUMBER
JK ECT 151

EA-SC-93-087-01
Attachment 2
Page 2 of 4

CALIBRATION STD. # PAL-410-004-01

0.018" I.D NOTCH x 0.370 LONG



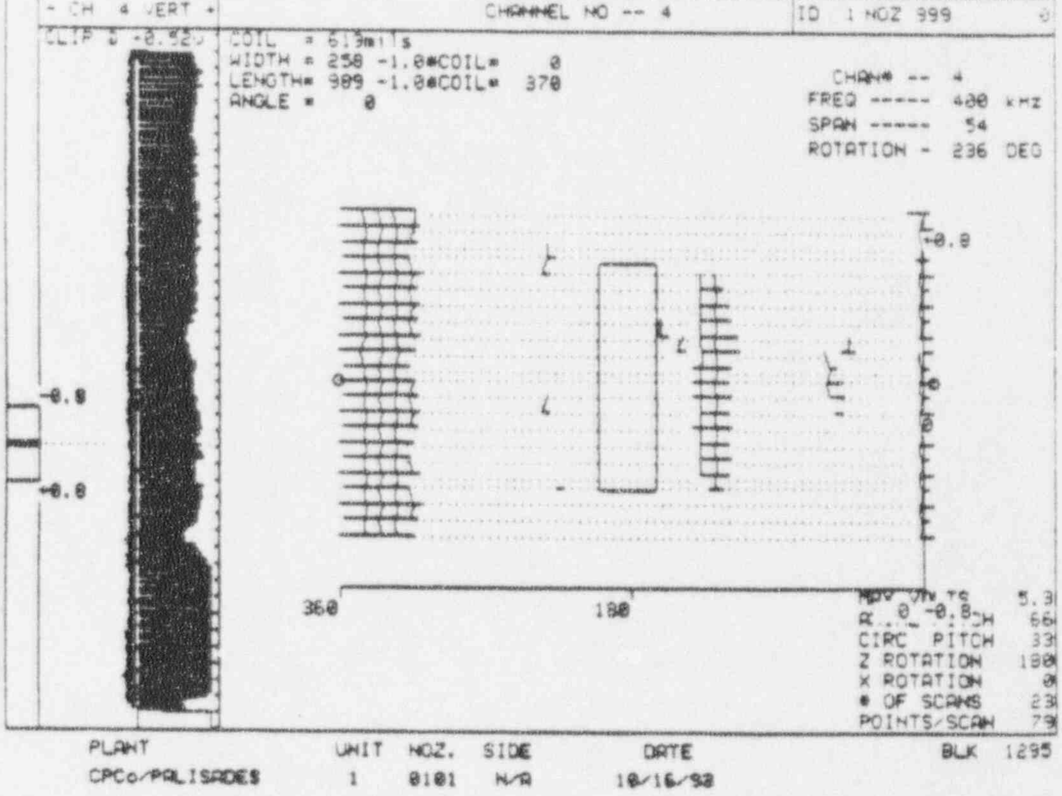
X1 DISPLAY
CHAN# -- 4
FREQ ----- 400 KHZ
SPAN ----- 54
ROTATION - 236 DEG

LEFT STRIP CHART
FREQ ----- 400 KHZ
SPAN ----- 54
ROTATION - 236 DEG

RIGHT STRIP CHART
CHAN# --
FREQ -----
SPAN -----
ROTATION -

SYSTEM CONFIGURATION
NAME -- 3COIL MRPC
# OF CHAN- 13

PLANT CPCo/PALISADES
UNIT 1
NOZ. 0101
SIDE N/A
DATE 10/16/93
BLK 1295



COIL = 619mils
WIDTH = 258 -1.0*COIL= 0
LENGTH= 989 -1.0*COIL= 370
ANGLE = 0

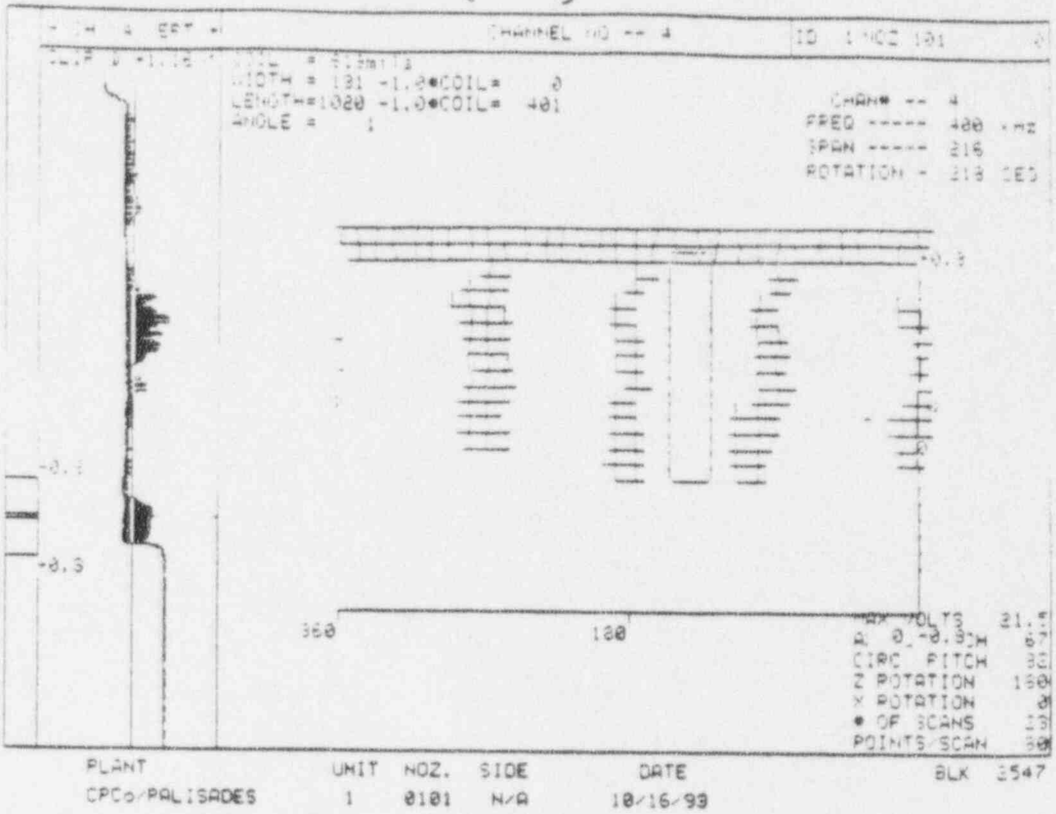
CHAN# -- 4
FREQ ----- 400 kHZ
SPAN ----- 54
ROTATION - 236 DEG

MDV UNITS 5.3
CIRC PITCH 33
Z ROTATION 180
X ROTATION 0
# OF SCANS 23
POINTS/SCAN 79

PLANT CPCo/PALISADES
UNIT 1
NOZ. 0101
SIDE N/A
DATE 10/16/93
BLK 1295

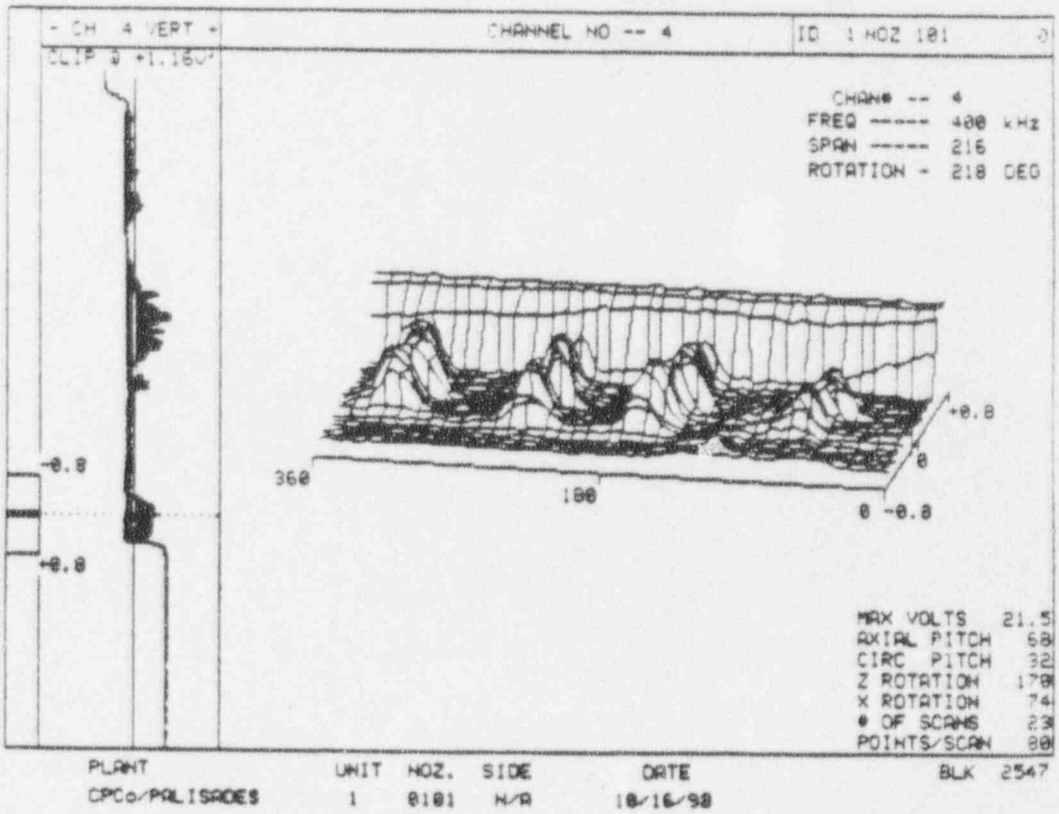
AXIAL CRACK INDICATIONS
(FOUR)

LONGEST
CRACK
~ .5"



```
- CH  4  VERT +            CHANNEL NO -- 4                ID  1 NOZ 101
CLIP @ +1.16V   [illegible]
                WIDTH = 131 -1.0*COIL=    0
                LENGTH=1020 -1.0*COIL=  401
                ANGLE =     1
                                                          CHAN# -- 4
                                                          FREQ ----- 400 kHz
                                                          SPAN ----- 216
                                                          ROTATION - 218 DEG

                                                          MAX VOLTS    21.5
                                                          A[illegible]CH  67
                                                          CIRC  PITCH    32
                                                          Z ROTATION    180
                                                          X ROTATION      0
                                                          # OF SCANS     23
                                                          POINTS/SCAN    80
PLANT                UNIT  NOZ.  SIDE      DATE                         BLK  2547
CPCo/PALISADES        1    0101   N/A     10/16/93
```



```
- CH  4 VERT +             CHANNEL NO -- 4                ID  1 NOZ 101
CLIP @ +1.16V
                                                          CHAN# -- 4
                                                          FREQ ----- 400 kHz
                                                          SPAN ----- 216
                                                          ROTATION - 218 DEG

                                                          MAX VOLTS    21.5
                                                          AXIAL PITCH    68
                                                          CIRC  PITCH    32
                                                          Z ROTATION    170
                                                          X ROTATION     74
                                                          # OF SCANS     23
                                                          POINTS/SCAN    80
PLANT                UNIT  NOZ.  SIDE      DATE                         BLK  2547
CPCo/PALISADES        1    0101   N/A     10/16/98
```

# EA-SC-93-087-01

# ATTACHMENT 3

# SMA Welding Specification

Proc No 10.41
Attachment 4
Revision 17
Page 1 of 2

# PROCEDURE TRAVELER

Procedure Title WELDING PROCESS SPECIFICATION (WPS): ABB/COMBUSTION ENGINEERING NUCLEAR SERVICES SHIELDED METAL ARC - MANUAL

Procedure No SMA-3.43 -937 Revision No 1 Date Initiated 10/19/93

Sponsor Chad Main Return to Initiator By 10/19/93

| Assigned Activity (✓) | Activity | Reviewer | Activity Person Hours | Activity Completed By (Print Name & Initial) |
|---|---|---|---|---|
| ✓ | ☑ Urgent Revision<br>☐ Urgent Editorial | | | Chad W Main CWM<br>Chad W Main 10/19/93 |
| N/A | Applicability Review<br>☐ Inactivate ☐ Retain-Revise ☐ Retain-No Revision ☐ Cancel<br>☐ Cancel - Replaced by: ________ ☐ Retain-Editorial | | | |
| ✓ | Draft Development<br>Start Date: / /<br>Completion Date: / / | | | |
| ✓ | Technical Review*<br>Comments: ☐ Yes ☒ No<br>Review Completed: 10 / 19 / 93<br>Comment Resolution: / / | Jerry Nordby | 1 | JCNordby, JCN |
| N/A | ALARA Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| N/A | Environmental Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| ✓ | User Review*<br>PQRs have been provided by CE for this procedure.<br>Comments: ☐ Yes ☒ No<br>Validation Performed: ☑ Yes ☐ No<br>Review Completed: 10 / 19 / 93<br>Comment Resolution: / / | Paul Reynolds | | Paul E Reynolds PER<br>Paul E Reynolds 10-19-93 |
| ✓ | PS&L Review*<br>Comments: ☐ Yes ☒ No<br>Safety Evaluation # 93-1227<br>Review Completed: 10 / 19 / 93<br>Comment Resolution: / / | Jeff Erickson<br>93-1227 | | Approved by telecon with Jeff Erickson 10/19/93<br>JSE 10/20/93 Chad W. Main 10/19/93 |
| ✓ | Sponsor Review<br>Review Completed: 10 / 19 / 93<br>Comment Resolution: / / | | | |
| ✓ | Manager Approval<br>Completed: 10 / 19 93 | JCNordby | | JCNordby 10/19/93 |
| N/A | Typing<br>In: / /<br>Out: / / | | | |
| ✓ | Sponsor Approval<br>Completed: 10 / 19 / 93 | | | Chad Main CWM |
| ✓ | DCC Control & Distribution<br>In: / /<br>Out: / / | | | |
| | ANII | K.L.BLAKE | | K.L.BLAKE KLB 10-20-93 |
| | | | | |
| | | | | |

Procedure No. SMA-3.43-937
Revision No. 1
Issued Date 10/19/93

# PALISADES NUCLEAR PLANT
# WELDING PROCEDURES

## TITLE:

WELDING PROCEDURE SPECIFICATION (WPS): ABB/COMBUSTION ENGINEERING NUCLEAR SERVICES

SHIELDED METAL ARC -- MANUAL

, 10/19/93
Procedure Sponsor Date

, 10/19/93
Technical Reviewer Date

Paul E. Reynolds , 10/19/93 , 1
User Reviewer Date Rev #

## PALISADES NUCLEAR PLANT
## SAFETY REVIEW

PS&L Log No 93-1227

| | SE Rev |
|---|---|
| Item Identification: No SMA-3.43-937 Rev 1 Title WELDING PROCESS SPECIFICATION (WPS): ABB/CE ENG. NUC. SVCS. SHIELDED METAL ARC - MANUAL<br>Describe Issue/Change: PRESSURIZER NOZZLE REPAIRS BY COMBUSTION ENGINEERING<br>Reason for Issue/Change: PROCEDURE REQUIREMENT BY ADMINISTRATIVE PROC. 5.06 | |

| | Yes | No |
|---|---|---|
| 1. Does the item involve a change to procedures as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 2. Does the item involve a change to the facility as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 3. Does the item involve a test or experiment not described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 4. Should the Technical Specifications or any of their Bases be changed in conjunction with this item?<br>TS Sections affected NONE<br>TS Sections reviewed 3.0, 4.0 | | X |

Justify No Answers below if logic is not obvious:

Although welding, post weld NDE testing and heat treating are discussed in the FSAR, the same processes that are discussed will be followed for this Vendor support.

Rev. 1 added clarification on the weld process that will be used for the Pressurizer (T-72) temperature element nozzles and thermowell(s).

If any Safety Review question listed above is answered "YES", perform a written USQ Evaluation according to Section 5.3.

If all Safety Review questions listed above are answered NO, written USQ Evaluation is not required. However, this Attachment shall accompany other review materials for the item to document that a Safety Evaluation was not required.

| | |
|---|---|
| 10/19/93<br>Prepared By Date | Approved by telecon with J. Erickson 10/19/93<br>SErickson 10/20/93<br>CWM 10/19/93<br>Reviewed By Date |

# WELDING PROCEDURE SPECIFICATION (WPS)
# ABB/COMBUSTION ENGINEERING
# NUCLEAR SERVICES

Page 1 of 5

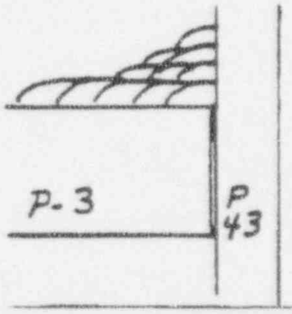
Company Name ABB Combustion Engineering By:
WPS SMA-3.43-937 Date 10/15/93 Support. PQR(s) SMA-3.43-01188
SMA-12.43-105
Rev. No. 1 Date 10/18/93 Weld Process(es) Shielded Metal Arc Type(s) Manual
(Automatic, Manual, Machine, or Semi-Auto.)
By:

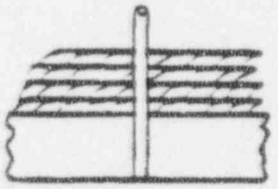
**JOINTS (QW-402)**

Joint Design Buildups and Fillets/Half Bead Technique
Backing (Yes) X No
Backing Material (Type) P-3 Base Material No Retainers
(Refer to both backing and retainers)

_ Metal _ Nonfusing Metal

_ Nonmetallic _ Other





The 1st two layers are temper bead and need not fuse into nozzle. Subsequent layers shall fuse into nozzles.

***BASE METALS (QW-403)**

P-No. 3 Group No. 3 to P-No. 43 Group No. N/C
OR
Specification Type and grade SB-166 or SB-168 Inco 600
to Specification type and grade SA533 - Grade 'B' - Class 1
OR
Chem. Analysis and Mech. Prop. Not Applicable
to Chem. Analysis and Mech. Prop. Not Applicable
Thickness Range:
Base Metal: Groove 3/16" minimum Fillet Unlimited
Pipe Dia. Range: Groove Unlimited Fillet Unlimited
Other

***FILLER METALS (QW-404)**

Spec No. (SFA) 5.11 Coated Electrodes - See Electrode Control, 3-(c)
AWS No. (Class) A5.11 ENiCrFe-3
F-No. 43 Consumable Insert None
A-No. N/C
Size of Filler Metals 3/32" and 1/8" diameters
Deposited Weld Metals Inconel - 182
Thickness Range: No single pass shall exceed 1/2" thickness
Groove Not Applicable
Fillet Unlimited
Electrode-Flux (Class) None
Flux Trade Name None
Other

***Each base metal filler metal combination should be recorded**
Independent Reviewer Date 10-18-93

# WELDING PROCEDURE SPECIFICATION (WPS)
# ABB/COMBUSTION ENGINEERING
# NUCLEAR SERVICES

WPS NO. SMA-3.43-937 Rev. 1

**POSITIONS (QW-405)**
Position(s) of Weld: All
Weld Progression: Up X Down ___
Position(s) of Fillet: None

**PREHEAT (QW-406)**
Preheat Temp. Min. 350 deg. F
Interpass Temp. Max. 450 deg. F
Preheat Maintenance: Yes
(Continuous or special heating, if applicable.) See page 4, 3(h).

**POSTWELD HEAT TREATMENT (QW-407)**
Temperature Range 500 ± 50 deg. F
Time Range 4 hours minimum
Air cool to ambient temperature

**GAS (QW-408)**

| | Percent Composition Gas(es) | (Mixtr) | Flow Rt |
|---|---|---|---|
| Shield. | None | | |
| Trail. | None | | |
| Back. | None | | |

**ELECTRICAL CHARACTERISTICS (QW-409)**
Current AC or DC: DC Polarity: RP Pulsed: No
Amps (Range): See Below Volts (Range): See Below
(Amps and volts range should be recorded for each electrode size, position, and thickness, etc.

Tungsten Electrode Size and Type: Not Applicable
(Pure Tungsten, 2% Thoriated, etc.)
Mode of Metal Transfer for GMAW: Not Applicable
(Spray arc, short circuiting arc, etc.)
Electrode Wire Feed Speed Range: Manually controlled for SMA process

**TECHNIQUE (QW-410)**
String or Weave Bead: Stringer or Weave to 3X core diameter
Orifice or Gas Cup Size: Not Applicable
Cleaning Initial: Grinder or Wire Brush Interpass: Same
Method of Back Gouging: None
Oscillation: Not to exceed 3X core diameter
Contact Tube to Work Distance: Not Applicable
Multiple or Single Pass (per side): Multiple
Multiple or Single Electrodes: Single
Travel Speed (Range): Manually Controlled
Peening: Not Allowed
| Other: * - Minimum bead length per unit inch of electrode

| Bead No.(s) | Process | Filler Metal | | Current | | Volt Range | *Min. Bead Length | Other Remarks, Comments |
|---|---|---|---|---|---|---|---|---|
| | | Class | Dia. | Type Polar. | Amp. Range | | | |
| All | SMA | SFA5.11 | 3/32 | DCRP | 55-65 | 22-23 | .42" | |
| | | | 1/8 | DCRP | 75-90 | 23-24 | .37" | |

## WELDING PROCEDURE SPECIFICATION

DWPS SMA-3.43-937

Date 10/15/93

Page 3 of 5

Rev. 1 Date 10/18/93

SPECIAL INSTRUCTIONS:

1. This procedure allows for use on a limited basis as defined below. The repair may be accomplished on P-3 materials made without PWHT or after the final PWHT.

2. Prior to repair, the area shall be examined by magnetic particle or liquid penetrant methods in accordance with the acceptance standards on the specific code edition. This shall be defined by Quality Assurance. Each layer of deposit shall be visually inspected for uniformity prior to depositing subsequent layer.

3. All welding shall be in accordance with ASME Section XI and IX and shall include the requirements listed below:

    (a) The repair area shall be suitably prepared for welding in accordance with the written procedure.

    (b) The weld metal shall be deposited by the manual shielded metal arc process using low hydrogen type electrode. The maximum bead width shall be three times the electrode core diameter.

    (c) All covered electrodes shall be from unopened hermetically sealed packages or heated ovens maintained between 225° F and 350° F. Electrodes exposed to the atmosphere for more than twenty minutes shall be re-heated at a temperature between 225° F and 350° F for at least eight (8) hours before re-issued for use. Electrodes exposed to the atmosphere for longer than 4 hours shall be discarded.

    (d) The weld area shall be preheated to a minimum of 350° F and maintained at that temperature for a minimum of 30 minutes prior to any welding. The width of the band to be preheated shall be 10 inches and shall be maintained at a minimum of 350° F during welding. The minimum preheat, and subsequent heat treat temperature requirements shall be monitored by use of thermocouples and recording equipment. Thermocouples may be attached by welding or mechanical methods.

## WELDING PROCEDURE SPECIFICATION

DWPS SMA-3.43-937

Date 10/15/93

Page 4 of 5

Rev. 1 Date 10/18/93

(e) The initial layer of weld metal shall be deposited over the entire area with 3/32" diameter electrode. The weld bead crown surface shall be removed by grinding or machining before depositing subsequent layers. The second layer shall be deposited over the entire area as before with 1/8" diameter electrodes.

Subsequent layers shall be deposited with 1/8" diameter electrode in a manner to ensure tempering of the prior beads and their heat affect zones. All subsequent layers shall be at least 1/8" from the outer most edge of the ground first layer.

(f) Examination of Repair Weld (See Below)

The completed weld (groove welds only) shall have the reinforcement of a groove weld including the final layer removed substantially flush with the surface prior to performing the required nondestructive examinations, (PT). The final PT shall be performed after the completed weld has been at ambient temperature for a minimum period of 48 hours to determine the presence of possible delayed cracking. See (j) below.

(g) Heat input shall be controlled within the specified bead length per unit length of electrode, as given on page 2.

(h) The weld area shall be maintained at a temperature of 450-550° F for a minimum of four hours after completion of the weld repair.

(i) The performance of the repair weld and all in process operations shall be witnessed by the authorized inspector if indicated on the traveler by the inspector.

(j) Postheat operations in (h) above may be performed after the second layer or 1/4" minimum thickness has been deposited.

# WELDING PROCEDURE SPECIFICATION

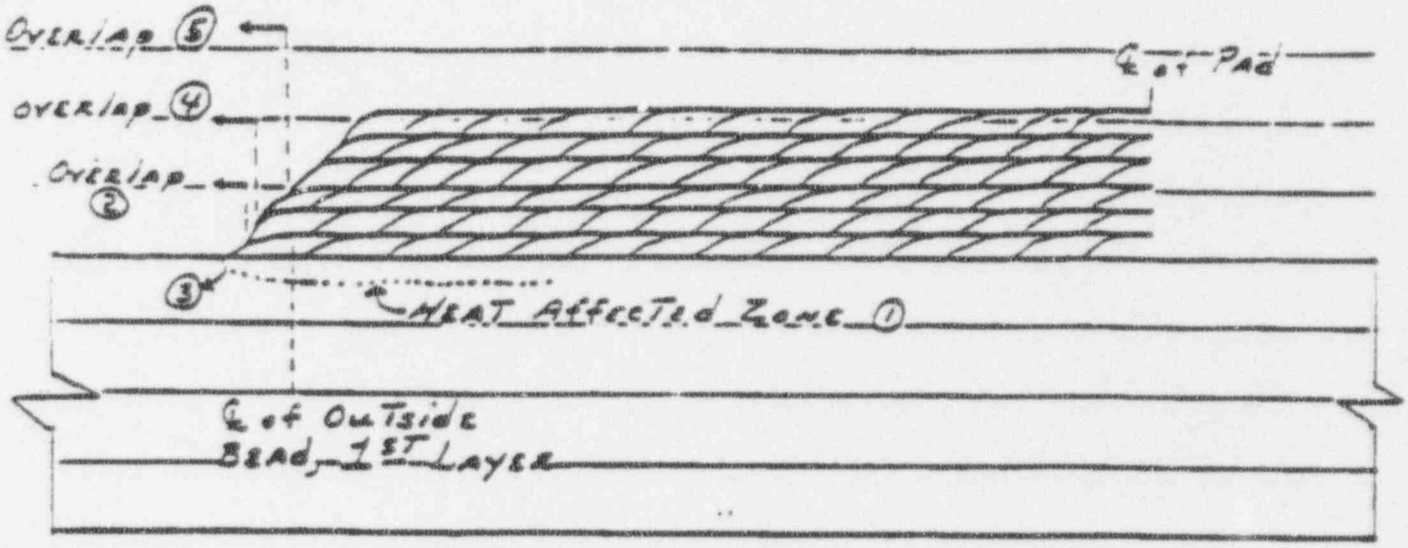
DWPS SMA-3.43-937

Date 10/15/93

Page 5 of 5

Rev. 1 Date 10/18/93

## "TEMPER BEAD TECHNIQUE & AFFECTS OF APPLICATION"



1. Heat affect zone created by 1st layer of deposit.

2. 75-80% overlap desired to achieve good tempering of 1st layer bead, and HAZ. outside bead of 2nd layer must not touch base material. Second layer deposit tempers the 1st layer, and large portion of HAZ, which causes refining and softening of grain structure within the HAZ.

3. Hardened area of outside bead of 1st layer. If outside bead of 2nd layer is allowed to touch base material, then this hardened area is moved further out, and refinement does not happen.

4. Overlap of layer 2 by layer 3 to be approximately the same as before, and thereby enhance the tempering affects on layer #1 and the HAZ.

5. Subsequent layers may be deposited as desired to enhance outer edge configuration and reduce grinding time (ALARA). Most of tempering affect has already occurred during layers 2&3, and any additional tempering will take place from the preheat and interpass. Complete capping of beads to achieve a straight upside will encourage bead rollover and require more grinding time.

# WELDING PROCEDURE QUALIFICATION RECORD

E-563 (4/80)

## COMBUSTION ENGINEERING, INC.

DATE 12-13-89

Editorial Correction(s) - 3/5/93, 10/15/93

MATERIAL SPEC. & GRADE SA533-Gr 'B' - Cl '1'

FOR WELDING P No 3 TO F No 43

WELDING PROCESS Shielded Metal Arc Half Bead Technique

FILLER METAL F No 43 Inconel A No N/C

SPEC. or ANALYSIS SFA5.11 ENiCrFe-3

ELECTRODE SIZE 3/32" and 1/8" diameters

FLUX N/A

SHIELDING GAS(ES) & COMPOSITION N/A

FLOW RATE N/A

TYPE CURRENT DCRP

PROCEDURE QUALIFICATION NO. SMA-3-43-01188

QUALIFIED TO CODE SECTION(S) III, IX & XI

TO ENiCrFe-3 Deposit

BACKING REQUIREMENTS Base Material is Backing

THICKNESS (& DIA. IF PIPE) 3.5" thick plate

TYPE WELD JOINT U Groove, 2" deep groove

POSITION TEST WELD Vertical ( 3-G

SINGLE or MULTIPLE PASS Multiple

NO. OF LAYERS (IF CLAD) N/A

NO. OF ARCS One

PREHEAT 350° F min.-soak 30 mins. before welding

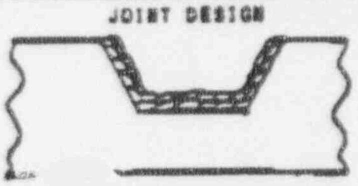
MAX. INTER PASS 450°F

MAINTAIN PREHEAT UNTIL PWHT Yes

POSTHEAT TREATMENT 500° F ± 50° F for 4 hrs. min. post-heat performed after 2 layers of butter deposited for 1/4" min. thickness

OTHER: Max. weave width - 3x core dia. test block at ambient temp. for 48 hours prior to final P.T. *No single pass deposit thickness exceeded 1/2"
**Bead Length/Inch Electrode

JOINT DESIGN



| BEAD NO. | PROCESS | WIRE DIA. | AMPHERES | ARC VOLTS | BEAD LENGTH |
|---|---|---|---|---|---|
| Layer #1 | SMA | 3/32" dia. | 55-65 | 22-23 | .62*** |
| Layer #2 | SMA | 1/8" dia. | 70-90 | 23-26 | .37*** |
| Balance | SMA | 1/8" dia. | 70-90 | 23-26 | .37*** |
| | | | | | |

% FERRITE IN AUSTENITIC CLAD DEPOSIT

DEPOSIT ANALYSIS C .051 Mn 7.73 P .006 S .010 Si .46

CR 13.57 Ni 67.3 Mo <.01 Co .03 N2 .016 Other Cu - .02

Fe - 8.53 Al - <.01 Ti - .48 CB+TA - 1.74 + .02

GUIDED BEND TESTS

FACE:

ROOT:

SIDE: 4 O.K. - John Arnold

MACRO:

CHARPY V-NOTCH IMPACT TESTS

| LOCATION | TEMP | FT/LBS | MILS LAT EXP |
|---|---|---|---|
| See Page 2 | | | |
| | | | |
| | | | |
| | | | |

DROP-WEIGHT TESTS

| TEMP | RESULTS |
|---|---|
| -40 | 1F |
| -30 | 1F |
| -20 | 2NF |
| | |
| NDT | -30°F |

NON.-DESTRUCTIVE TESTS

| | |
|---|---|
| P.T. | O.K - Tate/C.Carlton<br>each 1/4" deposit |
| U.T. | |
| M.T. | Prep O.K. - C. Carlton |
| VISUAL | O.K. - W. Gwaltney |

TENSILE TESTS @ Room Temperature

| SPEC. NO. | DIMENSIONS | | AREA SQ. IN. | ULTIMATE LOAD-LBS | ULTIMATE STRESS-PSI | CHARACTER AND LOCATION OF FAILU |
|---|---|---|---|---|---|---|
| | WIDTH | THK. | | | | |
| XS-1 | .751 | 1.813 | 1.3616 | 128,500 | 94,400 | Base Metal |
| XS-2 | .757 | 1.798 | 1.3611 | 128,750 | 94,600 | Base Metal |
| | | | | | | |
| All Weld Metal on Page 2 | | | | | | |

Other Liquid penetrant inspected after each 1/4" of deposit

Final Surface P.T. - O.K. W. Worley

WELDER See Below SYMBOL YX

DEPT CCS-9448

TEST NO 01188

TEST LAB. Met Lab

T.E. Bowman - AXZ
G.L. Burton - ASX
T.L. Bellew - AOJ
E.L. Keith - BUJ

We certify that the statements in this record are correct and that the test welds are prepared, welded and tested in accordance with requirements of the ASME Code.

COMBUSTION ENGINEERING, INC.

BY: W.V. Gwaltney

BY OTHER H.R. Zumbro TITLE

COMBUSTION ENGINEERING

POWER SYSTEMS GROUP
FIELD CONSTRUCTION

WELDING PROCEDURE SPECIFICATION

CWPS SMA-3.43-Q1138
Date 12/13/89
Page 2 of 3
Rev. 0 Date

<u>Hardness - Rockwell 'C'</u>

<u>Top</u>

HAZ = 21,22,21 R'C

<u>Bottom of Groove</u>

HAZ = 25,23,24 R'C

<u>All Weld Metal Tensile</u>

| | |
|---|---|
| Thickness | = .502 |
| Area | = .19792 |
| Yield KSI | = 67.2 |
| Yield Lbs. | = 13,300 |
| Tensile KSI | = 99.8 |
| Tensile Lbs. | = 19,750 |
| Elong. '2' Inches | = 2.71 |
| Elongation % | = 35.5 |
| Reduct. Area Dia. | = .392 |
| " " 180° | = .429 |
| Reduction % | = 33.3 |

<u>CVN's Base Metal</u>

| Sample # | Test Temp. | FT/Lbs Energy | % Shear | Mils Lat. Ex |
|---|---|---|---|---|
| XS-TA | +30 | 113 | 50 | 78 |
| XS-TB | +30 | 96 | 40 | 70 |
| XS-TC | +30 | 90 | 30 | 64 |

<u>CVN's HAZ</u>: (Bottom of Weld)

| Sample # | Test Temp. | FT/Lbs Energy | % Shear | Mils Lat. Ex |
|---|---|---|---|---|
| XS-ZD | +30 | 88 | 80 | 73 |
| XS-ZE | +30 | 89 | 90 | 78 |
| XS-ZF | +30 | 88 | 90 | 74 |

Test block received Q&T, plus forty (40) hrs. @ 1100-1200°F heat treatment prior to welding. Block dimensions were 3.5" thick, x 18" wide , x 31" long.

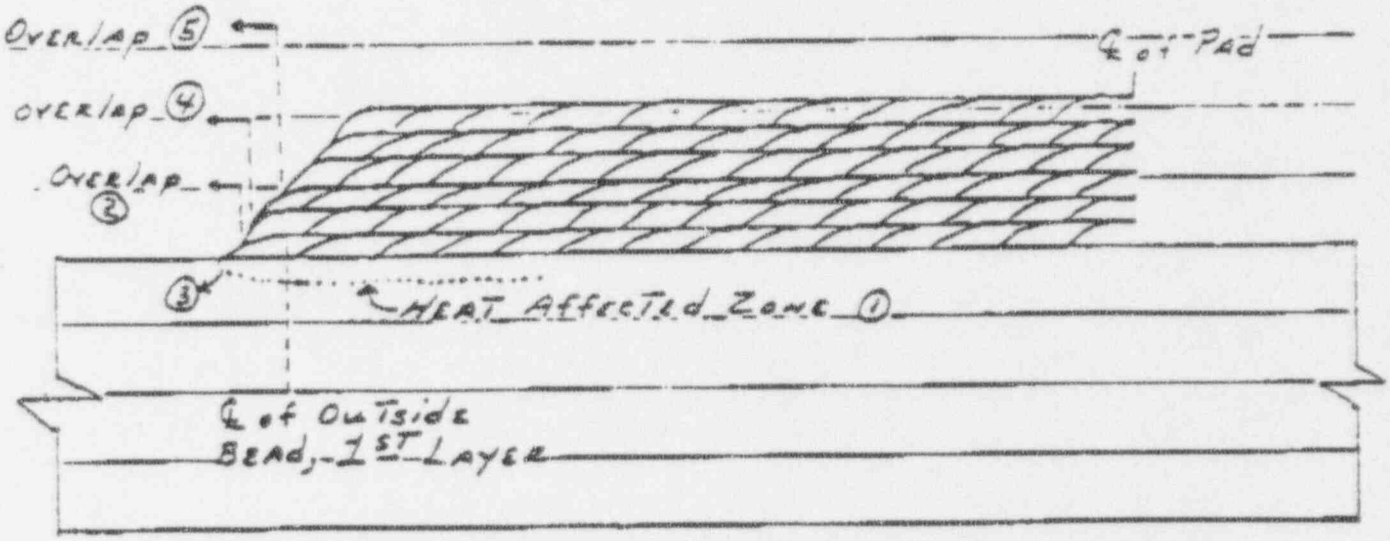
**COMBUSTION ENGINEERING**

POWER SYSTEMS GROUP
FIELD CONSTRUCTION

WELDING PROCEDURE SPECIFICATION

DWPS SMA-3.43-Q1188
Date 12/13/89
Page 3 of 3
Rev 0 Date

"TEMPER BEAD TECHNIQUE & AFFECTS OF APPLICATION"



1. Heat affect zone created by 1st layer of deposit.

2. 75-80% overlap desired to achieve good tempering of 1st layer bead, and HAZ. outside bead of 2nd layer must not touch base material. Second layer deposit tempers the 1st layer, and large portion of HAZ, which causes refining and softening of grain structure within the HAZ.

3. Hardened area of outside bead of 1st layer. If outside bead of 2nd layer is allowed to touch base material, then this hardened area is moved further out, and refinement does not happen.

4. Overlap of layer 2 by layer 3 to be approximately the same as before, and thereby enhance the tempering affects on layer #1 and the HAZ.

5. Layers 4, 5, & 6 may be deposited as desired to enhance outer edge configuration and reduce grinding time (ALARA). Most of tempering affect has already occurred during layers 2&3, and any additional tempering will take place from the preheat and interpass. Complete capping of beads to achieve a straight upside will encourage bead rollover and require more grinding time.

E-363 (1/74)

# WELDING PROCEDURE QUALIFICATION RECORD

COMBUSTION ENGINEERING, INC.

DATE December 10, 1974
torial correction October 15, 1993*

PROCEDURE QUALIFICATION NO. SMA-12.43-105
QUALIFIED TO CODE SECTION(S) III

MATERIAL SPEC. & GRADE SA-533 Gr. B Cl. 1 Q&T TO SB-168

FOR WELDING P No 12 TO P No 43

THICKNESS (& DIA. IF PIPE) 2 1/2"

WELDING PROCESS Shielded Metal Arc

TYPE WELD JOINT Single "V"

FILLER METAL F No 43 A No -

POSITION TEST WELD Horizontal (2 G)

SPEC or ANALYSIS SFA-5.11 ENiCrFe-3 (182)

SINGLE or MULTIPLE PASS Multiple

ELECTRODE SIZE 1/8", 5/32"

NO. OF LAYERS (IF CLAD) N/A

FLUX N/A

NO. OF ARCS Single

SHIELDING GAS(ES) & COMPOSITION N/A

PREHEAT 60°F Minimum

FLOW RATE N/A

MAX. INTER-PASS 350°F

TYPE CURRENT DC-RP

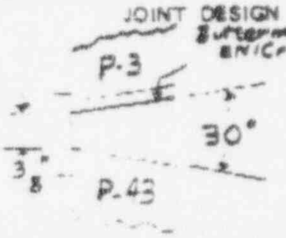
MAINTAIN PREHEAT UNTIL PWHT N/R

BACKING REQUIREMENTS Strip Removed

POSTHEAT TREATMENT Buttering 1150°F + 50°F For 30 Hrs. Furnace Cool to 600°F (Completed Joint as Welded)

* OTHER ~~No single pass thickness exceeded 1/2"~~
P-3 and P-12 are same per prev. ASME Code.

JOINT DESIGN



| BEAD NO. | PROCESS | WIRE DIA. | AMPERES | ARC VOLTS | INCHES/MIN. |
|---|---|---|---|---|---|
| | SMA | 1/8" | 90 | 24 | |
| | SMA | 5/32" | 125 | 24 | |

% FERRITE IN AUSTENITIC CLAD DEPOSIT

DEPOSIT ANALYSIS C ___ Mn ___ P ___ S ___ Si ___
Cr ___ Ni ___ Mo ___ Co ___ N2 ___ Other ___

GUIDED BEND TESTS

FACE
ROOT
SIDE 4 Acceptable

MACRO:

CHARPY V-NOTCH IMPACT TESTS

| LOCATION | TEMP | FT/LBS | MILS LAT EXP |
|---|---|---|---|
| 1/4T HAZ | +10°F | 101,108,124 | |
| P-3 Side | | | |

DROP-WEIGHT TESTS

| TEMP | RESULTS |
|---|---|
| | |

NDT °F

NON-DESTRUCTIVE TESTS

| | |
|---|---|
| LIQUID PENETRANT | Acceptable |
| RADIOGRAPHIC | Acceptable |
| ULTRASONIC | |
| MAG. PARTICLE | |
| VISUAL | |

TENSILE TESTS

| TYPE SPECIMEN | ULTIMATE STRESS—PSI | CHARACTER & LOCATION OF FAILURE |
|---|---|---|
| Trans. | 95,300 | Ductile in Weld |
| Trans. | 93,300 | Ductile in Weld |

WELDER W. C. Jones SYMBOL BBE

DEPT Chattanooga, Tennessee

TEST NO E-7059-D

TEST LAB. Met R&D Dept.

We certify that the statements in this record are correct, and that the test welds were prepared, welded and tested in accordance with requirements of the ASME Code.

COMBUSTION ENGINEERING, INC.

BY: B. B. Yutte

BY OTHERS N. Dimiraddi TITLE Eng Supv

MA-3.43-29

# EA-SC-93-087-01

# ATTACHMENT 4

# Corrosion Letter

October 15, 1993
MCC-93-525

Mr. Paul Gire
Consumers Power Company
Palisades Nuclear Plant
27790 Blue Star Memorial Highway
Covert, MI   47043

Subject:    Corrosion of Palisades Pressurizer Material

Dear Mr. Gire:

Attached for your use/review is a draft evaluation of the corrosion of primary pressure boundary materials exposed to borated water. Admittedly, the data are limited, but the results indicate there will be only minor corrosion over the next fuel cycle at the repaired nozzle locations. These data have been previously used to assess corrosion at Arkansas-2, Palo Verde-1, etc. using a similar approach as described in the report.

Contact me if you need additional information.

Sincerely,

J F Hall

J. F. Hall
Supervisor, Corrosion Technology

JFH/b
cc: S. W. Lurie
K. Coe
R. Taylor
J. Amburn
T. Magee

ABB Combustion Engineering Nuclear Power

Combustion Engineering, Inc    1000 Prospect Hill Road    Telephone (203) 688-1911

# CORROSION OF PRIMARY PRESSURE BOUNDARY MATERIALS AT PALISADES

## 1.0 INTRODUCTION

There are several Alloy 600 pressure boundary penetrations at the Palisades nuclear plant. Typical applications include pressurizer heater sleeves, pressurizer temperature nozzles, hot and cold leg piping instrument/RTD nozzles, reactor vessel (RV) leakage monitoring tubes, RV vent pipe and RV instrumentation. All of these nozzles are welded to the primary system components by J-groove partial penetration welds. In recent years, a number of these Alloy 600 penetrations in several ABB-CE plants have developed leaks as a result of ID initiated stress corrosion cracks. During the 1993 refueling outage at Palisades, the pressurizer upper head and lower shell temperature instrumentation nozzles developed leaks. Consumers Power Company elected to apply temporary leak repairs to return the plant to service.

The temporary leak repairs at Palisades will result in non-clad pressurizer shell material being exposed to borated water or steam. The pressurizer shell is SA-533 Grade B Class 1 steel, a low alloy grade. Low alloy and carbon steels used as pressure boundary materials are clad with stainless steel or Alloy 600 weld metal to isolate the materials from the primary coolant, thereby minimizing corrosion and corrosion product generation. The objective of this evaluation was to determine and document the expected corrosion for SA-533 Grade B steel. The results will also be applicable to other grades such as SA-508 Class 2 low alloy steel and SA-106 Grade B carbon steel used for primary system piping.

## 2.0 LITERATURE DATA

Reference (1) presents the only published literature data that are applicable to Palisades. During the 1965 refueling outage at Yankee Rowe, inspections discovered two small areas where the reactor vessel cladding had been breached.

The cladding defects wee mechanically produced after a surveillance capsule became loose and dumped mechanical test specimens and other debris into the lower head of the reactor vessel. The lower head base metal was A302B steel which had been clad with Type 304 stainless steel plate using an intermittent spot welding technique. This fabrication process resulted in large areas of the cladding-base metal interface being unbonded. Thus, the breach in the cladding exposed large areas of the underlying base metal to the reactor coolant.

Because of concern about corrosion and hydrogen embrittlement, the reactor vendor initiated a test program to determine corrosion rates for A302B steel under operating and shutdown conditions and to determine if hydrogen absorption was a concern. In this program, specimens of A302B were exposed to aerated and derated solutions of boric acid (2000-2500 ppm B) at temperatures ranging from 70°F to 500°F. The specimens included both electrically insulated coupons of A302B and coupons electrically grounded to Type 304 stainless steel to assess galvanic effects. Most of the testing was at low temperatures (70° to 140°F) in 2500 ppm B aerated and derated solutions for up to 121 days. For these conditions, the test program well characterized the corrosion rates of A302B. The reactor vendor also conducted a few short term (6-14 days) tests at 300-500°F in derated solutions containing 2000 ppm B.

The results of the study showed that hydrogen absorption was not a concern and that the exposed A302B steel would corrode uniformly at a rate of about 3 mpy (mils per year) which was sufficiently low to be of no concern over the remaining 25 year lifetime of the plant.

C-E re-examined the Reference (1) data in developing estimated corrosion rates applicable to the Palisades pressurizer applications in which the steels will be exposed to 640°F steam (low B levels) and water.

## 3.0 CORROSION RATE FOR PRESSURIZER MATERIAL

### 3.1 Assumptions

C-E used three basic assumptions in developing a corrosion rate applicable to Palisades. They were as follows:

1. The corrosion of SA-533 Grade B Class 1 steel in boric acid solutions is equivalent to that of A302B. Both grades are low alloy steels but there are minor compositional differences, with the most significant being higher Ni in the SA-533 Grade B Class 1 material. The presence of Ni will not adversely affect corrosion. Similarly, there are only minor differences between A302B and SA-508 Class 2 or 3 and SA-106 Grade B and these differences will not significantly affect corrosion rates.

2. During the upcoming cycle, Palisades will operate 80 percent of the time.

3. While operating, the coolant will be derated. While shut down, the coolant will be aerated.

### 3.2 Rates for High Temperature Operation

Palisades primary coolant temperature during operation is approximately 640°F for the pressurizer. The maximum test temperature included in the Reference (1) program was 500°F. Data were obtained for six specimens of A302B after only one week of testing in a refreshed autoclave with a 2000 ppm B solution. For these specimens, the average corrosion rate was 0.6 mpy. For the specimen with the greatest observed weight loss, the corrosion rate was 1.0 mpy.

These values for corrosion rates, which are based on short term tests, are probably higher than would have been obtained had test times been significantly longer. Carbon and low alloy steels usually follow a logarithmic or parabolic corrosion rate law. The time required to reach a steady-state condition may exceed 100 days. Rates during the initial transient stage (which includes seven days) will be high compared to the steady-state corrosion rates.

There are no corrosion rate data for low alloy steels in borated water at temperatures above 500°F. However, the Reference (1) program did include tests at 300°F and 400°F in derated borated water. These tests showed decreasing corrosion rates with increasing temperature. Based on this, C-E judge that the (steady state) corrosion rate at 640°F will not be significantly greater than the rate at 500°F.

In addition, the available data are from tests with B levels of 2000 ppm, significantly greater than expected at Palisades during the current fuel cycle, and, thus, they are conservative with respect to actual conditions. This is especially true for the steam spare nozzle location since boric acid has limited volatility.

## 3.3 Rates for Low Temperature Conditions

During any unscheduled outage, the material may be exposed to low temperature aerated borated water. Reference (1) presented data for tests at 70, 100 and 140°F in aerated water with 2500 ppm B. For this analysis, 100°F was assumed to be of coolant temperatures during cold shutdown. The tests continued for 121 days with several interim weight loss determinations which showed that steady state rates had been obtained. For the Reference (1) tests, the average corrosion rate for 100°F was 7.0 mpy with an upper bound of the data indicating a worst case corrosion rate of 7.9 mpy.

The non-clad pressurizer or material will be coupled to the stainless steel clad or Alloy 600 nozzles in the pressurizer. The use of dissimilar metals will cause some concern about galvanic effects. In the Reference (1) tests, the A302B specimens were both insulated from and connected to Type 304 stainless steel, which chemically is similar to the stainless steel used for cladding of the primary system. No difference in corrosion rates for the two types of specimens were observed and thus galvanic corrosion should not be a problem.

The limited corrosion that will occur will not be a localized form of corrosion (deep pitting, stress corrosion cracking, etc.). C-E experience in aerated borated water indicates that the corrosion morphology will consist of the superposition of shallow pits with no deep penetrations. Reference (1) also indicated that corrosion would be uniform with no localized forms of corrosion being observed.

### 3.5 Overall Corrosion Rates

Based on a split of 80 percent hot operations and 20 percent cold shutdown, corrosion rates for the pressurizer material at Palisades were determined as follows using the rates described above:

"Worst case" corrosion rate - 1.0 mpy x 0.8 +
7.9 mpy yr. x 0.2 = 2.4 mils/year

### 3.6 Additional Considerations

The corrosion rate cited above is most applicable to situations where the material is exposed to water environments. In areas of steam, the cited rate will be conservative because of reduced boric acid levels.

## 4.0 RECOMMENDATION

For analysis purposes, ABB-CE recommends a corrosion rate of 3 mils/year for the Palisades pressure boundary material.

## 5.0 REFERENCE

1. "Absorption of Corrosion Hydrogen by A302B Steel at 70°F to 500°F," WCAP-7099, December 1, 1967.

# EA-SC-93-087-01

# ATTACHMENT 5

# Traveler 2003067-001

# PROCEDURE TRAVELER

Procedure Title ABB/Combustion Engineering Nuclear Services Traveler No. 2003067-001 Weld Repair/Modification Of Pressurizer Nozzle(s)

Procedure No 2003067-001 Revision No 2 Date Initiated 10/19/93

Sponsor Chad Main Return to Initiator By 10/19/93

| Assigned Activity (✓) | Activity | Reviewer | Activity Person Hours | Activity Completed By Print Name & Initial |
|---|---|---|---|---|
| ✓ | ☒ Urgent Revision<br>☐ Urgent Editorial | | .5 | Chad Main<br>Chad W. Main /19/93 |
| N/A | Applicability Review<br>☐ Inactivate ☐ Retain-Revise ☐ Retain-No Revision ☐ Cancel<br>☐ Cancel - Replaced by: ______ ☐ Retain-Editorial | | | |
| ✓ | Draft Development<br>Start Date: / /<br>Completion Date: 10/19/93 | | .1 | |
| ✓ | Technical Review*<br>Comments: ☒ Yes ☐ No<br>Review Completed: 10/19/93<br>Comment Resolution: 10/19/93 | Jerry Nordby | .25 | JC Nordby, JCN |
| N/A | ALARA Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | Information Copy Provided to ALARA | | |
| N/A | Environmental Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| ✓ | User Review*<br>Comments: ☐ Yes ☒ No<br>Validation Performed: ☐ Yes ☒ No<br>Review Completed: 10/19/93<br>Comment Resolution: / / | LJ Ross | | Approved by telecon with RB Kasper 10/19/93 Chad W. Main 10/19/93 |
| ✓ | PS&L Review*<br>Comments: ☐ Yes ☒ No<br>Safety Evaluation # 93-1226<br>Review Completed: 10/19/93<br>Comment Resolution: / / | Jeff Erickson<br>93-1226 | | Approved by telecon with Jeff Erickson 10/19/93<br>KSC 10/20/93 Chad W. Main 10/19/93 |
| ✓ | Sponsor Review<br>Review Completed: 10/19/93<br>Comment Resolution: / / | | | |
| ✓ | Manager Approval<br>Completed: 10/19/93 | RB Kasper | | Approved by telecon with RB Kasper 10/19/93 |
| N/A | Typing<br>In: / /<br>Out: / / | | | Chad W. Main 10/19/93 |
| ✓ | Sponsor Approval<br>Completed: 10/19/93 | | | Chad Main<br>Chad W. Main CWM 10/19/93 |
| ✓ | DCC Control & Distribution<br>In: / /<br>Out: / / | | | |
| | A.N.I.I. | K.L. Blake | | K.L. Blake KLB 10-20-93 |
| | | | | |

EA-SC-93-087-01
Attachment 5
Page 2 of 18

## PALISADES NUCLEAR PLANT
## SAFETY REVIEW

Proc No 3.07
Attachment 1
Revision 7
Page 1 of 1

PS&L Log No 93-1226

Item Identification: No 2003067-001 Rev 2 Title ABB/CE NUCLEAR SERVICES TRAVELER: WELD REPAIR/MODIFICATION OF PRESSURIZER NOZZLE(S)

SE Rev

Describe Issue/Change: PRESSURIZER NOZZLE REPAIRS BY COMBUSTION ENGINEERING

Reason for Issue/Change: PROCEDURE REQUIREMENT BY ADMINISTRATIVE PROC. 10.41

1. Does the item involve a change to procedures as described in the FSAR? Yes [✓ No]
   FSAR Sections affected NONE
   FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22

2. Does the item involve a change to the facility as described in the FSAR? Yes [✓ No]
   FSAR Sections affected NONE
   FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22

3. Does the item involve a test or experiment not described in the FSAR? Yes [✓ No]
   FSAR Sections affected NONE
   FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22

4. Should the Technical Specifications or any of their Bases be changed in conjunction with this item? Yes [✓ No]
   TS Sections affected NONE
   TS Sections reviewed 3.0, 4.0

Justify No Answers below if logic is not obvious:

Although welding, post weld NDE testing and heat treating are discussed in the FSAR, the same processes that are discussed will be followed for this Vendor support.

This traveler and the Palisades Work Order will control the work performed on the Pressurizer (T-72) temperature element nozzles and thermowell(s).

Rev. 2 changed drawing number and weld procedure revisions and added editorial clarification to several steps.

If any Safety Review question listed above is answered "YES", perform a written USQ Evaluation according to Section 5.3.

If all Safety Review questions listed above are answered NO, written USQ Evaluation is not required. However, this Attachment shall accompany other review materials for the item to document that a Safety Evaluation was not required.

Approved by telecon with J. Erickson 10/19/93

, 10/19/93
Prepared By Date

, 10/20/93
Reviewed By Date

wll
10/19/93

Procedure No. 2003067-001
Revision No. 2
Issued Date 10/19/93

# PALISADES NUCLEAR PLANT
# MAINTENANCE PROCEDURE

## TITLE:

ABB-COMBUSTION ENGINEERING NUCLEAR SERVICES
TRAVELER NO. 2003067-001

WELD REPAIR/MODIFICATION OF PRESSURIZER NOZZLE(S)

Chad W. Mayer , 10/19/93
Procedure Sponsor Date

, 10/19/93
Technical Reviewer Date

RB Kasper , 10/19/93, 2
User Reviewer Date Rev #

# WELD REPAIR/MODIFICATION OF PRESSURIZER NOZZLE(S)

UTILITY: CONSUMERS POWER COMPANY

SITE: PALISADES

NOZZLE NO.: PRESSURIZER NOZZLE REPAIR

1.0 TABLE OF CONTENTS AND LIST OF EFFECTIVE PAGES:

APPROVED BY:

Paul E. Reynolds 10-19-93
TASK MANAGER DATE

Chad W. Mau 10/19/93
OWNER REPRESENTATIVE DATE

10-19-93
QUALITY REPRESENTATIVE DATE

K F Blake 10-20-93
AUTHORIZED INSPECTION AGENCY DATE

Keith E. Coe 10/19/93
ENGINEERING DATE

## 2.0 REFERENCES

**NOTE:** The applicable revision for each procedure, drawing, etc. shall be released by SNSCE to the Task and Quality Assurance Managers.

2.1 DRAWINGS:

2.1a ABB/Combustion Engineering Dwg. No. D-9417-C093-019, Rev. 02.

2.1b ABB/Combustion Engineering Dwg. No. D-9417-C093-021, Rev. 01.

2.2 ABB/Combustion Engineering Nuclear Services Quality Assurance Manual, QAM-100, Fourth Edition, Rev. 1.

2.3 Instruction Manual: Pressurizer; Consumers Power Company - Palisades Plant.

2.4 ASME Code Section XI, 1983 Edition, Summer 1983 Addenda.

2.5 ASME Code Section II and III, 1986 Edition with no Addenda. (Materials)

2.6 ABB/CE Procedure No. DWPS SMA-3.43-937, Rev. 1.

2.7 ABB/CE Procedure No. O.P.-9.2, Rev. 7.

2.8 ABB/CE Procedure No. WPS SMA-43.43-909, Rev. 2.

2.9 ABB/CE Procedure No. STD-100-089, Rev. 7.

2.10 ABB/CE Procedure No. O.P.-9.4, Rev. 12.

2.11 ABB/CE Procedure No. PAL-410-005, Rev. 0.

2.12 ABB/CE Procedure No. DWPS GTA-8.8-910, Rev. 10.

2.13 ABB/CE Procedure No. KSM-1.X-900, Rev. 0.

2.14 ABB/CE Procedure No. WS-TC-900, Rev. 1.

2.15 ABB/CE procedure No. O.P.- 9.8, Rev. 8

2.16 Designated sign-offs/abbreviations in this traveler shall be in accordance with the following legend.

S - Supervisor/Worker
Q - Quality Operations
O - Owner/Client
A - Authorized Nuclear Inspector
W - Witness
I - Inspect
H - Hold
MPE - Magnetic Particle Examination
UT - Ultrasonic Test
WIR - Weld Inspection Record
LPE - Liquid Penetrant Examination
UTE - Ultrasonic Test Examination
ROI - Report of Inspection

## 3.0 PREREQUISITES

3.1 All required personnel have received training in Health Physics, Quality Control, Radiation Control, and ALARA procedures and have been trained in the work tasks to be performed.

3.2 Prewelding ECT has been completed and the location of the nozzle to be repaired has been identified by Consumers Power Company in writing.

3.3 Special tooling is on hand in sufficient quantity for the intended program.

3.4 Scaffolding at the pressurizer where work is to be performed has been erected, if required.

3.5 Insulation has been removed.

3.6 Cover nozzle opening to preclude debris from entering RCS.

3.7 Provide a system of tool and material accountability for all items entering the primary system, if applicable.

3.8 Assure that the pressurizer water level is below the nozzle elevation prior to performing any task.

3.9 Locate and record all information from the nozzle such as code numbers, heat numbers, and nozzle location. Report this information to SNSCE for evaluation. Obtain Consumers Power approval/concurrence for the nozzle to be welded prior to proceeding.

3.10 All covered electrodes shall be baked before use at a temperature of 550+/- 50° F for two hours. The temperature of the oven shall not exceed 300° F, when the electrodes are placed in the oven. After baking and before the electrodes are allowed to cool below 225°they shall be tranferred to a holding or drying oven operating at a temperature between 225°F and 350°F.

During the repair, the electrodes may be maintained in heated ovens in the repair area. The oven temperature shall be maintained between 225°F and 350°F. Electrodes exposed to the atmosphere for more than 20 minutes min shall be dried at a temperature between 225°F and 350°F for at least 8 hrs before reissued for use. Electrodes exposed to the atmosphere for more than 4 hrs shall be rebaked at 550°F+/-50°F for 2 hrs. Electrodes shall not be rebaked more than once.

3.11 Welding materials shall be controlled during repair per ref. 2.15 so that they are identified as acceptable material until consumed.

STP NO.

4.0 PERFORMANCE

NOTE: The following steps shall be performed in the sequence listed. Nozzles may be worked in parallel.

| | | | | |
|---|---|---|---|---|
| 4.1 | Verify satisfactory completion of prerequisites.<br>REMARKS: ____________ | S | W | ________ |
| | | Q | W | ________ |
| | | O | - | |
| | | A | - | |
| 4.2 | Layout and prepare for NDE the area required for the weld buildup and 5" min. radius around the buildup. | S | W | ________ |
| | | Q | W | ________ |
| | | O | - | |
| | NOTE: Pay special attention to the annulus between the nozzle and vessel shell.<br>REMARKS: ____________ | A | - | |
| 4.3 | Perform magnetic particle test of base metal pad buildup area and 5" minimum radius around pad area per OP-9.2, (yoke)<br>The following indications are unacceptable:<br>a. Any cracks or linear indications.<br>b. Rounded indications with dimensions greater than 3/16 inch.<br>c. Four (4) or more rounded indications in a line separated by 1/16 inch or less, edge to edge.<br>REMARKS: ____________ | S | - | |
| | | Q | I | ________ |
| | | O | - | |
| | | A | - | |
| | | MPE | | ________ |

4.4 Perform ultrasonic test of base metal pad buildup area per PAL-410-005, and 5" minimum radius cwh 10/19/93
Acceptance criteria:

(1) Any area, where one or more discontinuities produce a continuous total loss of back reflection accompanied by continuous indications on the same plane that cannot be encompassed with a circle whose diameter is 3 inches or 1/2 of the plate thickness, whichever is greater, is unacceptable.

(2) In addition, two or more defects smaller than described in (1) shall be unacceptable unless separated by a minimum distance equal to the greatest diameter of the larger defect or unless they may be collectively encompassed by the circle described in (1).

REMARKS: ______

| | | |
|---|---|---|
| S | _ | |
| Q | I | ______ |
| O | _ | |
| A | _ | |
| UTE | | ______ |

4.5 Clean all areas where UT and MT testing was performed using approved cleaning solution.
NOTE: Pay special attention to the annulus between the nozzle and the vessel shell.

REMARKS: ______

| | | |
|---|---|---|
| S | W | ______ |
| Q | _ | |
| O | _ | |
| A | _ | |

4.6 Set up preheat equipment on pressurizer per STD-100-089 and KSM-1.X-900 and WS-TC-900. Thermocouples shall be located between 5"to 10" from the edge of the weld pad build-up.

REMARKS: ______

| | | |
|---|---|---|
| S | W | ______ |
| Q | _ | |
| O | _ | |
| A | _ | |

4.7 Preheat pad buildup area and 5" radius per WPS-SMA-3.43-937. Hold preheat at 350 F min. 450°F max. for a minimum of 30 minutes prior to start of welding.

REMARKS: ______

| | | |
|---|---|---|
| S | W | ______ |
| Q | W | ______ |
| O | _ | |
| A | _ | |

CAUTION: THE 350°F PREHEAT MINIMUM MUST BE MAINTAINED CONTINOUSLY THROUGHOUT THE WELDING OPERATION AND UNTIL INITIATION OF THE POST WELD HEAT TREATMENT OF STEP 4.12.

4.8 Deposit first layer of pad buildup per WPS-SMA-3.43-937 using 3/32" dia electrode. Verify interpass temperature. Heat Input per SMA-3.43-937 (Bead length/unit length of electrode) Shall be verified no less than once per welder.
REMARKS: ____________

S W ______
Q I ______
O _
A _
WIR ______

e

4.9 Grind first layer to remove approximately 1/2 of the deposited weld material. Verify interpass temperature.
REMARKS: ____________

S W ______
Q I ______
O _
A _

4.10 Deposit second layer per WPS-SMA-3.43-937, using 1/8" dia. electrode. Heat Input per SMA-3.43-937 (Bead length/unit length of electrode) Shall be verified no less than once per welder. Verify interpass temperature.
REMARKS: ____________

S W ______
Q I
O _
A _
WIR ______

e

4.11 Deposit the third layer and subsequent layers using 1/8" dia. electrodes. Each of these weld deposit layers (third and subsequent layers) shall fuse to the nozzle at the weld/nozzle interface. Deposit sufficient number of layers to meet the requirments of ref. 2.1a or 2.1b. Verify interpass temperature.

S W ______
Q I ______
O _
A _
WIR ______

e
101

4.12 Perform postweld heat treat of pad buildup and 5" radius area around the pad per WPS-SMA-3.43-937 and STD-100-089. Hold temperature at 500° +/- 50°F for a minimum of four (4) hours.
REMARKS: ____________

S W ______
Q W ______
O _
A _

e

4.13 Drop temperature and allow to cool to ambient temperture.
Record date and time buildup reaches ambient temperture.
Ambient temperture is defined as follows:
"That temperature the material reaches during cooldown when the recorded temperature does not change by a ten (10) degree F increment during a period of two (2) hours".
REMARKS: ______________________

S W ________
Q W ________
O _
A _

NOTE: Final nondestructive testing is not to be performed until after pad buildup areas have remained at ambient for a minimum of 48 hours.

4.14 Remove preheat equipment and thermocouples.
Prepare surface of the weld buildup and all attachment areas for non-destructive testing.
Weld buildup to be ground per ref.2.1a or 2.1b.
Mark areas where temporary attachments are removed with approved marker.
REMARKS: ______________________

S W ________
Q I ________
O _
A _
ROI ________

4.15 PT pad buildup per O.P.-9.4.
The following indications are unacceptable:
a. Any cracks or linear indications.
b. Rounded indications with dimensions greater than 3/16 inch.
c. Four (4) or more rounded indications in a line separated by 1/16 inch or less, edge edge.

*REMARKS: A.N.I HOLD POINT IS DIRECTION TO MAKE BEST EFFORT TO CONTACT ANII IF CONTACT CANNOT BE MADE YOU MAY PROCEED WITH ACTIVITIES. ASB 10-20-93

NOTE: Should unacceptable indications be encountered, proceed with the following repair cycle.

S W ________
Q I ________
O _
A *H ________
LPE ________

4.16 Grind to remove indications. Notify CPCo Engineering prior to grinding. Maximum grinding depth allowed is only to within 3/16" of the original base material.
REMARKS: ______________________

S W ________
Q W ________
O _
A _

4.17 P.T. grindouts per O.P.-9.4.
The following indications are unacceptable:
a. Any cracks or linear indications.
b. Rounded indications with dimensions greater than 3/16 inch.
c. Four (4) or more rounded indications in a line separated by 1/16 inch or less, edge to edge.
REMARKS: ______________________________

S W ________
Q I ________
O _
A _
LPE ________

4.18 Weld repair grindout per WPS-SMA-43.43-909.
REMARKS: ______________________________

S W ________
Q I ________
O _
A _
WIR ________

4.19 P.T. final surface per O.P.-9.4.
The following indications are unacceptable:
a. Any cracks or linear indications.
b. Rounded indications with dimensions greater than 3/16 inch.
c. Four (4) or more rounded indications in a line separated by 1/16 inch or less, edge to edge.
REMARKS: ______________________________

S W_ ________
Q I ________
O _
A _
LPE ________

4.20 Ultrasonic test pad buildup,and 5" minimum radius per PAL-410-005.
The following acceptance criteria shall apply:
All indications which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such reflectors and evaluate them in terms of the acceptance standards given in (a) and (b) below.

(a) Discontinuities are unacceptable if the amplitude exceeds the reference level, and discontinuities have lengths which exceed:
  (1) 1/4 in. for t up to 3/4 in., inclusive
  (2) 1/3 t. for t from 3/4 in. to 2-1/4 in., inclusive
  (3) 3/4 in. for t over 2-1/4 in.

where t is the thickness of the weld being examined; if a weld joins two members having different thicknesses at the weld, t is the thinner of these two thichnesses.

(b) Where discontinuities are interpreted to be cracks, lack of fusion, or incomplete penetration, they are unacceptable, regardless of discontinuity or signal amplitude.

S _ ________
Q I ________
O _
A _
UTE ________

4.21 M.T. 5" radius and attachment areas per OP 9.2.
The following indications are unacceptable:
a. Any cracks or linear indications.
b. Rounded indications with dimensions greater than 3/16 inch.
c. Four (4) or more rounded indications in a line separated by 1/16 inch or less, edge to edge.

REMARKS: ________________________________
________________________________________
________________________________________

S W________
Q I________
O _
A _
MPE ________

NOTE: If the nozzle(s) is required to be severed continue on Nuclear Services Traveler 2003067-002.

4.22 Install thermowell and weld per WPS-GTA-8.8-910 and Ref. 2.1, (a) or (b). P.T. root pass per 4.23.

REMARKS: ________________________________
________________________________________
________________________________________

S W________
Q I ________
O _
A _
WIR________

|  |  |  |  |
|---|---|---|---|
| 4.23 | P.T. root and final weld per O.P.-9.4. | S | W______ |
|  | The following indications are unacceptable: | Q | I ______ |
|  |  | O | - |
|  | a. Any cracks or linear indications. | A | - |
|  | b. Rounded indications with dimensions greater than 1/16 inch. | LPE | ______ |
|  | REMARKS: ______ |  |  |
| 4.24 | Remove all tools and equipment from the pressurizer. | S | W ______ |
|  | QC inspect for final housekeeping and removal of | Q | W ______ |
|  | all equipment. Return to as-found condition. | O | - |
|  | REMARKS: ______ | A | - |
| 4.25 | QC complete Final Inspection Checklist in | S | - |
|  | accordance with Reference 2.2. | Q | I ______ |
|  | REMARKS: ______ | O | - |
|  |  | A | - |

DATA SHEET 5.1 - PRESSURIZER TOP HEAD NOZZLE

4.1 S W ________
Q W ________
O _
A _

4.2 S W ________
Q W ________
O _
A _

4.3 S _
Q I ________
O _
A _
MPE ________

4.4 S _
Q I ________
O _
A _
UTE ________

4.5 S W ________
Q _
O _
A _

4.6 S W ________
Q _
O _
A _

4.7 S W ________
Q W ________
O _
A _

4.8 S W ________
Q I ________
O _
A _
WIR ________

4.9 S W ________
Q I_
O _
A _

4.10 S W ________
Q I
O _
A _
WIR ________

4.11 S W ________
Q I ________
O _
A _
WIR ________

4.12 S W ________
Q W ________
O _
A _

4.13 C W ________
Q W________
O _
A _

4.14 S W ________
Q _ ________
O _
A _

4.15 S W ________
Q I ________
O _
A _
LPE ________

4.16 S W_ ________
Q W_ ________
O _
A _

4.17 S W _________
Q I _________
O _
A _
LPE _________

4.18 S W_ _________
Q I _________
O _
A _
WIR _________

4.19 S W_ _________
Q I _________
O _
A _
LPE _________

4.20 S _ _________
Q I _________
O _
A _
UTE _________

4.21 S W _________
Q I _________
O _
A _
MPE _________

4.22 S W_ _________
Q I _________
O _
A _
WIR _________

4.23 S W _________
Q W _________
O _
A _
LPE _________

4.24 S W_ _________
Q W _________
O _
A _

4.25 S _
Q I_________
O _
A _

DATA SHEET 5.1 - PRESSURIZER VESSEL SIDE NOZZLE

4.1 S W ________
Q W ________
O _
A _

4.2 S W ________
Q W ________
O _
A _

4.3 S _
Q I ________
O _
A _
MPE ________

4.4 S _
Q I ________
O _
A _
UTE ________

4.5 S W ________
Q _
O _
A _

4.6 S W ________
Q _
O _
A _

4.7 S W ________
Q W ________
O _
A _

4.8 S W ________
Q I ________
O _
A _
WIR ________

4.9 S W ________
Q I_
O _
A _

4.10 S W ________
Q I
O _
A _
WIR ________

4.11 S W ________
Q I________
O _
A _
WIR ________

4.12 S W ________
Q W ________
O _
A _

4.13 S W ________
Q W________
O _
A _

4.14 S W_ ________
Q _ ________
O _
A _

4.15 S W ________
Q I ________
O _
A _
LPE ________

4.16 S W ________
Q W ________
O _
A _

4.17 S W ________
Q I ________
O _
A _
LPE ________

4.18 S W_ ________
Q I ________
O _
A _
WIR ________

4.19 S W_ ________
Q I ________
O _
A _
LPE ________

4.20 S _ ________
Q I ________
O _
A _
UTE________

4.21 S W ________
Q I ________
O _
A _
MPE ________

4.22 S W_ ________
Q I ________
O _
A _
WIR ________

4.23 S W ________
Q W ________
O _
A _
LPE ________

4.24 S W_ ________
Q W ________
O _
A _

4.25 S _
Q I ________
O _
A _

# EA-SC-93-087-01

# ATTACHMENT 6

# Inconel 600 PWSCC

# Status Report

To: KVCedarquist

From: PDFitton Paul D Fitton

Date: May 22, 1991

Subject: PALISADES PLANT
INCONEL 600
PRIMARY WATER STRESS CORROSION CRACKING
STATUS REPORT

cc KEOsborne, Palisades MGKlyver, Palisades
JRSchepers, Palisades DJMalone, Palisades
RPMargol, Palisades BVVanWagner, Palisades

[redacted]

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Please find attached a status report of the work that has been completed to date on Primary Water Stress Corrosion Cracking of Inconel 600. This is not intended to be a final report; additions or deletions may be appropriate as additional information becomes available. I have attempted to capture what I know on the subject of PWSCC of inconel 600 in this document.

Please review the attached status report. I will provide the status of the recommendation section at your convenience. I will remain available to support your efforts in this area as you see fit. I suggest we both attend the next Inconel 600 Working Group meeting in late August at CE in Windsor. I will leave that to your judgement and management approval.

# STATUS REPORT ON PRIMARY WATER STRESS CORROSION CRACKING OF INCONEL 600 PRIMARY SYSTEM PRESSURE BOUNDARY MATERIAL

## 1.0 EXECUTIVE SUMMARY

The Nuclear Power Industry has begun to see a significant number of occurrences of Primary Water Stress Corrosion Cracking (PWSCC) of Inconel 600 in NSSS penetration applications. Palisades has 241 Inconel 600 Primary Coolant System penetrations. The new steam generator tubing is Inconel 600. The development of PWSCC in a Primary System boundary can significantly impact plant availability and be expensive to repair. Calvert Cliffs required over one year to repair the first pressurizer heater sleeve cracks.

The recommended actions have been developed to meet the following objectives:

1. Avoid mid-cycle shutdowns via an inspection/replacement program.
2. Minimize cost by accepting a reasonable measure of risk.
3. Appropriately address regulatory concerns.
4. Ensure nuclear and personnel safety.

Alternatives range from doing nothing to replacing all Inconel 600 PCS boundary material. A summary of the recommendations is as follows:

1. Perform additional visual inspections of pressurizer penetrations each refueling outage.
2. Develop contingency plans to repair leaking pressurizer penetrations.
3. Continue to participate in industry initiatives to understand and mitigate PWSCC in PCS penetrations.
4. Replace high risk Inconel 600 material in the pressurizer.

These recommendations seek to balance risk with cost.

PWSCC of Inconel 600 will be a life extension issue. PWSCC is dependent on a susceptible material, temperature, stress, and time. The relationship between these factors is not very well defined. As plant life increases within the nuclear industry, we may begin to see PWSCC at some lower temperature PCS locations. If that occurs, additional measures will be appropriate.

A single PWSCC initiated PCS pressure boundary leak will take at least 2 to 4 weeks to repair. This excludes additional time that may be required to perform additional inspections, address licensing/regulatory concerns, and find replacement material. The two pressurizer RTD's may be particularly difficult to repair quickly. In general, Palisades nozzle design is easier to repair than newer plants, and the particular lots of inconel 600 used at Palisades have relatively favorable material properties. Operating time is a factor, so this will become more of a concern as the plant ages. Combustion Engineering has qualified equipment and procedures available for most repairs.

## 2.0 INTRODUCTION

A special CEOG Working Group was formed in November of 1989 to address Primary Water Stress Corrosion Cracking (PWSCC) of Inconel 600. This Working Group agreed to the following objectives:

1. Identify the susceptibility of Inconel 600 penetrations to PWSCC.
   a. Understand what contributed to Calvert Cliffs-2, SONGS-3, and St. Lucie failures.
   b. Assess the susceptibility of installed components.
2. Address NRC concerns.
3. Investigate options to mitigate PWSCC in Primary System pressure boundary components.

In January of 1991 the Inconel 600 Working Group agreed to investigate PWSCC concerns related to steam generator tubing. This was due to the discovery of PWSCC in the Maine Yankee steam generator tubing in December of 1990. The scope of this effort is undefined.

As a participant, Consumers Power also had the following objectives:

1. Share expertise, cost, and resources in dealing with PWSCC of Inconel 600. PWSCC could have a large impact on plant availability.
2. Assess the susceptibility of Palisades to PWSCC in Inconel 600 PCS penetrations.
3. Develop plans to mitigate PWSCC concerns (if necessary).

The Inconel 600 Working Group developed a series of tasks aimed at accomplishing the objectives. A summary of each task is provided in Attachment 2. The tasks are listed below:

1. Determine root cause of pressurizer heater sleeve PWSCC.
   A. CEOG Task 633 Pressurizer Nozzle Evaluation
   B. CEOG Task 636 Pressurizer Heater Sleeve Evaluations
   C. CEOG Task 639 Pressurizer Heater Sleeve Thermal Analysis
2. Determine material properties of nozzles and sleeves installed in plants.
   A. CEOG Task 631 Pressurizer Heater Sleeve Information Package
   B. CEOG Task 634 Inconel 600 Penetrations Information Package

# STATUS REPORT ON PRIMARY WATER STRESS CORROSION CRACKING OF INCONEL 600 PRIMARY SYSTEM PRESSURE BOUNDARY MATERIAL

3. Support position that PWSCC is not a safety related concern.
   A. CEOG Task 637 Pressurizer Shell Corrosion Testing
4. Provide inspection method.
   A. CEOG Task 635 Qualification of Eddy Current Examination Techniques

System Engineering performed a visual external inspection of the pressurizer heater sleeves during the 89Maout, 90Maout, and 90Refout. No evidence of leaking pressurizer heater sleeves was found.

## 3.0 GENERAL DISCUSSION

Primary Water Stress Corrosion Cracking (PWSCC) of Inconel 600 products has become a nuclear power industry concern. Palisades has 241 Primary Coolant System penetrations that have Inconel 600 sleeves or nozzles. The widespread use of Inconel 600 in Primary System penetrations makes PWSCC a significant reliability and regulatory concern.

The following identifies failures that have been identified to date.

1. Calvert Cliffs Unit 2 experienced through wall cracking attributable to PWSCC in 20 out of 120 pressurizer heater sleeves.
2. SONGS Unit 3 experienced PWSCC in 4 pressurizer instrument nozzles. The nozzle material had a very high yield strength. The failure was attributed to a particular material heat number.
3. St. Lucie inspected one nozzle of the same heat number supplied to SONGS-3. It was cracked. They replaced all 6 nozzles of similar heat number.
4. Calvert Cliffs Unit 2 inspected pressurizer heater nozzles. They found 1 leaking and cracked. The original material was of low yield strength but had been reworked twice.
5. The Navy has experienced PWSCC failures of forged Inconel 600 at temperatures lower than CE pressurizer temperatures. Navy nozzles are rolled into place and welded.
6. Edf (French) has experienced PWSCC of forged Inconel 600, including circumferential indications. Edf nozzles are rolled and welded.
7. Westinghouse has experienced PWSCC of forged Inconel 600 steam generator tube plugs.
8. Westinghouse has experienced PWSCC of Inconel 600 steam generator tubes.

# STATUS REPORT ON PRIMARY WATER STRESS CORROSION CRACKING OF INCONEL 600 PRIMARY SYSTEM PRESSURE BOUNDARY MATERIAL

9. Maine Yankee has experienced PWSCC of Inconel 600 steam generator tubing.
10. Arkansas Nuclear Unit 1 (B&W Plant) experienced a cracked pressurizer nozzle in December of 1990.

Repairs of cracked Primary System boundary material are expensive, dose intensive, and time consuming. Primary Water Stress Corrosion Cracking (PWSCC) involves intergranular stress corrosion cracking of alloy steels in a primary water environment. Three things are needed to develop PWSCC. They are:

1. Residual or operating stress. In the ID of these nozzles and tubes the stress must be a tensile stress. Current thinking is about 40 ksi of tensile stress is required to initiate PWSCC in Inconel 600.
2. Temperature. PWSCC is highly temperature dependent. CE believes (based on literature) the corrosion rate doubles for every temperature increase of 10C (18F). This is why the pressurizer is most vulnerable.
2. The material must be susceptible to PWSCC. Desirable characteristics of Inconel 600 tubing products (sleeves and steam generator tubing) are well researched. Much less is known about hot forged Inconel 600 (nozzles). High material yield strength is undesirable.

PWSCC continues to pose a large economic risk to the Palisades Plant. This risk is shared by all operating nuclear plants with Inconel 600 penetrations. We should not be surprised by the failure of any single Inconel 600 penetration. The probability of developing a PWSCC initiated PCS leak is increased by

1. High service temperatures
2. High residual stresses developed during installation
3. High material yield strength
4. Service time

PWSCC will not occur in inconel 600 without residual stress. CE has estimated the minimum stress to initiate a PWSCC crack at 40 ksi. Higher residual stress levels will shorten the time to initiate a crack. Higher service temperatures and high material yield strength will shorten the time to initiate a PWSCC crack. It is unclear exactly what the minimum temperature is below which no cracks will occur. CE estimates that material with a yield strength greater than 50 ksi is unfavorable; ie more likely to crack. This general guidance helps provide the basis for identifying penetrations with the highest susceptibility to PWSCC. This does not mean PWSCC will never occur in relatively low probability locations. The probability is lower, but not zero.

Temperature is a key factor in the development of PWSCC. The rate of PWSCC will double for every 18F increase in temperature. It is therefore reasonable to expect most of the initial problems to occur in the pressurizer. The installation processes used throughout the PCS are relatively similar; as such the residual stresses should be similar. The relationship between temperature and PWSCC rates is very helpful in developing an assessment of areas most at risk. It is clear that most initial failures will occur in pressurizer penetrations. As such, it is reasonable to focus most inspection efforts in this area. It is important to note that ongoing inspection programs at other commercial nuclear power plants provide a much larger data base to make conclusions from, and to continuously evaluate previous assumptions. It will be worthwhile to use this information to periodically re-evaluate Palisades response to this issue.

One of the key points in determining that the PWSCC of Inconel 600 penetrations is not a safety issue is the axial orientation of the cracks. Circumferential cracking can cause a catastrophic failure of the pressure boundary, potentially ejecting a nozzle or sleeve. The residual stresses that are present in the heat affected zone of the welds result in a hoop stress that may cause axial cracking, not circumferential cracking.

Some work done under CEOG Task 636 directly supports this conclusion. The residual stresses created near the heat affected zone are directly dependent on the inconel 600 material properties. Pre-reaming results in high hardness/high yield strength at the ID of the sleeve/nozzle. Welding then creates residual stresses that are limited by the material properties at the surface. The residual stresses govern material susceptibility. High strength non-reamed material is of slightly less concern, but residual stress is still governed by material properties. Low strength material is also under tensile stress due to welding, but susceptibility is lower because residual stresses cannot exceed the yield strength of the material.

Additional work determined most of the sleeve/nozzle area is actually under compressive stress. Tensile stress is required to develop PWSCC. Lower stress levels are required to propagate a crack than to initiate one, so developing a high enough tensile stress on the ID of the sleeve/nozzle is critical in initiating a crack. Post weld machining was actually beneficial in removing a layer of the material under the highest tensile stress.

It is also worth noting that pressurizer heater sleeve failures have occurred due to the failure of pressurizer heaters. Both Arkansas Nuclear Unit 2 and San Onofre have experienced heater sleeve failures caused by the swelling of a failed pressurizer heater. The failed heater can be extremely difficult to remove. As time goes on the heater swells and places enough pressure on the heater sleeve to cause cracking. The prompt replacement of a failed pressurizer heater can prevent this problem.

## 4.0 SUSCEPTIBILITY OF PALISADES PRESSURIZER HEATER SLEEVES TO PWSCC

Pressurizer heater sleeves are fabricated from a tubular cold worked form of Inconel 600. The susceptibility of cold worked Inconel 600 is reasonably well known. Significant research has been done due to the widespread use of cold worked Inconel 600 in Steam Generator tubing. Combustion Engineering completed CEN-393-1 titled "Evaluation of Pressurizer Heater Sleeve Susceptibility to Primary Water Stress Corrosion Cracking". This was done as CEOG Task 631, and completed in November of 1989. Additional work was completed in CEOG Task 636, "Pressurizer Heater Sleeve Evaluations".

Palisades pressurizer heater sleeves were categorized in the low susceptibility range for PWSCC. This determination was made based on the low yield strength of the material, absence of pre-installation reaming of the sleeve, and the absence of rework on the heater sleeves. Plants having inconel 600 with a yield strength above 50 ksi, or those having pre-installation reaming done were categorized as moderate risk units. Plants having both a high yield strength material and pre-installation reaming have been categorized as high susceptibility. The susceptibility ratings are relative measures of probability, not absolute measures that PWSCC will or will not occur.  Two units were identified as high susceptibility, six units as moderate susceptibility, and seven units as low susceptibility.  Calvert Cliffs Unit 2 was a high susceptibility plant.

The development of PWSCC in the steam generator tubing at Maine Yankee is a cause for concern . Steam generator tubing sees lower service temperatures than those experienced in the pressurizer. The steam generator tubing installed in the Maine Yankee plant has favorable properties: ie it is not highly susceptible to PWSCC. Steam generator tubing is explosively expanded into place, which may introduce high residual stresses at the tube sheet. This is where the Maine Yankee tubes cracked.

The plants with unfavorable pressurizer heater sleeve material should provide a valid indication of concern prior to pressurizer heater sleeves cracking at Palisades. Due to the statistical nature of PWSCC, and the minor differences that may occur in installing individual sleeves, we should not be surprised if a few failures occur in lower susceptibility tubing. As such, we should be prepared to respond to a small number of pressurizer heater sleeve failures.

## 5.0 <u>SUSCEPTIBILITY OF PRIMARY SYSTEM INCONEL 600 NOZZLES TO PWSCC</u>

All Palisades Primary Coolant System nozzles contain some Inconel 600. All Inconel 600 forged products have some susceptibility to PWSCC. The relationship between material yield strength and PWSCC that helps classify cold worked Inconel 600, does not work very well for hot forged products (nozzles). Evaluations of grain boundary and carbide location have also been unsuccessful in quantifying the susceptibility of hot forged Inconel 600.

The relationship between PWSCC and temperature helps reduce the area of highest concern. All Inconel 600 nozzles that have developed PWSCC to date are in the pressurizer. This is what we would expect based on system operating temperature. The temperature runs about 50F hotter than the rest of the PCS. This would increase the corrosion rate by a factor of eight compared to the rest of the PCS. This is also supported by the fact that PCS nozzle cracking has not been identified during the 10 year ISI inspections that are required by Section XI. If widespread PWSCC was occurring at lower temperatures, it would have been detected by the ASME Section XI program, or a boric acid walkdown at some of the many nuclear plants that are in service. Section XI inspection criteria apply to all plants, presenting a large data base of information.

It remains clear that three conditions are necessary to develop PWSCC in any Inconel 600 product. They are:
1. Susceptible material
2. Temperature
3. Residual or operating stresses that produce a high tensile

stress in the material

Combustion Engineering has unsuccessfully tried to identify nozzle characteristics related to PWSCC susceptibility. This was done under CEOG Task 633. CE evaluated the BG&E nozzle. No evidence of chemical contamination was found. This supports the cracking being PWSCC. Hot worked Inconel 600 produces more variations in yield strength, grain size, and carbide precipitation. This makes evaluating characteristics that promote PWSCC much more difficult. Previous work done on steam generator tubing does not accurately predict the susceptibility of hot forged nozzles.

The BG&E nozzle cracks were initiated on the internal diameter (ID). The crack growth rate was very slow. This indicates a high tensile stress existed on the nozzle ID, and was initially relieved by cracking. Crack growth slowed because operating stresses are much lower than presumed residual stresses. Higher stress is necessary to initiate crack growth than to propagate growth.

Calvert Cliffs Unit 2 found the leaking nozzle during an external inspection. Boric acid crystals were present. SONGS-3 found their leak due to steam leakage observed during a startup walkdown.

Due to the high probability that PWSCC that will occur first in the pressurizer, each pressurizer nozzle was evaluated in Attachment 1. A brief summary is provided below:

Pressurizer Surge Line Nozzle - moderate susceptibility
Pressurizer Spray Nozzle - moderate susceptibility
PORV Nozzle - high susceptibility
Pressurizer Safety Valve Nozzle- high susceptibility
Pressurizer Upper Level Nozzles- moderate susceptibility
Pressurizer Lower Level Nozzles- moderate susceptibility
Pressurizer Temperature Nozzles- moderate susceptibility

## 6.0 SAFETY SIGNIFICANCE

PWSCC of Inconel 600 nozzles and sleeves is not a nuclear safety concern for Combustion Engineering plants. All cracking that has occurred to date has been axial. While this may result in through wall leakage, axial cracks will not cause a catastrophic failure of the pressure boundary.

Some circumferential cracking has been observed in French PWR's. EdF (French) plants roll nozzles into place prior to welding. This results in a stress riser at the roll transition. PWSCC can develop at this location resulting in a circumferential crack. CE nozzles are not rolled into place. They were slid into place and welded. No circumferential indications have been found in CE nozzles.

The leakage path through a sleeve or nozzle can be rather tortuous. This results in relatively low leak rates in the surrounding area. Combustion Engineering has constructed a mockup of a pressurizer heater sleeve and measured actual carbon steel base metal corrosion in the area of the simulated PWSCC initiated leak. This work was done as CEOG Task 637. The corrosion rate was estimated for one full operating cycle, and the pressure boundary integrity was not affected. It is important to note that if a leak remains active and undetected long enough, significant erosion/corrosion of the base metal may occur.

## 7.0 REPAIR OPTIONS

Cracked pressurizer heater sleeves and nozzles have been replaced at a number of plants. Both Combustion Engineering and Babcock and Wilcox have qualified repair techniques, procedures, and equipment available for pressurizer heater sleeves. The Combustion Engineering technique can be used on a single heater sleeve. Combustion Engineering has qualified techniques, equipment, and procedures available for most PCS nozzle locations. The Inconel 600 Working Group is looking at future activities to assure materials and equipment are available for all likely repairs. A single cracked PCS penetration would probably take three to four weeks to repair. Repairing multiple failures would take longer. Replacement material is not presently readily available in significant quantities. The Calvert cliffs Unit 2 repair took well over one year.

## 8.0 RECOMMENDED ACTIONS

The recommended actions have been developed to meet the following objectives:

1. Avoid mid-cycle shutdowns via an inspection/replacement program.
2. Minimize cost by accepting a reasonable measure of risk.
3. Appropriately address regulatory concerns.
4. Ensure nuclear and personnel safety.

A. INSPECTION

1. Continue to perform boric acid walkdowns on the PCS.
2. Continue to monitor the results of 10 year ISI inspections

on PCS nozzles.

3. Install a small piece of removable insulation on each pressurizer nozzle location. This will permit a bare metal visual examination. An ESSR has been submitted for a cost estimate of this task.
4. Perform and document visual external inspections of every pressurizer nozzle/sleeve each refueling outage. This should be done and documented as a VT-2 exam with the insulation removed.
5. Develop a PT process for inspecting the internal heat affected zone of the pressurizer safety valve nozzles, if they are not replaced.

B. REPAIR

1. Be prepared to repair Inconel 600 leaks that may develop.
   a. Determine the lead time for replacement PCS penetrations material. Evaluate advance purchase of selected material, possibly within the CEOG program.
   b. Purchase replacement nozzles for the pressurizer safety valve flanges. These should eventually be replaced.
   c. Evaluate the cost benefit of paying to modify vendor equipment and procedures to repair Palisades pressurizer RTD penetrations.

C. REPLACE

1. Determine the most appropriate replacement material(s) for inconel 600 PCS penetrations.
1. Replace high strength inconel 600 material in the pressurizer. ESSR's have been submitted to replace five pressurizer nozzles with a yield strength of 77 ksi.
2. Replace pressurizer heaters promptly if they fail. This should occur during the next outage of acceptable duration.

D. PARTICIPATE IN INCONEL 600 INDUSTRY INITIATIVES

1. Sponsor an effort to define the stress characteristics of butt welds on safe ends. The stress characteristics of these welds has significant implications for Palisades. Palisades nozzle joint design is relatively unique. This task is extremely important; if residual stress is not present PWSCC will not occur, even in highly susceptible material. CE will be quoting this task before June 14, 1991.
2. Participate in the CEOG Task to develop a justification for operation with an unknown PWSCC initiated leak. This document will support the inspection recommendations that will be made by the CEOG Inconel 600 Working Group, and support the justification for restart after a single leak.

3. Evaluate participation in zinc injection studies looking at reducing the susceptibility of Inconel 600 to PWSCC.
4. Participate in CEOG Inconel 600 Working Group activities. This includes EPRI efforts on Inconel 600. This will also help identify other failures that may occur at other plants. Experience within the industry will directly impact the measures taken to assure acceptable economic risks are taken at Palisades.
5. Evaluate participation in CEOG efforts in the area of remedial measures. This may include nickel plating, stress relief, etc.

## 9.0 ATTACHMENTS

Attachment 1; Summary Table of PWSCC Variables and Effects
Attachment 2; Summary of Palisades Pressurizer Nozzle Penetration Susceptibility to PWSCC
Attachment 3; Summary of CEOG Task 633 "Pressurizer Nozzle Evaluation"
Attachment 4; Summary of CEOG Task 634 "Inconel 600 Penetration Information"
Attachment 5; Summary of CEOG Task 635 "Qualification of Eddy Current Exam Techniques"
Attachment 6; Summary of CEOG Task 636 "Pressurizer Heater Sleeve Evaluations"
Attachment 7; Summary of CEOG Task 637 "Pressurizer Shell Corrosion Testing"
Attachment 8; Summary of CEOG Task 639 "Pressurizer Heater Sleeve Thermal Analysis"

## STATUS REPORT ON PRIMARY WATER STRESS CORROSION CRACKING OF INCONEL 600 PRIMARY SYSTEM PRESSURE BOUNDARY MATERIAL

### ATTACHMENT 1

| | Variable | Known Effects | Corrective Action /Comments |
|---|---|---|---|
| ENVIRONMENT | Primary Water | Will result in PWSCC with stress & susceptible material | |
| | Temperature | Increase of 18F in temperature doubles the PWSCC rate | |
| STRESS | Stress | Tensile stress of 40 ksi is believed to be the threshold above which PWSCC may occur | Higher stresses increase susceptibility |
| MATERIAL | Cold Drawn & Annealed | Low Temperature Anneal | Westinghouse SG tubing more susc<br>Higher yield strength higher susceptibility |
| | | High Temperature Anneal | CE SG tubing more resistant but not immune |
| | Hot Forged | No Apparent Screening Criteria | |

12-14-90

# PRESSURIZER SURGE LINE NOZZLE (1) (ASSEMBLY 985-01)

Service : Pressurizer Liquid Space (653F)

Inconel 600

| | | |
|---|---|---|
| 985-03 | Safe End | Yield 51,200 psi |
| 985-12 | Ring Assembly | Yield unknown psi |

Rework: None

Cold Work:

Source of Residual stress: Welding both ends of safe end. Welding on one end of ring assembly.

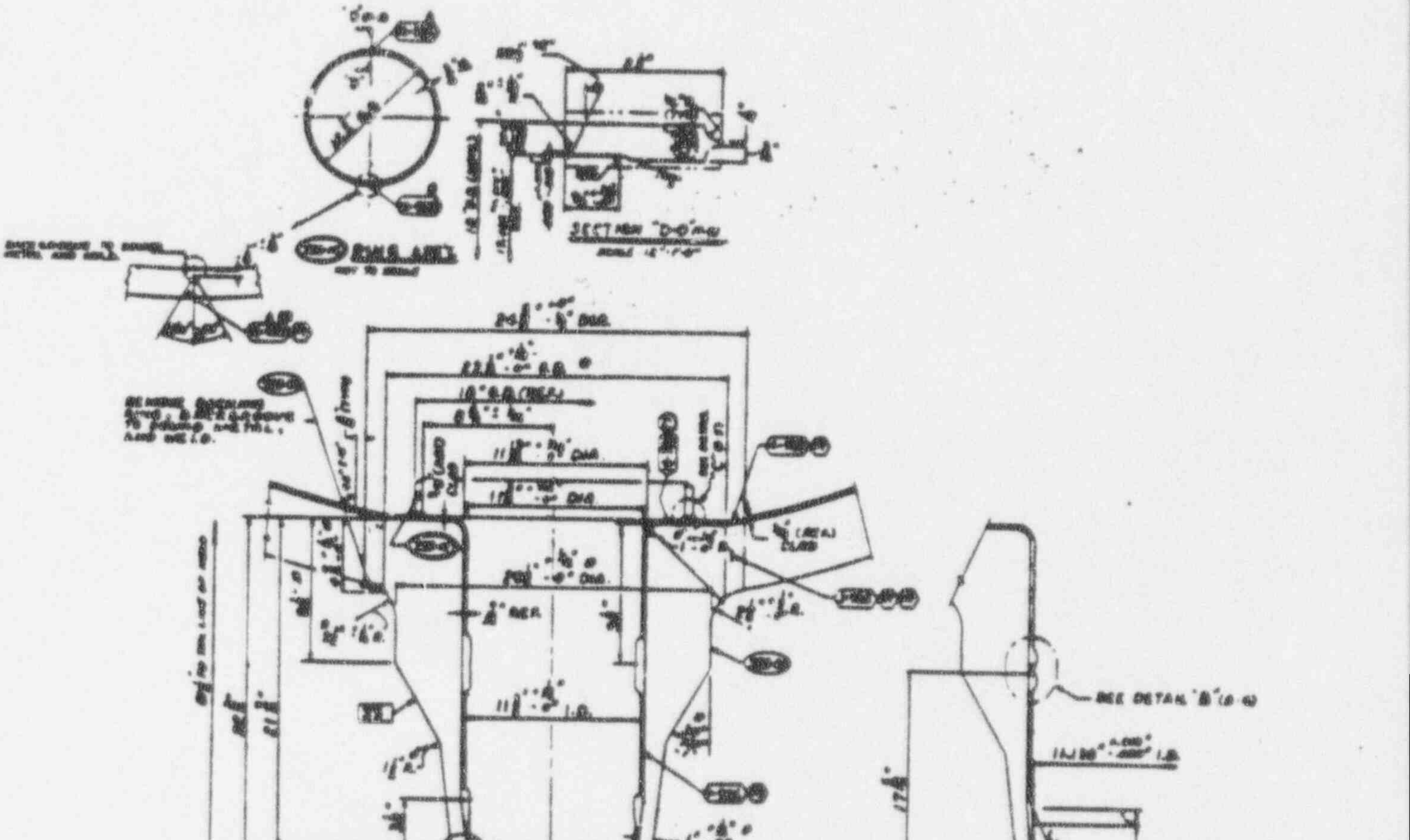
Discussion: The safe end should be considered medium risk to develop PWSCC. It has been exposed to a high service temperature and has been welded on both ends. The nozzle material is slightly above the 50 ksi guideline for high risk applications. This particular nozzle is at the bottom of the liquid space. This should be the lowest temperature location in the pressurizer. PWSCC that has occurred to date has been in the pressurizer steam space. The thickness and geometry of the safe end will have unknown effects on the susceptibility of the nozzle. The fact a repair would involve two external welds would be helpful if a repair is required.

It is unknown what the susceptibility of the ring assembly would be. The repair would be extremely difficult. The absence of operating differential pressure is helpful; this is not a pressure retaining component. One of the key requirements for PWSCC to occur is either residual of operating stress. The lack of differential pressure eliminates operating stress as a source of stress.

References: CEOG Task 634
CE Drawing E-231-985 (M-1LA SH 985)

Drawings (See attached page):

SURGE LINE NOZZLE PAGE 2



## SPRAY NOZZLE (1) (ASSEMBLY 986-01)

Service : Pressurizer Steam Space (653F)

Inconel 600

| | |
|---|---|
| 986-03 | Yield 77,500 psi |
| 986-05 | Yield unknown psi |

Rework: None

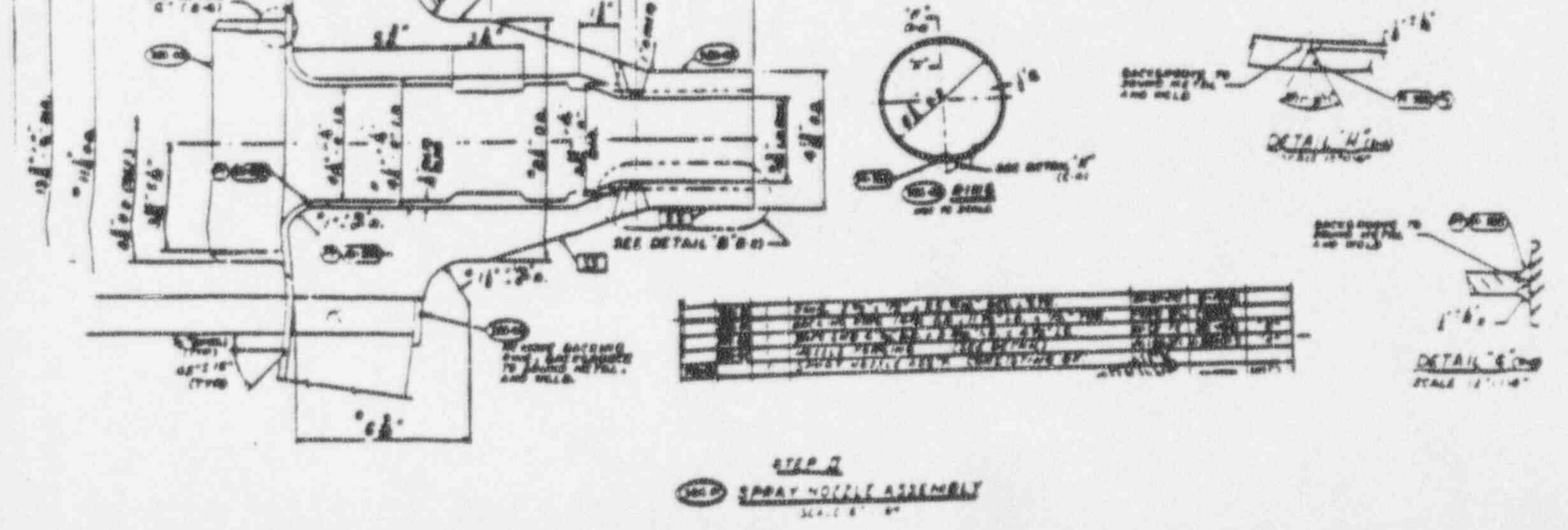
Cold Work:

Source of Residual stress: welding two ends of safe end (986-03); welding on one end of ring (986-05).

Discussion: The safe end nozzle should be considered moderate risk to develop PWSCC. It is welded on both ends. Due to the steady stream of pressurizer spray liquid, the service temperature would be closer to the cold leg temperature than to the pressurizer temperature. This greatly reduces the risk of developing PWSCC at this location. The nozzle material is well above the 50 ksi guideline for high risk applications. PWSCC that has occurred to date has been in the pressurizer steam space. The thickness and geometry of the safe end will have unknown effects on the susceptibility of the nozzle. The fact a repair on the safe end would involve only external welds, and that it is located on top of the pressurizer would be helpful if a repair is required. The susceptibility of the ring is unknown at this time.

References: CEOG Task 634
CE Drawing E-231-986 (M-1LA SH 986)

Drawings:



## RELIEF VALVE NOZZLE (PORV) ASSEMBLY (1) (986-11)

Service : Pressurizer Steam Space (653F)

Inconel 600

986-13 Yield 77,500 psi

Rework: None identified. This nozzle was not reworked during the PORV Replacement Project.

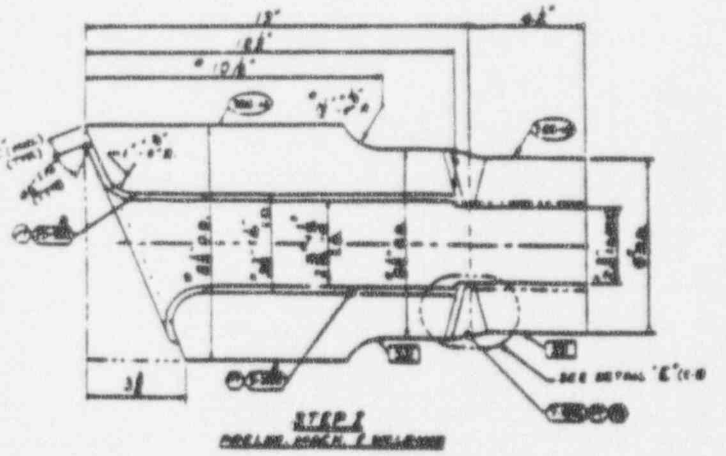
Cold Work: None identified.

Source of Residual stress: welding both ends;

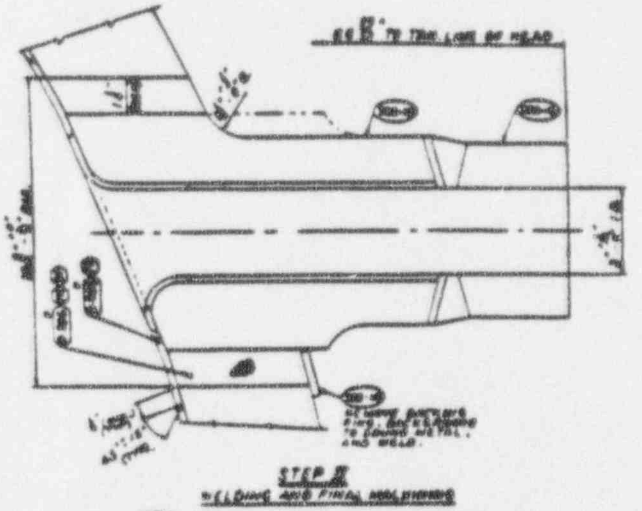
Discussion: **These nozzles should be considered high risk to develop PWSCC. They are exposed to a high service temperature and have been welded on both ends. The nozzle material is well above the 50 ksi guideline for high risk applications.** PWSCC that has occurred to date has been in the pressurizer steam space. The thickness and geometry of the pipe will have unknown effects on the susceptibility of the nozzle. The fact that this nozzle is located on top of the pressurizer would be helpful if a repair is required.

References: CEOG Task 634
CE Drawing E-231-986 (M-1LA SH 986)

Drawings:

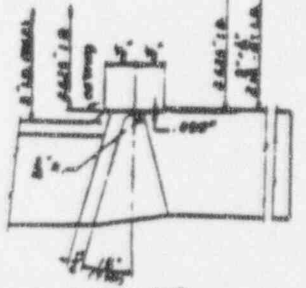


STEP I
PRELIM. MACH. & WELDING

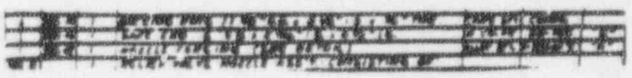


STEP II
WELDING AND FINAL MACHINING

RELIEF VALVE NOZZLE ASSEMBLY



DETAIL 'E'



## SAFETY VALVE FLANGES (3) (ASSEMBLY 986-15)

Service : Pressurizer Steam Space (653F)

Inconel 600

| | |
|---|---|
| 986-16A | Yield 77,500 psi |
| 986-16B | Yield 77,500 psi |
| 986-16C | Yield 77,500 psi |

Rework: None identified

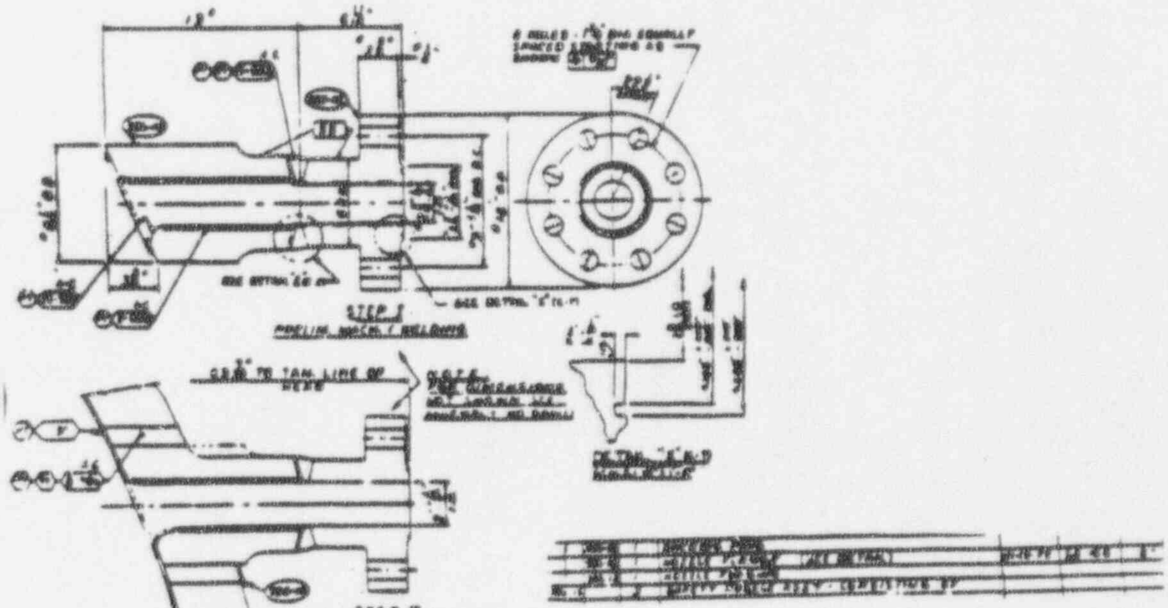
Cold Work: None identified

Source of Residual stress: welding one end only.

Discussion: These nozzles should be considered high risk to develop PWSCC. They are exposed to a high service temperature and have been welded on one end. The nozzle material is well above the 50 ksi guideline for high risk applications. The PWSCC that has occurred to date has been in the pressurizer steam space. The thickness and geometry of the flange will have unknown effects, but will probably reduce the susceptibility of a through wall crack developing. The fact that a repair would only involve one external weld, and that it is located on top of the pressurizer, would be helpful if a repair is required.

References: CEOG Task 634
CE Drawing E-231-986 (M-1LA SH 986)

Drawings:



12-14-90

TOP HEAD LEVEL NOZZLES (4) (ASSEMBLY 985-09)

Service : Pressurizer Steam Space (653F)

Inconel 600

| | |
|---|---|
| 985-07A | Yield 46,200 psi |
| 985-07B | Yield 46,200 psi |
| 985-07C | Yield 46,200 psi |
| 985-07D | Yield 46,200 psi |

Rework: None

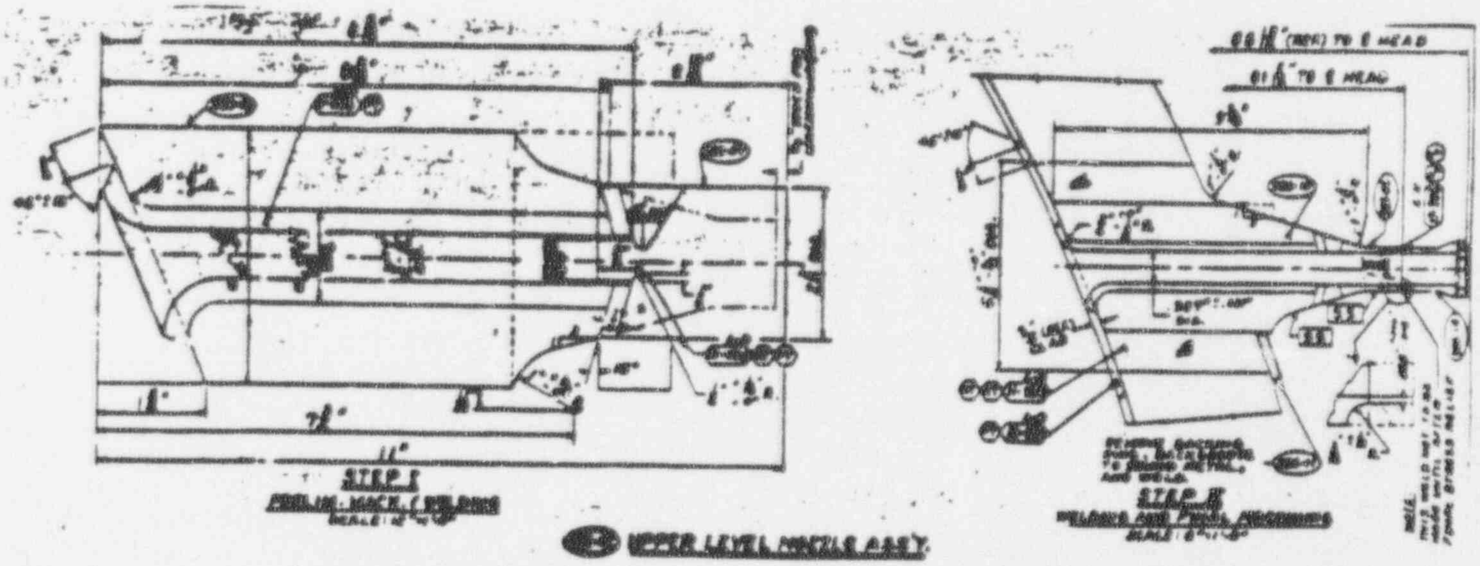
Cold Work:

Source of Residual stress: welding; both ends

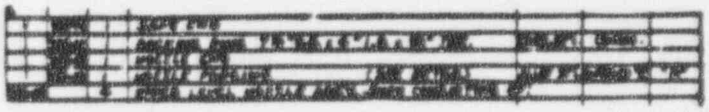
Discussion: These nozzles should be considered medium risk to develop PWSCC. They are exposed to a high service temperature and have been welded on both ends. The nozzle material is below the 50 ksi guideline for high risk applications.

References: CEOG Task 634
CE Drawing E-231-985 (M-1LA SH 985)

Drawings:



UPPER LEVEL NOZZLE ASSY.



# BOTTOM HEAD LEVEL NOZZLES (4) (ASSEMBLY 985-05)

Service : Pressurizer Liquid Space (653F)

Inconel 600

| | |
|---|---|
| 985-07A | Yield 46,200 psi |
| 985-07B | Yield 46,200 psi |
| 985-07C | Yield 46,200 psi |
| 985-07D | Yield 46,200 psi |

Rework: None

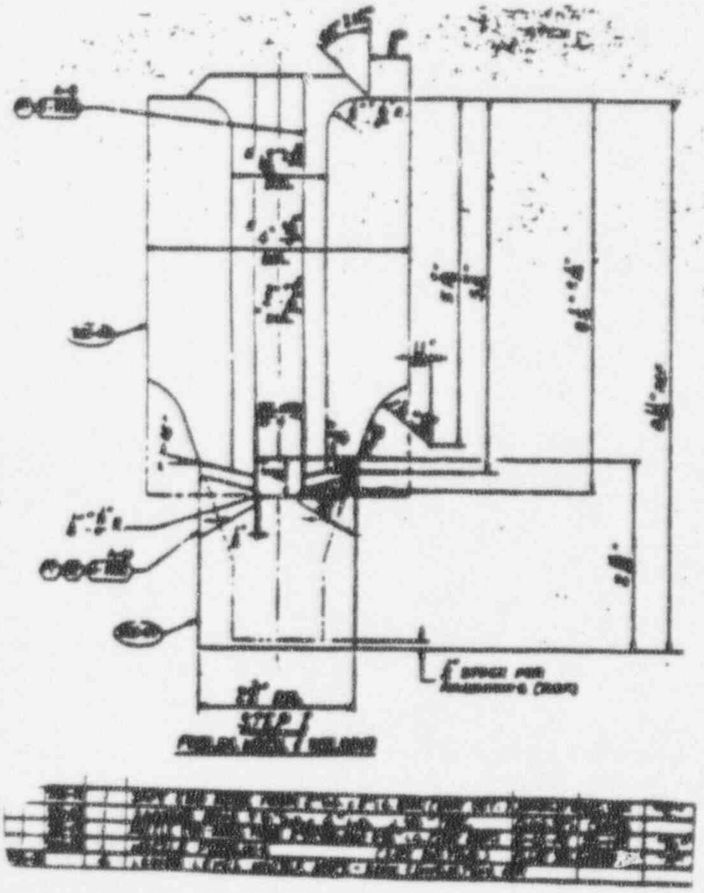
Cold Work:

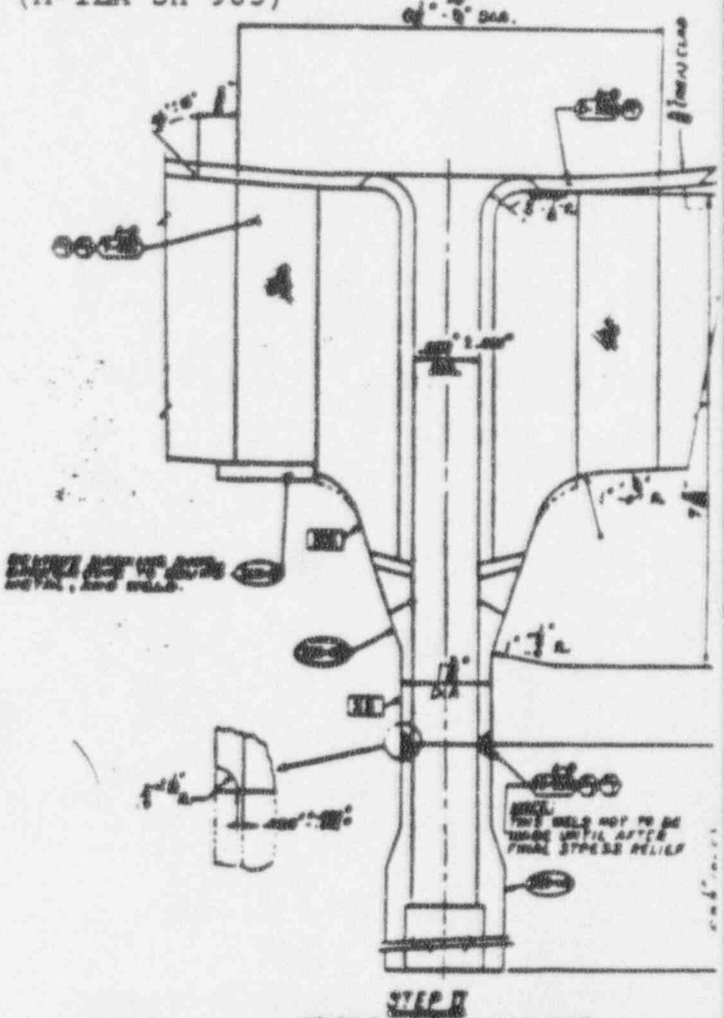
Source of Residual stress: welding; both ends

Discussion: These nozzles should be considered medium risk to develop PWSCC. They are exposed to a high service temperature and have been welded on both ends. The nozzle material is below the 50 ksi guideline for high risk applications. PWSCC that has occurred to date has been in the pressurizer steam space.

References: CEOG Task 634
CE Drawing E-231-985 (M-1LA SH 985)

Drawings:


STEP I
PRELIM. MACH'G & WELDING



STEP II
WELDING AND FINAL MACHINING
LOWER LEVEL NOZZLE ASSY

Attachment 2
Page 8

12-14-90

TEMPERATURE NOZZLES (2) (ASSEMBLY 986-07/18)

Service: (Assembly 986-07) Pressurizer Liquid Space (653F)
(Assembly 986-18) Pressurizer Steam Space (653F)

Inconel 600

| | | |
|---|---|---|
| 986-08 | Temperature Nozzle | Yield 46,200 psi |
| 986-19 | temperature Nozzle | Yield 46,200 psi |

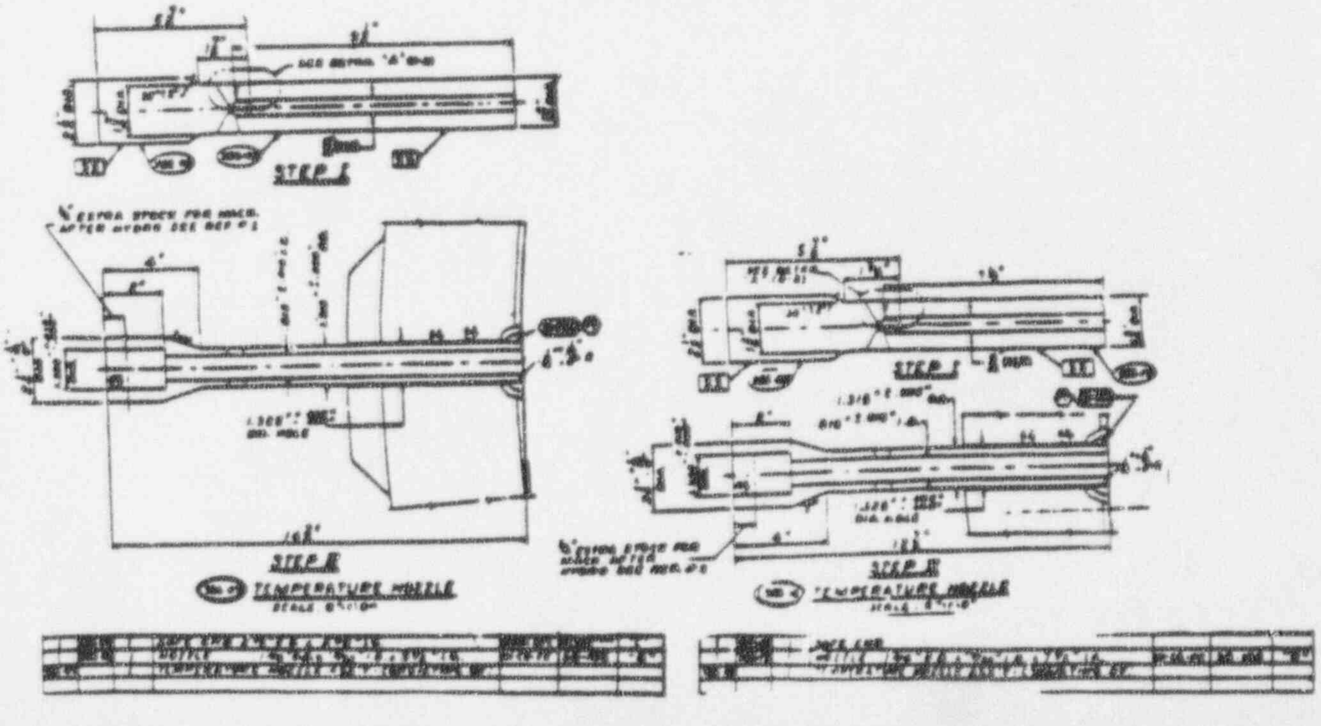
Rework: None

Source of Residual stress: Partial penetration welds done on the inside of the pressurizer. These nozzles have the same configuration as those that failed at other CE plants.

Discussion: These nozzles should be considered medium risk to develop PWSCC. They are exposed to a high service temperature and have been welded on one end. The nozzle material is below the 50 ksi guideline for high risk applications. PWSCC that has occurred to date has been in the pressurizer steam space. The internal J weld geometry makes repairs more difficult than on other Palisades nozzles.

References: CEOG Task 634
CE Drawing E-231-986 (M-1LA SH 986)

Drawings:



# CEOG TASK 633

# PRESSURIZER NOZZLE EVALUATION

## OBJECTIVE

Provide an assessment of susceptibility to PWSCC of CE pressurizer instrument nozzles fabricated from forged Inconel 600.

## STATUS

This test is complete. The final report was issued 02-18-91.

## SCOPE

1. Compile manufacturing data.
2. Complete destructive evaluation of Calvert Cliffs-2 leaking pressurizer nozzle.
3. Evaluate the Calvert Cliffs-2 nozzle and SONGS-3 leaking nozzles.
4. Develop susceptibility criteria for hot forged Inconel 600, or identify additional activities.
5. Complete report.

## DISCUSSION

There is very little published information on PWSCC susceptibility of hot forged Inconel 600. It is likely that additional work will be required in this area. Preliminary information indicates hot forged Inconel 600 is different than cold worked Inconel 600. Tubular products are cold worked.

Pressurizer heater sleeves are tubular materials. Other PCS nozzles were produced from hot forged Inconel 600. The following summarizes information known to date:

1. SONGS-3 experienced PWSCC of 4 pressurizer instrument nozzles. These nozzles had very high yield strength. The failure was attributed to a particular material heat number.
2. St. Lucie inspected 1 nozzle of the same heat number. It was cracked. They replaced all 6 nozzles of similar heat number.
3. Calvert Cliffs-2 inspected pressurizer nozzles. They found 1 leaking and cracked. The original material was of low yield strength but had been reworked twice.
4. The Navy has experienced PWSCC failures of forged Inconel 600 at temperatures lower than CE pressurizer temperatures. Navy nozzles are rolled into place and welded.

CEOG TASK 633

PRESSURIZER NOZZLE EVALUATION

DISCUSSION (continued)

5. EdF has experienced PWSCC of forged Inconel 600, including circumferential indications. Edf nozzles are rolled and welded. EdF found two cracked nozzles and performed NDE on some additional pressurizer nozzles. They found 40 additional nozzles that were cracked but not yet leaking.

   It is expected that these criteria will identify the most likely new crack locations. If PWSCC becomes widespread, the criteria may need to be broadened to ensure that all leaks are found. A nozzle would be classified as high risk if it is in the pressurizer, and either has a high yield strength or has been reworked.

6. B&W and Westinghouse have forged Inconel 600 nozzles in their NSSS. ANO-1 (B&W Plant) recently experienced a cracked Inconel 600 nozzle in the pressurizer. B&W performed stress relief of the pressurizer after the nozzle welding was done. B&W had used this argument (stress relief) as the basis for saying PWSCC would not occur on B&W plants. The nozzle material has a yield strength of 46 ksi, and a microstructure typical of low temperature annealed forged alloy 600.

7. Both B&W and Westinghouse have experienced PWSCC of forged Inconel 600 tube plugs. Both companies cold work the material during installation.

CE nozzles are not rolled. They were slid into place and welded. It is presently believed that the rolling introduced a stress that has led to circumferential cracking.

CE has evaluated the BG&E nozzle. CE concluded that:

1. The mechanism was Primary Water Stress Corrosion Cracking (PWSCC).
2. The material was typical for forged material.
3. Low strength forged Inconel 600 will crack.

No evidence of chemical contamination was found. This supports the cracking being PWSCC. Hot worked Inconel 600 produces more variations in yield strength, grain size, and carbide precipitation. This makes evaluating characteristics that promote PWSCC much more difficult. Previous work done on steam generator tubes (cold worked) probably will not accurately predict the susceptibility of hot forged nozzles. CE is looking at the affects of the J weld on the metal microstructure.

The BG&E nozzle cracks initiated on the internal diameter (ID). Crack growth indicated the rate was very slow. This indicates high tensile stress existed on the nozzle ID, and was initially relieved by the cracking. Crack growth slowed because operating stresses are much lower than presumed residual stresses. Higher stress is necessary to initiate a crack than to propagate one.

CE also evaluated a failed SONG-3 nozzle. The material properties were very different than the Calvert Cliffs Unit 2 nozzle. There are no clearly defensible criteria for classifying the susceptibility of forged Inconel 600 products.

## CEOG TASK 633

## PRESSURIZER NOZZLE EVALUATION

Calvert Cliffs-2 found their leaking nozzles during an external inspection. Boric acid crystals were present. SONGS-3 found their leak due to steam leakage observed during a startup walkdown.

All Inconel 600 forged product has some susceptibility to PWSCC. The CEOG Inconel 600 Working Group has developed the following <u>draft</u> criteria for identifying high susceptibility locations:

1. **Service temperature.** All cracks found to date have been located in the pressurizer. The service temperature is 50° higher than the PCS temperature.
2. **Material yield strength.** All cracks found to date have been in nozzle materials with a yield strength greater than 50 ksi. The one Calvert Cliffs Unit 2 nozzle that is an exception was reworked twice. It was repaired with stick welding, not tig welding as originally done by CE.
3. **Rework or cold work.** Reworking a nozzle can introduce higher residual stresses. CE did not roll or expand nozzles during installation.

It is expected that these criteria will identify the most likely new crack locations. If PWSCC becomes widespread, the criteria may need to be broadened to ensure that all leaks are found. A nozzle is classified as high risk if it is in the pressurizer, and either has a high yield strength or has been reworked.

<u>BUDGET</u>

| | |
|---|---|
| Total: | $152,000 |
| Participants: | 9 |
| Palisades Share: | $ 17,000 |
| Authorized Per WBS: | 43001 |

# CEOG TASK 634

## INCONEL 600 PENETRATION INFORMATION

### OBJECTIVE

Define the metallurgical properties of Inconel 600 penetrations installed in CE plants.

### SCOPE

1. Provide the material and fabrication history for all Inconel 600 primary pressure boundary penetrations.

2. Identify non-conformance that were identified during construction.

### DISCUSSION

This task is being done to help understand the metallurgical properties of the material currently installed in CE plants. This is a long lead time task that will help us assess the susceptibility of individual penetrations to PWSCC.

### STATUS

Final report received 1-23-91. Work is complete.

### BUDGET

| | |
|---|---|
| Total: | $205,000 |
| Participants: | 8 |
| Palisades Share: | $ 25,600 |
| Authorized Per WBS: | 43001 |

## CEOG TASK 635

## QUALIFICATION OF EDDY CURRENT EXAM TECHNIQUES

Palisades is not participating in this task.

### OBJECTIVE

This task will provide a qualified eddy current technique for inspecting pressurizer heater sleeves. If leakage were to develop in one sleeve this would provide a qualified method of inspecting the other sleeves.

### STATUS

This task is complete. Palisades did not participate in this task.

### SCOPE

1. Develop heater sleeve standards.
2. Qualify NDE technique and procedure against known standards.

### DISCUSSION

The CEOG Working Group felt it would be beneficial to have a qualified method available for inspecting pressurizer heater sleeves. This will allow all sleeves to be inspected if a leak occurs. This will reduce the time needed to respond to a leaking penetration.

This technique was used at Maine Yankee in the spring of 1990. 4 sleeves were inspected in 18 hours. No defects were found.

Palisades elected not to participate in this task due to budgetary considerations.

### BUDGET

| | |
|---|---|
| Total cost: | $36,000 * |
| Participants: | 4 |
| Palisades Cost: | 0 - Not participating |

* St. Lucie is paying for a majority of the project cost. This cost allows CEOG participants to use the technology.

## CEOC TASK 636

## PRESSURIZER HEATER SLEEVE EVALUATIONS

### OBJECTIVES

1. Compare metallurgical condition of Calvert Cliffs-2 heater sleeves that did not crack with sleeves that cracked in service at Calvert Cliffs-2 and ANO.

2. Determine the magnitude and orientation of stresses in pressurizer heater sleeves.

3. Determine the effects of localized stress relief.

### STATUS

A draft copy of the final report was issued for comment on 05-01-91.

### SCOPE

1. Destructively examine 8 Calvert Cliffs-2 (CC-2) sleeves and 2 ANO sleeves.

2. Evaluate data from failed sleeves and sleeves that did not fail. Try to characterize failure.

### DISCUSSION

Task 1 is complete. All 10 heater sleeves have been destructively examined. The following are the results:

1. CE found smeared metal on the ID of 9 of 10 sleeves. 1 sleeve from ANO was not smeared. They found smeared metal in the non-machined/reamed area of 4 sleeves.

2. They found evidences of intergranular penetrations 1 grain deep on 1 sleeve in a non-reamed area. This was also observed in some new Inconel 690 tubing. This is probably due to the manufacturing process.

3. No significant microstructure differences were observed.

Welding introduces many variables affecting sleeves. CE preliminary conclusion is that the CC-2 sleeves would all have cracked over time. There were no differences in the metallurgy of the cracked and non-cracked sleeves.

CE constructed a mockup to determine if the tensile stress required for PWSCC was caused by welding. Destructive examination of the heat affected zone demonstrated that the welding process does produce the necessary tensile hoop stress. The stress was found where it was predicted, confirming previous thoughts on the mechanism.

## CEOG TASK 636

## PRESSURIZER HEATER SLEEVE EVALUATIONS

DISCUSSION (continued)

CE examined four pressurizer heater sleeve mockups to determine the affects of welding on residual stress. The four mockups were:

1. Reamed and then welded.
2. Welded in a non-reamed area.
3. Welded in non-reamed area and then reamed.
4. Welded in reamed area and then stress relieved.

CE concluded:

1. Stress relief may lower residual stress, but may actually change the Inconel 600 structure to make it more susceptible to PWSCC.

2. There are high tensile stresses near the heat affected zone at the inner surface. These stresses are circumferential which would produce an axial PWSCC crack.

3. The non-prereamed welding also produced high stresses, but not as high. Applying EPRI's predictive model concludes that the statistical life of the non-prereamed sleeve is 4½ times longer. PWSCC is still predicted to occur.

4. Residual stress values are not absolute numbers. They are relative measures of residual stress.

5. This work directly supports the earlier conclusions with some engineering basis. The residual stresses caused near the Heat Affected Zone by welding are directly dependent on the material properties. Pre-reaming results in high hardness/high yield strength at the ID of the sleeve. Welding then creates residual stresses that are limited by the materials properties at the surface. The residual stresses govern PWSCC susceptibility. High strength non-reamed material is slightly less concern, but residual stress is still governed by material properties. Low strength material is tensilly stressed due to welding, but susceptibility is lower because residual stresses are governed by material properties. The present CE number for susceptibility is 40 ksi residual stress.

6. All Inconel 600 sleeves are susceptible to PWSCC. The susceptibility is relative and time related. Installation processes and material properties will affect the susceptibility of each plant and each sleeve. Many sleeves may not experience PWSCC during the 40 year life of the plant.

7. Post weld reaming did not produce tensile stresses. It actually appeared helpful in lowering the tensile stress on the inner sleeve diameter.

8. Reamed and non-reamed areas remote from the weld have compressive or low tensile stresses.

9. The original plant rankings (CEN-393) of heater sleeve susceptibility should not be changed.

## CEOC TASK 636

## PRESSURIZER HEATER SLEEVE EVALUATIONS

DISCUSSION (continued)

Corrosion testing to determine the minimum residual stress necessary to produce PWSCC was completed in May of 1991. C-ring specimens were stressed to different stress levels to determine the affects on PWSCC initiation. The maximum induced stress was 80 ksi. Testing did not produce PWSCC initiated cracks. This may be due to the yielding of the C-ring specimen, resulting in a lower stress being present. The test results do indicate that the welding process induces a tensile stress greater than 80 ksi.

An analysis of a sleeve that failed at ANO-2 in 1987 determined that that failure was also due to PWSCC. Several heaters failed and swelled. The heater induced a large tensile stress on the heater sleeve which resulted in a PWSCC leak developing in the pressurizer heater sleeve.

BUDGET

| | |
|---|---|
| Total: | $256,000 |
| Participants: | 7 |
| Palisades Share: | $ 36,600 |
| Authorized Per WBS: | 43001 |

# CEOC TASK 637

## PRESSURIZER SHELL CORROSION TESTING

### OBJECTIVE

To demonstrate that the development of a leak on-line will not seriously erode the pressure boundary and jeopardize plant safety.

### STATUS

The task is complete. The final report was issued 04-29-91.

### SCOPE

1. Construct a mock-up of a pressurizer heater sleeve. Measure corrosion rates of shell material associated with a PWSCC initiated leak.

### DISCUSSION

Existing corrosion data is very conservative. The corrosion that actually occurred at BG&E was minor. Measuring corrosion under actual leakage conditions will accurately represent what we would expect in the plant. This supports the position that a PWSCC initiated leak will not jeopardize plant safety.

The testing that was performed is conservative. The erosion/corrosion test began with a significant crack, and utilized steam generator tubing. Steam generator tubing is thinner than pressrizer heater sleeves. CE used SA-533B base material, five inches thick, with a two to eight mil clearance between the tube and base material. Test temperature was 600F with 800 PPM boron.

The preliminary test results are as follows:

1. There was no hidden corrosion damage. A visual inspection is an effective method of ascertaining damage.
2. The corrosion consisted primarily of pitting, with very little base metal erosion.
3. Very little base material was removed during the test. Most of the base metal inner bore was not corroded.

This test demonstrated that previously published erosion/corrosion data is excessive for this application.

### STATUS

Testing has been completed. The test report will be issued on 2-1-91. CPCo voted yes on Supplement 1.

### BUDGET

| | 1990 | 1991 |
|---|---|---|
| Total: | $60,000 | $28,500 (Supplement 1) |
| Participants: | 9 | 7 |
| Palisades Share: | $ 7,500 | 4100 |
| Authorized Per WBS: | 43001 | 43001 |

## CEOG TASK 639

## PRESSURIZER HEATER SLEEVE THERMAL ANALYSIS

### OBJECTIVE

This task will help determine why the PWSCC that occurred at Calvert Cliffs-2 occurred where it did, and will help us understand where we should be most concerned.

1. Develop a temperature profile of a typical pressurizer heater sleeve.

### STATUS

This task is complete. The final report was issued 04-29-91.

### SCOPE

1. Develop a computer model simulating expected thermal profiles.

### DISCUSSION

The area cracking that has occurred appears to be between 644°F and 647°F. The temperature in this region of the sleeve is relatively independent of the insulation configuration.

### BUDGET

| | |
|---|---|
| Total: | $53,000 |
| Participants: | 7 |
| Palisades Share: | $ 7,600 |
| Authorized Per WBS: | 43001 |

# EA-SC-93-087-01

# ATTACHMENT 7

# GTA Welding Spec

Proc No 10.41
Attachment 4
Revision 17
Page 1 of 2

# PROCEDURE TRAVELER

Procedure Title WELDING PROCEDURE SPECIFICATION (WPS): ABB/COMBUSTION ENGINEERING NUCLEAR SERVICES GAS TUNGSTEN ARC -- MANUAL

Procedure No GTA-8.8-910 Revision No 10 Date Initiated 10/15/93

Sponsor Chad Main Return to Initiator By 10/16/93

| Assigned Activity √/I | Activity | Reviewer | Activity Person Hours | Activity Completed By Print Name & Initial |
|---|---|---|---|---|
| ✓ | ☑ Urgent Revision<br>☐ Urgent Editorial | | | Chad Main 10/15/93 |
| N/A | Applicability Review<br>☐ Inactivate ☐ Retain-Revise ☐ Retain-No Revision ☐ Cancel<br>☐ Cancel - Replaced by: ______ ☐ Retain-Editorial | | | |
| ✓ | Draft Development<br>Start Date: / /<br>Completion Date: 10/15/93 | | | |
| ✓ | Technical Review*<br>Comments: ☐ Yes ☒ No<br>Review Completed: 10/16/93<br>Comment Resolution: / / | Jerry Nordby | .5 | J.NORDBY JJN |
| N/A | ALARA Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | Copy provided to ALARA for Information Only | | |
| N/A | Environmental Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| ✓ | User Review*<br>PQR performed by CE for this procedure.<br>Comments: ☐ Yes ☑ No<br>Validation Performed: ☑ Yes ☐ No<br>Review Completed: 10/16/93<br>Comment Resolution: / N/A / | Scott Cedarquist | .1<br>— | SCC 10/16/93<br>Scott Cedarquist |
| ✓ | PS&L Review*<br>Comments: ☐ Yes ☒ No<br>Safety Evaluation # ~~[illegible]~~<br>Review Completed: 10/16/93<br>Comment Resolution: / / | Jeff Erickson<br>93-014 | .1 | J.S.ERICKSON JSE<br>Accepted per telecon 10/16/93 |
| ✓ | Sponsor Review<br>Review Completed: 10/16/93<br>Comment Resolution: / / | | | |
| ✓ | Manager Approval<br>Completed: 10/16/93 | | | J.C.Nordby JJN |
| N/A | Typing<br>In: / /<br>Out: / / | | | |
| ✓ | Sponsor Approval<br>Completed: 10/16/93 | | | Chad Main |
| ✓ | DCC Control & Distribution<br>In: / /<br>Out: / / | | | |
| | ANII | K.L BLAKE | | K.L BLAKE KLB 10-20 93 |
| | | | | |

Procedure No. GTA-8.8-910
Revision No. 10
Issued Date 7/19/93

# PALISADES NUCLEAR PLANT
# WELDING PROCEDURES

## TITLE:

WELDING PROCEDURE SPECIFICATION (WPS): ABB/COMBUSTION ENGINEERING NUCLEAR SERVICES

GAS TUNGSTEN ARC -- MANUAL

Chad W. / 10/16/93
Procedure Sponsor / Date

/ 10/16/93
Technical Reviewer / Date

Scott Cedarquist / 10/16/93 / 10
User Reviewer / Date / Rev #

# PALISADES NUCLEAR PLANT
# SAFETY REVIEW

PS&L Log No 93-1214

Item Identification: No GTA-8.8-910 Rev 10 Title WELDING PROCEDURE SPECIFICATION (WPS): ABB/CE ENG. NUC. SVCS. GAS TUNGSTEN ARC - MANUAL

SE Rev

Describe Issue/Change: PRESSURIZER NOZZLE REPAIRS BY COMBUSTION ENGINEERING

Reason for Issue/Change: PROCEDURE REQUIREMENT BY ADMINISTRATIVE PROCEDURE 5.06

| | Yes | No |
|---|---|---|
| 1. Does the item involve a change to procedures as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 2. Does the item involve a change to the facility as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 3. Does the item involve a test or experiment not described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 4. Should the Technical Specifications or any of their Bases be changed in conjunction with this item?<br>TS Sections affected NONE<br>TS Sections reviewed 3.0, 4.0 | | X |

Justify No Answers below if logic is not obvious:

Although welding, post weld NDE testing and heat treating are discussed in the FSAR, the same processes that are discussed will be followed for this Vendor support.

If any Safety Review question listed above is answered "YES", perform a written USQ Evaluation according to Section 5.3.

If all Safety Review questions listed above are answered NO, written USQ Evaluation is not required. However, this Attachment shall accompany other review materials for the item to document that a Safety Evaluation was not required.

Accepted by Jeff Erickson per telecon 10/16/93 CWM

| | |
|---|---|
| Chad W. [illegible] 10-15-93 | J Erickson 10/18/93 |
| Prepared By Date | Reviewed By Date |

# WELDING PROCEDURE SPECIFICATION (WPS)
# ABB/COMBUSTION ENGINEERING
# NUCLEAR SERVICES

Company Name ABB Combustion Engineering By: W. V. Gwaltney
WPS GTA-8.8-910 Date 08/10/84 Support. PQR(s) GTA-8.8-100
GTA-8.8-104
Rev. No. 10 Date 07/19/93 Weld Process(es) Gas Tungsten Arc Type(s) Manual
(Automatic, Manual, Machine, or Semi-Auto.)
By: W.V. Gwaltney

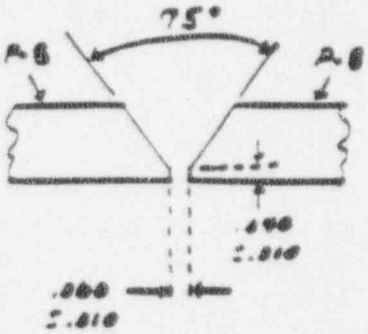
**JOINTS (QW-402)**

Joint Design Single "V" Groove No Retainers
Backing (Yes) X No
Backing Material (Type) Argon Gas
(Refer to both backing and retainers)

__ Metal __ Nonfusing Metal

__ Nonmetallic X Other

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.



***BASE METALS (QW-403)**

P-No. 8 Group No. 1 to P-No. 8 Group No. 1
OR
Specification Type and grade SA240 Type 304
to Specification type and grade SA312 Type 316
OR
Chem. Analysis and Mech. Prop. Not Applicable
to Chem. Analysis and Mech. Prop. Not Applicable
Thickness Range:
Base Metal: Groove 1/16" to 3/4" max. Fillet Unlimited
Pipe Dia. Range: Groove 1" to Unlimited Fillet Unlimited
Other

***FILLER METALS (QW-404)**

Spec No. (SFA) 5.9 ER308/ER308L Stainless Bare Wire (solid)
AWS No. (Class) ER308/ER308L
F-No. 6 Consumable Insert None
A-No. 8
Size of Filler Metals .062" or .093" Diameters
Deposited Weld Metals Not to exceed 1/2" thickness per pass.
Thickness Range: no min. to 3/4" max.
Groove no min. to 3/4"; 100% GTA
Fillet Unlimited
Electrode-Flux (Class) None
Flux Trade Name None
Other Qualified to weld grooves, fillets, and repairs on P8 base materials with A8 stainless filler in all positions.
SA312 "t" qualified = .375", SA240 "t" qualified = .187"

***Each base metal filler/metal combination should be recorded**
Independent Reviewer K.E. Coe K.E. Coe Date 7/28/93

# WELDING PROCEDURE SPECIFICATION (WPS)
# ABB/COMBUSTION ENGINEERING
# NUCLEAR SERVICES

WPS NO. GTA-8.3-910 Rev. 10

**POSITIONS (QW-405)**
Position(s) of Groove All
Weld Progression: Up X Down ___
Position(s) of Fillet All

**PREHEAT (QW-406)**
Preheat Temp. Min. 60 deg. F
Interpass Temp. Max. 350 deg. F
Preheat Maintenance None
(Continuous or special heating, if applicable.) None

**POSTWELD HEAT TREATMENT (QW-407)**
Temperature Range None
Time Range None

**GAS (QW-408)**

| | Percent Composition | | |
|---|---|---|---|
| | Gas(es) | (Mixtr) | Flow Rt |
| Shield. | Argon | 99.99% | 10±3 CFH |
| Trail. | None | | |
| Back. | Argon | 99.99% | 5±2 CFH |

Backing gas not applicable to fillet welds.

**ELECTRICAL CHARACTERISTICS (QW-409)**
Current AC or DC DC Polarity SP Pulsed No
Amps (Range) See Below Volts (Range) See Below
(Amps and volts range should be recorded for each electrode size, position, and thickness, etc.

Tungsten Electrode Size and Type 3/32" Diameter EWTh-2%
(Pure Tungsten, 2% Thoriated, etc.)
Mode of Metal Transfer for GMAW Not Applicable
(Spray arc, short circuiting arc, etc.)
Electrode Wire Feed Speed Range Manually as Needed

**TECHNIQUE (QW-410)**
String or Weave Bead Stringer or Weave
Orifice or Gas Cup Size 3/8" I.D. max.
Cleaning Initial Grinder or S.S. Wire Brush Interpass Same
Method of Back Gouging None
Oscillation 1/4" max.
Contact Tube to Work Distance Manually Controlled to 3/8" max.
Multiple or Single Pass (per side) Single or Multiple
Multiple or Single Electrodes Single
Travel Speed (Range) Manually
Peening Not Allowed
Other

| Bead No.(s) | Process | Filler Metal | | Current | | Volt Range | Travel Speed Range | Other Remarks, Comments |
|---|---|---|---|---|---|---|---|---|
| | | Class | Dia. | Type Polar. | Amp. Range | | | |
| All | GTA | SFA5.9 | .062<br>.093 | DCSP<br>DCSP | 80-110<br>95-125 | 11-12<br>11-12 | Manual<br>Manual | |

# WELDING PROCEDURE QUALIFICATION RECORD

EA-SC-93-087-01
Attachment 7
Page 6 of 7
E-563 (1/7

## COMBUSTION ENGINEERING, INC.

DATE November 10, 1972

Editorial Correction: 07/19/93

PROCEDURE QUALIFICATION NO. GTA-8.8-100

QUALIFIED TO CODE SECTION(S) III

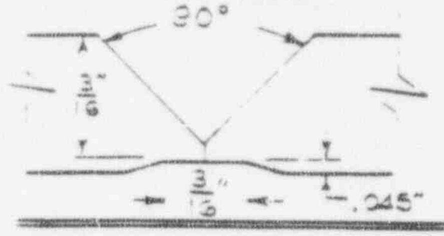
MATERIAL SPEC. & GRADE SA-240 Tp 304 TO SA-240 Tp 304

| | | | |
|---|---|---|---|
| FOR WELDING P No 8 TO P No 8 | | THICKNESS (& DIA. IF PIPE) | 2"Ø X 3/16" |
| WELDING PROCESS | Gas Tungsten Arc | TYPE WELD JOINT | Single "V" |
| FILLER METAL F No 7 A No 7 | | POSITION TEST WELD | Horiz. & Vert. Fixed |
| SPEC. or ANALYSIS | SFA-5.9 ER-308 | SINGLE or MULTIPLE PASS | Multiple |
| ELECTRODE SIZE | 1/16"Ø EWTH-2 | NO. OF LAYERS (IF CLAD) | - |
| FLUX | | NO. OF ARCS | Single |
| SHIELDING GAS(ES) & COMPOSITION | Argon | PREHEAT | 60°F Min. |
| FLOW RATE | 10 CFH | MAX. INTER-PASS | 300°F Max. |
| TYPE CURRENT | DC-SP | MAINTAIN PREHEAT UNTIL PWHT | - |
| BACKING REQUIREMENTS | | POSTHEAT TREATMENT | None |

OTHER: Argon Back Purge @ 5 CFH "T" range qualifies = 0.062" min. to 0.375 m

No trail gas, [illegible], 02/24/93

JOINT DESIGN



| BEAD NO. | PROCESS | WIRE DIA. | AMPERES | ARC VOLTS | INCHES/MIN. |
|---|---|---|---|---|---|
| All | GTA | 1/16" | 95-105 | 11-13 | |
| | | | | | |
| | | | | | |
| | | | | | |

% FERRITE IN AUSTENITIC CLAD DEPOSIT

DEPOSIT ANALYSIS C ___ Mn ___ P ___ S ___ Si ___

Cr ___ Ni ___ Mo ___ Co ___ N2 ___ Other ___

**GUIDED BEND TESTS**

FACE 4 Acceptable
ROOT 4 Acceptable
SIDE
MACRO:

**CHARPY V-NOTCH IMPACT TESTS**

| LOCATION | TEMP | FT/LBS | MILS LAT EXP |
|---|---|---|---|
| | | | |

THIS DOCUMENT IS THE PROPERTY OF COMBUSTION ENGINEERING, INC., WINDSOR, CONN. AND IS NOT TO BE REPRODUCED, OR USED TO FURNISH ANY INFORMATION FOR MAKING DRAWINGS OR APPARATUS EXCEPT WHERE PROVIDED FOR BY AGREEMENT WITH SAID COMPANY.

**DROP-WEIGHT TESTS**

| TEMP | RESULTS |
|---|---|
| | |

NDT °F

**NON-DESTRUCTIVE TESTS**

| | |
|---|---|
| LIQUID PENETRANT | |
| RADIOGRAPHIC | |
| ULTRASONIC | |
| MAG. PARTICLE | |
| VISUAL | Acceptable |

**TENSILE TESTS**

| TYPE SPECIMEN | ULTIMATE STRESS—PSI | CHARACTER & LOCATION OF FAILURE |
|---|---|---|
| Trans. | 86,200 | Base Material |
| Trans. | 84,800 | Base Material |
| Trans. | 84,200 | Base Material |
| Trans. | 85,000 | Base Material |

WELDER C. Overby SYMBOL M1

DEPT Chattanooga

TEST NO GTA-8.8-100

TEST LAB. Met R&D Dept.

We certify that the statements in this record are correct, and that the test welds were prepared, welded and tested in accordance with requirements of the ASME Code.

COMBUSTION ENGINEERING, INC

BY J. Dinwiddie

BY OTHER K.E. Coe K.E. Coe 4/29/93 TITLE Engineer

WAS IA-88-7,8

E-663 (4/80

# WELDING PROCEDURE QUALIFICATION RECORD

## COMBUSTION ENGINEERING, INC.

DATE January 20, 1982

Editorial Correction: 07/19/93

PROCEDURE QUALIFICATION NO GTA-8.8-104

QUALIFIED TO CODE SECTION(S) III, IX and RDT

MATERIAL SPEC. & GRADE SA-312 Type 316 TO SA-312 Type 316

FOR WELDING P No 8 TO P No 8

WELDING PROCESS Gas Tungsten Arc

FILLER METAL F No ~~6~~ 36 CE Hackett 03/02/93 A No 8

SPEC. or ANALYSIS SFA-5.9/RDT M1-2T ER-16-8-2

ELECTRODE SIZE 3/32" Ø EWTH-2

FLUX N/A

SHIELDING GAS(ES) & COMPOSITION Argon

FLOW RATE 12-15 CFH

TYPE CURRENT D.C.-S.P. Hi frequency start

BACKING REQUIREMENTS Argon Purge @ 5 CFH

THICKNESS (& DIA. IF PIPE) .375" x 8.00" Ø

TYPE WELD JOINT U-Groove

POSITION TEST WELD Horizontal Fixed (2

SINGLE or MULTIPLE PASS Multiple

NO. OF LAYERS (IF CLAD) N/A

NO. OF ARCS One

PREHEAT 60°F

MAX. INTER-PASS 350°F

MAINTAIN PREHEAT UNTIL PWHT As welded

POSTHEAT TREATMENT As welded

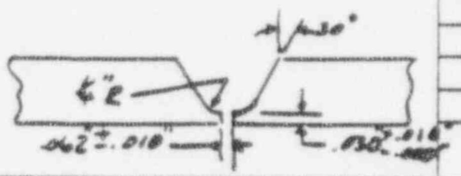
"T" range qualifies = 0.062" min to 0.750"

OTHER: Purge maintained for at least the first 3/16" thickness of weld deposit.

Purge: Argon, 5 CFH 02/26/93 CE Hackett

No trail gas —

JOINT DESIGN



| BEAD NO | PROCESS | WIRE DIA | AMPERES | ARC VOLTS | INCHES/MIN |
|---|---|---|---|---|---|
| All | GTA | 1/16" | 125-130 | 11-12 | |

% FERRITE IN AUSTENITIC CLAD DEPOSIT

DEPOSIT ANALYSIS C 0.043 Mn 1.61 P 0.014 S 0.014 Si 0.46

Cr 16.32 Ni 9.69 Mo 1.85 Co 0.04 N2 0.045 Other Cu - 0.

V - 0.04 Ti-<0.01 Cb+Ta-<0.01 Tungsten -<0.01

GUIDED BEND TESTS

FACE

ROOT

SIDE 4 Ok (Transverse)

MACRO

Acceptable

(Full Penetration)

CHARPY V-NOTCH IMPACT TESTS

| LOCATION | TEMP | FT/LBS | MILS LAT EXP |
|---|---|---|---|
| | | | |

DROP-WEIGHT TESTS

| TEMP | RESULTS |
|---|---|
| NDT | °F |

NON-DESTRUCTIVE TESTS

| | |
|---|---|
| P.T. | Ok H.Patrick (8-25-81) |
| R.T. | Ok C.S.Matthews (8-31-81) |
| U.T. | |
| M.T. | |
| VISUAL | |

TENSILE TESTS

| SPEC. NO. | DIMENSIONS WIDTH | DIMENSIONS THK. | AREA SQ. IN | ULTIMATE LOAD-LBS | ULTIMATE STRESS-PSI | CHARACTER AND LOCATION OF FAILU |
|---|---|---|---|---|---|---|
| OB-A | .785 | .376 | .29516 | 27550 | 93.3 | Base Metal-Du |
| OB-B | .770 | .406 | .31262 | 29500 | 94.4 | Base Metal-Du |

OTHER Chem.Analysis-Base Mat'l: C-0.049, Mn-1.77, P-0.024, S-0.012, Si-0.61, Ni-13.16, Cr-17.07, Mo-2.96, Ti-<.01, Cb-<.01 V- 0.05, Co-0.07, Cu- 0.14, N2- 0.12

WELDER J.W.Ragon SYMBOL AUK

DEPT Chattanooga

TEST NO 960001

TEST LAB Metallurgical R&D Lab.

We certify that the statements in this record are correct, and that the test welds are prepared, welded and tested in accordance with requirements of the ASME Code.

COMBUSTION ENGINEERING, INC

BY E.W. Turner

BY OTHER

TITLE K.C. Coe
K.C. Coe 4/19/93

# EA-SC-93-087-01

# ATTACHMENT 8

# Half Bead Welding Effects

CONSUMERS
POWER
COMPANY

Internal
Correspondence
JCN93*029

To SSOverway, Palisades

From JCNordby, Palisades

Date October 18, 1993

Subject Effects of Half Bead Welding on Base Metals

CC DJVandeWalle, Palisades

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Modifications will be made to TE-0101 and TE-0102 on the pressurizer using the half bead welding technique as an alternative to conventional postweld heat treatment (PWHT). However, a question was raised as to what effect this welding technique will have on pressurizer and/or nozzles. As a result I am writing this letter to inform you that, for the intended application, there will be no significant adverse effects on the pressurizer and/or nozzle resulting from the use of ABB/Combustion Engineering welding procedure specification (WPS) SMA-3.43-937 (half bead welding).

Essentially, the reason there will be no adverse mechanical effects on the pressurizer and/or nozzle is the fact that all of the WPSs have been qualified in accordance with ASME Section IX and the half bead welding rules of ASME Section XI. Because there is no way of nondestructively evaluating the mechanical properties of a production weld, WPS qualification test coupons are prepared and destructively tested to establish ranges of variables which will produce sound welds. This qualification has been done for SMA-3.43-937.

No significant adverse metallurgical effects on the pressurizer and/or nozzle are assured basically through control of preheat, interpass and PWHT temperatures. From the standpoint of the pressurizer base metal, the qualification tests described above assure a sound microstructure. The inconel nozzle is a different case.

Inconel is a nickel alloy. Corrosion resistance is one of its more important properties. Outside of the heat affected zone (HAZ) from welding, the inconel nozzle will only see temperatures well under its maximum design temperature and therefore no adverse effects will occur. The area of concern is the HAZ.

The corrosion resistance of the heat affected zone (HAZ) is not verified by the mechanical tests required by WPS qualification. Although far less vulnerable to the effects of temperature on corrosion resistance than austenitic stainless steel, the amount of carbide precipitation resulting from welding temperatures is limited by the 450°F interpass temperature. In addition, the 500°F ±50°F PWHT temperature is far below that required for carbide precipitation (in fact, it is lower than operating temperatures).

The inconel weld metal itself is of least concern. Aside from the qualification tests described above and the inherent as-welded toughness of nickel alloys, the carbon in this weld metal is stabilized. Because of additions of columbium and tantalum, this material will not experience additional carbide precipitation resulting in possible lowering of corrosion resistance, either from the heat of subsequent beads or PWHT.

In conclusion, it should be noted that this modification has been performed at other plants with success. While welding will always have an effect on base metal properties, the question is not simply will the effect be detrimental, but will the effect be detrimental for the intended application. For this intended application, the effects of welding using SMA-3.43-937 will not adversely affect the pressurizer and/or nozzles.

# EA-SC-93-087-01

# ATTACHMENT 9

# Circumferential Crack
# Potential Memo

EXCELLENCE BUILT THROUGH DESIGN

CONSUMERS
POWER
COMPANY

Internal
Correspondence

RBJ93*064

To Design Package File

From RBJenkins, Palisades For RBJ

Date October 18, 1993

Subject NUCLEAR ENGINEERING AND CONSTRUCTION ORGANIZATION POTENTIAL FOR CIRCUMFERENTIAL CRACKS IN MODIFIED PRESSURIZER INSTRUMENTATION NOZZLES

CC

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## INTRODUCTION

Modifications are currently being prepared for two temperature instrumentation nozzles in the Palisades Plant pressurizer. The modifications are being conducted in order to eliminate primary coolant system leakage through what are believed to be axial cracks in the temperature instrumentation nozzles.

The axial cracking phenomenon in these Inconel 600 sleeves, while new at Palisades, has been experienced in the nuclear power industry at many installations over the last several years. In addition, the modifications being contemplated for the instrumentation nozzles have been successfully completed at other plants. The difference between the modifications being considered at Palisades from those completed at other plants is that the Palisades modifications are being planned very shortly after circumferential cracking was discovered in the PORV line. The recent PORV line cracking experience has raised awareness of the potential for circumferential cracking in Inconel 600.

It is the purpose of the discussion below to explain how the PORV line cracking and temperature instrumentation line cracking are different in some very significant aspects and why the differences can explain why circumferential cracking in the temperature instrumentation nozzles is not expected.

## REVIEW OF INSTRUMENT LINE EXPERIENCE

Reference (1) summarizes relevant pressurizer instrumentation cracking experience in France. The nozzle configurations are not unlike those of current concern at Palisades. The welding is a partial penetration/fillet weld detail. The impact of the weld shrinkage is to constrict the instrument tube circumferentially. The instrumentation lines see little in terms of axial loads. Detailed NDE and other test work showed that:

- Most cracks were axial
- Only axial cracks penetrated beyond half the wall thickness
- Weld residual stresses are higher in the circumferential direction than in the axial direction.

Reference (2) is a very comprehensive discussion of pressurizer instrumentation and weld configurations very similar to those of current concern. The conclusions of that work scope include the following:

- The J-weld construction can generate very high residual tensile hoop stresses adjacent to the weld
- Pre-installation reaming tends to result in higher residual stresses
- Axial stresses tend to be compressive or relatively low tensile
- Based upon service experience, laboratory studies and stress analysis, the initiation and propagation of circumferential cracks is unlikely

Reference (3) reviews control rod drive and incore instrumentation nozzle cracking via detailed analysis work. Although the specific application is the reactor vessel, the conclusions apply to the pressurizer instrumentation configurations as well. Those conclusions note that hoop stresses in those systems are greater than axial stresses and that weld residual stresses are significantly higher than externally applied or other operational loads.

## REVIEW OF THE PORV LINE EXPERIENCE

Reference (4) and its enclosures document the PORV line/nozzle cracking. The cracking actually occurred in the Inconel 600 side of the safe end-to-pipe weld. The metallurgical work shows cracks growing radially from the pipe inner diameter and fanning lightly to the outer diameter. While there may have been some axial cracks, joint leakage was clearly a circumferential rather than an axial cracking phenomenon.

The primary difference between the PORV line phenomenon with respect to the instrumentation cracking both at Palisades and elsewhere is that the PROV line weld is a full butt weld and not a partial penetration weld, J-weld or fillet weld. All of these types of welds will provide circumferential weld shrinkage and the resultant potential for axial cracks. The instrumentation line welds, when shrinking axially, see little resistance or restraint to shrinkage from the instrumentation configuration. The instrumentation element is essentially free to be shrunk by the weld. Very near the weld, there may be some axial compressive stress as noted in Reference (2). However, this lack of axial restraint results in an essentially "plane stress" load environment.

For the PORV line condition, the load environment is very different. The butt weld is through-thickness. Therefore, it can shrink the pipe side (or nozzle side) very efficiently. If the pipe side was free and the nozzle side was free during weld shrinkage, it would be very difficult to produce significant axial stress in the pipe or safe end as the pipe could deflect to accommodate the weld shrinkage much as the temperature element would. However, during the field welding of the joint of concern, the nozzle end is fixed by the vessel. The pipe end, while not as rigidly confined as the nozzle end, is well supported if only to support its weight. Therefore, the load environment in the area of the field weld is more akin to "plane strain" because axial movement of the pipe/nozzle is very limited. This constrained configuration permits the development of an axial residual stress field that simply could not have been achieved in the typical temperature instrumentation element configuration.

The design of the PORV line can result in high axial residual weld stresses if the fabrication process (to include welding) does not reduce them due to heat treatment etc. The joint fitup and root configuration can make the joint vulnerable to these residual stresses.

## PALISADES TEMPERATURE NOZZLE MODIFICATION

The modifications to the temperature instrumentation nozzles incorporate pressurizer pad-to-sleeve welds that are essentially the same as the existing J-welds as far as their impact on residual stress fields is concerned. The new welds have the appearance of a fillet weld. As noted, these welds are not as efficient as butt welds in inducing axial stress into the instrumentation nozzle.

For the modification where the nozzle is cut, the temperature element will be essentially free on either side of the exterior weld when the pipe is cut. The cut may reduce axial residual weld stresses induced by the weld shrinkage with the restraint of the element by the inside J-weld. With the cut, the above discussion applies directly with regard to the lack of a mechanism for developing residual axial stress (potentially leading to circumferential cracks).

For the modification where the nozzle is not cut, an axial residual stress field between the new weld (outside) and the J-weld (inside) may exist due to the existing restraint during the welding process. No similar residual stress field will exist external to the new weld. Therefore, an undesirable residual stress loading exists between the welds while all the axial operational loads (internal pressure) will be reacted by the new weld only. While any potential axial residual tensile stress loading is undesirable, that resulting from the current modification is not of immediate concern. The reasons are as follows:

- There are essentially no externally applied mechanical loads to the nozzle
- The potential axial stress distribution from the modification will be new and will require time for the initiation and propagation of the cracks
- The potential axial stress between the welds would be totally self limiting as it is caused by stiffness (restraint) and any local cracking between the pressurizer inner and outer diameter would relieve the load which caused it to occur

## CONCLUSION

Joint configuration and the fabrication process combine to limit the impact of any deleterious effects of weld residual stress in the design of the temperature instrumentation nozzle modification. These considerations along with an awareness of the time limitation of the duty cycle for the joint combine to provide assurance that a catastrophic failure due to circumferential cracking will not occur.

## REFERENCES

1. Alter et al, "Stress Corrosion Cracking of Pressurizer Instrumentation Nozzles in the French 1300 MWe Units," Proceedings on the Fifth International Symposium on Environmental Degradation of Materials in Nuclear Power Systems - Water Reactors, American Nuclear Society, August 1991

2. "Evaluation of Pressurizer Penetrations and Evaluation of Corrosion After Unidentified Leakage Develops, CE-NPSD-690-P," Combustion Engineering Owner's Group, January 1992

3. Safety Evaluation of the Potential For and Consequence of Reactor Vessel Head Penetration Alloy 600 ID Initiated Nozzle Cracking," CEN-607, Combustion Engineering Owner's Group, May, 1993

4. Letter from GBSlade to Nuclear Regulatory Commission, Palisades Plant - Pressurizer Safe End Crack Engineering Analysis and Root Cause Evaluation, October 7, 1993

# EA-SC-93-087-01

# ATTACHMENT 10

# Pressurizer Specification

; Design Specification is certified to be correct and complete and in compliance with the requirements of N-141 of the ASME Boiler and Pressure Vessel Code, Section III, Nuclear Vessels, 1965 Edition, through Winter 1966 addenda.

David L. Sibiga
No. 15540

Certified By 
Registration No. 15540
State of Connecticut
Date October 9, 1991

VERIFICATION STATUS: COMPLETE

The Safety-Related design information contained in this document has been verified to be correct by means of:
✓ Design Review using Checklist(s) 6 of QAM 101.
___ Alternate Analysis - Copy attached.
___ Verification Testing - Test Report No. ___
Gregory Sloneski / / Oct. 4, 1991
Independent Reviewer: Name/Signature/Date

# ENGINEERING SPECIFICATION

# FOR

# A PRESSURIZER ASSEMBLY

## SPECIFICATION NO. 70P-001

Revision 2

Nuclear Power Systems
COMBUSTION ENGINEERING, INC.
Windsor, Connecticut

Prepared By: Robert C. Wheeler Date: 10/4/91
R.C. Wheeler, Cognizant Engineer

Approved By: Date: 10/10/91
J.D. Edmundson, Supervisor, Fatigue Evaluation

Approved By: RODoney Date: 10-10-91
R.O. Doney, Manager, Plant Mechanical Systems

Approved By: Date: 10-10-91
P.J. Hammer, Project Manager

Issue Date: 10/10/91

FORM 40C

COMBUSTION ENGINEERING, IN

| ADDRESSEE | SUBJECT | FROM — DATE |
|---|---|---|

2966C
14

To: W. W. Roberts, Chatt. (3) ✓

APPROVAL OF ASME 1966 WINTER ADDENDA FOR PRESSURIZER

W. K. Wilhelm

February 16, 1967

P-SE-442

xc: V. C. Hall
J. D. Crawford
F. P. Fagan
F. J. Hanzalek
T. L. Kettles (2)
F. A. Lowe, Chatt.
E. W. Woollacott
Project Files

cc. Hastings
J. Abel
G. Carroll
STAN KNIGHT

Reference: (A) W.W. Roberts TT No. 9 to W.K. Wilhelm dated February 2, 1967.

Approval is granted in response to reference (A) to use the Winter 1966 Addenda of the ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Vessels.

This approval applies only to the pressurizer contract, and is void if any increase in cost or extension of delivery results from its application.

WKWilhelm
W. K. Wilhelm

WKW/TLK/JDC:ds

QUALITY CONTROL
MAR 1 1967
S.R.K.

P02278

FORM 42A

COMBUSTION ENGINEERING, INC.

| ADDRESSEE | SUBJECT | FROM — DATE |
|---|---|---|
| Mr. Stan Knight ✓<br>cc: Mr. J. Abel<br>Mr. G. Carroll<br>Mr. R. Armstrong | Consumers Pressurizer<br>Contract 2966C | Nuclear Contract<br>Engineering<br>March 2, 1967 |

The following list of governing specifications are forwarded on a preliminary basis for planning purposes. The list will be confirmed and/or amended by shop order as soon as the contract has been finalized.

1. CEND Specification No. 7CP-001 as tentatively modified by Proposal No. 4-12526-1, Contract 20355 and later agreements.

2. Section III of ASME Code including all Addenda thru Winter 1966 Addenda.

3. Special Code Cases:

| | | |
|---|---|---|
| a. | Case 1338-3 | UT of plate |
| b. | Case 1359-1 | UT of forgings |
| c. | Case 1332-2 | Low Alloy forgings |
| d. | Case 1339-2 | Low Alloy Plate |
| e. | Case 1336 | "Inconel" forgings, plate and tube |

4. CE Purchase Specs:

| | | |
|---|---|---|
| a. | P3F12(b) | Low alloy plate |
| b. | P3C9(d) | Low alloy forgings |
| c. | P43C1(c) | "Inconel" forgings |
| d. | P43B2(b) | "Inconel" pipe |
| e. | P43F3(c) | "Inconel" plate |
| f. | P1F11(b) | Carbon steel plate |

5. M&P Specs:

| | |
|---|---|
| 2.4.1.3(a) | Radiographic Inspection |
| 2.4.2.4(c) | MT Inspection |
| 2.4.3.9(c) | PT, Materials |
| 2.4.3.10(a) | PT, Seal Surfaces |
| 2.4.4.9(c) | UT, Clad Bond |
| 2.4.4.15(b) | UT, Plate |
| 5.3.1.4(c) | Quench and Temper A-533 Plate |
| 5.3.1.5(d) | " " " A-516 Plate |
| 5.5.2.8(d) | Fabrication of Nuclear Shells |

5. M&P Specs: (Cont'd)

Contract Supplement 2966C-1(c) to 5.5.2.8(d)
5.5.2.9(c) Fabrication of Carbon Steel
Contract Supplement 2966C-1(a) to 5.5.2.9(c)
5.5.3.1(a) Cleaning Nuclear Vessels
5.5.6.8(c) Fabrication of heads
Contract Supplement 2966C-1(a) to 5.5.6.8(c)
6.1.1.2(b) General Welding Procedure.

WW Roberts
W. W. Roberts

WWR/lh

Contract 2966C Sheet 1 of 2

# FORM N-1 MANUFACTURERS DATA REPORT FOR NUCLEAR VESSELS

As required by the Provisions of the ASME Code Rules and the National Board

1. Manufactured by Combustion Engineering, Inc., 911 W. Main Street, Chattanooga, Tennessee (Name and address of Manufacturer)

2. Manufactured for Consumers Power Co., 212 W. Michigan Avenue, Jackson, Michigan (Name and address of Purchaser)

3. Type Vert. (Horiz. or Vert.) Kind Heat Ex. (Tank, Jacketed, Heat Ex.) Vessel No (66601 (Mfrs. Serial No.)) ( (State & State No.)) Nat'l Bd. No. 20851 Yr. Built 1969

Items 4-8 incl. to be completed for single wall vessels, jackets of jacketed vessels, or shells of heat exchangers

4. Shell: Material A-533 Gr. B Cl. 1 Alloy Steel (Kind & Spec. No.) T.S. 80,000 (Min. of range specified) Nominal Thickness 6 in. Corrosion Allowance 1/16 in. Diam 9 ft 2-1/2 in. Length Over Heads 26 ft 8-1/

5. Seams: Long Welded H.T.¹ Yes X.R. Yes Efficiency (If Class B

Girth Welded H.T.¹ Yes X.R. Yes No. of Courses 2

6. Heads: (a) Material A-533 Gr. B Cl. 1 Alloy Steel T.S. 80,000 (b) Material A-533 Gr. B Cl. 1 Alloy Steel T.S. 80,000

| Location (Top, bottom, ends) | Thickness | Crown Radius | Knuckle Radius | Elliptical Ratio | Conical Apex Angle | Hemispherical Radius | Flat Diameter | Side to Press (Convex or Conca |
|---|---|---|---|---|---|---|---|---|
| (a) Top | 4-1/8 | 55-5/8" | | | | 55-5/8" | | Concave |
| (b) Bottom | 4-1/8 | 55-5/8" | | | | 55-5/8" | | Concave |

If removable, bolts used (Material, Spec. No., T.S., Size, Number) Other fastening (Describe or attach sketch

7. Jacket Closure (Describe as ogee & weld, bar, etc. If bar give dimensions, describe or sketch)

8. Constructed for ~~operating~~ design press.² 2500 psi at Max. temp. 700 °F Charpy Impact 30 ft-lb at temp. of 40 °F. ~~Pneumatic~~ Hydrostatic or ~~Combination~~ Test Pressure 3125 p

Items 9 and 10 to be completed for tube sections.

Tube Sheets: Stationary. Material (Kind & Spec. No.) Diam. (Subject to press.) in. Thickness in. Attachment (Welded, Bolted)

Floating. Material (Kind & Spec. No.) Diam. in. Thickness in. Attachment

10. Tubes: Material (Kind & Spec. No.) O.D. in. Thickness inches or gage Number Type (Straight or

Items 11 to 14 incl. to be completed for inner chambers of jacketed vessels, or channels of heat exchangers.

11. Shell: Material (Kind & Spec. No.) T.S. (Min. of range specified) Nominal Thickness in. Corrosion Allowance in. Diam ft. in. Length ft.

12. Seams: Long (Welded, Dbl., Single) H.T.¹ (Yes or No) X.R. Efficiency (If Class B)

Girth H.T.¹ X.R. No. of Courses

13. Heads: (a) Material T.S. (b) Material T.S. (c) Material T.S.

| Location | Thickness | Crown Radius | Knuckle Radius | Elliptical Ratio | Conical Apex Angle | Hemispherical Radius | Flat Diameter | Side to Press (Convex or Conc. |
|---|---|---|---|---|---|---|---|---|
| (a) Top, bottom, ends | | | | | | | | |
| (b) Channel | | | | | | | | |
| (c) Floating | | | | | | | | |

If removable, bolts used (a) (Material, Spec. No., T.S., Size, Number) (b) (c) Other fastening (Describe or attach ske

14. Constructed for specified operating press. psi at Max. temp. °F Charpy Impact ft-lb at temp. of °F Pneumatic Hydrostatic or Combination Test Pressure

¹ Postweld Heat-Treated.

² List other internal or external pressures with coincident temperature when applicable.

## FORM N-1 (back)

tems below to be completed for all vessels where applicable.

ety Valve Outlets: Number Three (3) Size 3" Location Top Head

*16. zzles:

| Purpose (Inlet, Outlet, Drain) | Number | Diam. or Size | Type | Material | Thickness | Reinforcement Material | How Attached |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | "See Attachment | | | | | |
| | | | | | | | |

17. Inspection Openings: Manholes, No. One Size 16" Location Top Head
Handholes, No. Size Location
Threaded, No. Size Location

18. Supports: Skirt Yes (Yes or No) Lugs (Number) Legs (Number) Other (Describe) Attached Welded to botto head. (Where & How)

19. Remarks: Pressurizer to be used in the primary system of a pressurized water nuclear power plant.

(Brief description of service for which vessel was designed)

## CERTIFICATION OF DESIGN

Design information on file at Combustion Engineering, Inc., Chattanooga, Tennessee
Stress analysis report on file at Combustion Engineering, Inc., Chattanooga, Tennessee
Design specifications certified by T. L. Kattles Prof. Eng. Yes State N.Y. Reg. No. 029729
Stress analysis report certified by Frank P. Hill Prof. Eng. Yes State Tenn. Reg. No. 5215

ertify that the statements made in this report are correct and that all details of material, design, construction, and workmanship o vessel conform to the ASME Code for Nuclear Vessels.

Date January 15 19 69 Signed Combustion Engineering, Inc. (Manufacturer) By H. N. Dinwiddie
H. N. Di..widdie

Certificate of Authorization Expires December 31, 1970

## CERTIFICATE OF SHOP INSPECTION

VESSEL MADE BY Combustion Engineering, Inc. at Chattanooga, Tennessee

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the Stat of and employed by Hartford Steam Boiler Insp. & Ins. Co. of Hartford, Connectic have inspected the pressure vessel described in this manufacturer's data report on January 12 19[illegible], and state that to the best of my knowledge and belief, the manufacturer has constructed this pressure vessel in accordance with the ASME Code for Nuclear Vessels.

By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressure vessel described in this manufacturer's data report. Furthermore, neither the Inspector nor his employer shall be liable in any manne for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date June 16 19 69

M. R. McLellan
Inspectors Signature

Commissions National Board 2928
National Board or State and No.

M. R. McLellan

## CERTIFICATE OF FIELD ASSEMBLY INSPECTION

I, the undersigned, holding a valid commission issued by the National Board of Boiler and Pressure Vessel Inspectors and/or the State of and employed by of have compared the statements in this manufacturer's data report with the described pressure vessel and state that parts referred to a data items , not included in the certificate of shop inspection hav been inspected by me and that to the best of my knowledge and belief the manufacturer has constructed and assembled this pressur vessel in accordance with the ASME Code for Nuclear Vessels. The described vessel was inspected and subjected to a h atic test of psi.

By signing this certificate neither the Inspector nor his employer makes any warranty, expressed or implied, concerning the pressur vessel described in this manufacturer's data report. Furthermore, neither the Inspector nor his employer shall be liable in any manne for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

Date 19

Inspectors Signature

Commissions
National Board or State and No.

Contract ›6C

Sheet 2 of 2

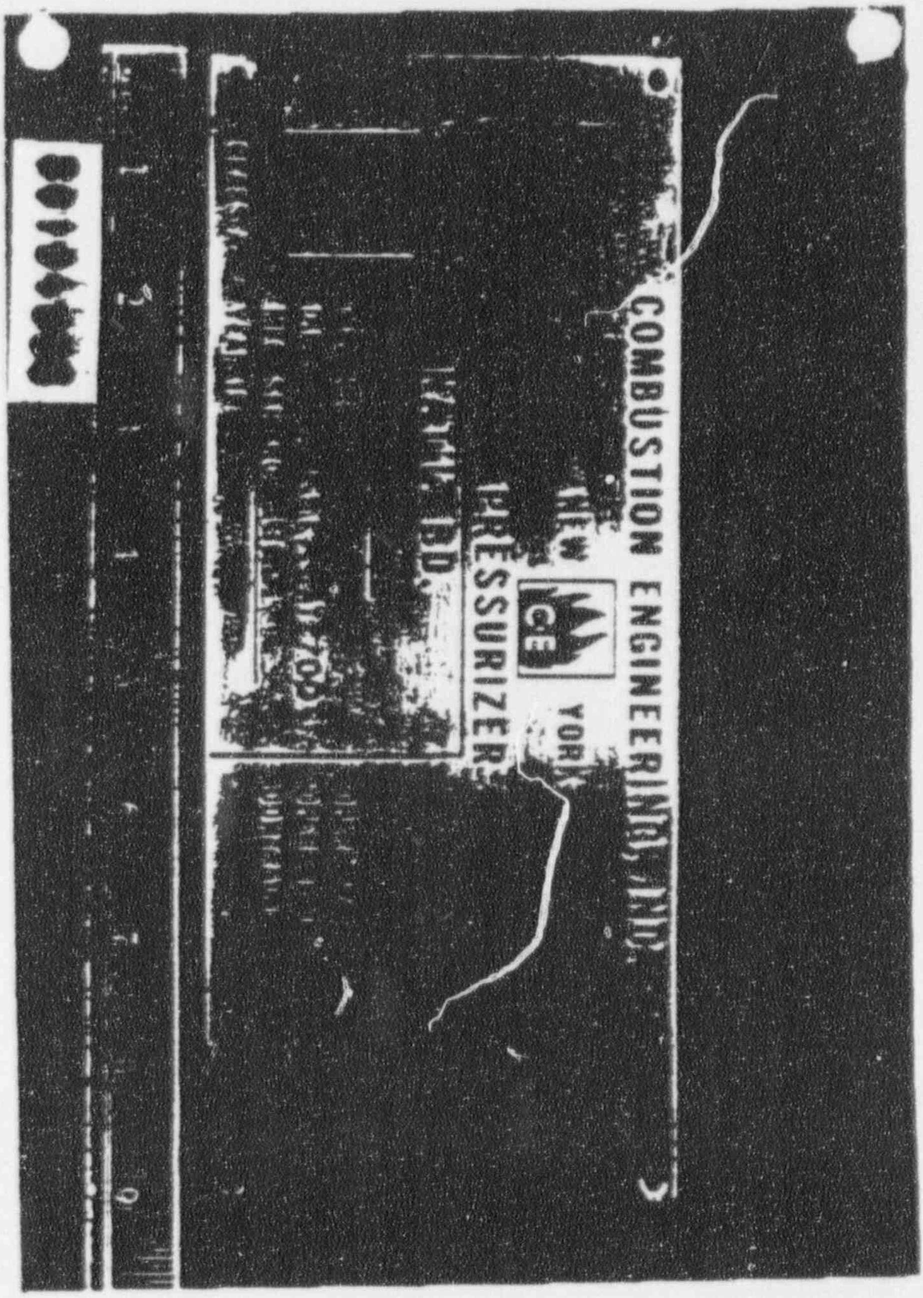
Natl.. BD. No. 20851

FORM N-1 MANUFACTURERS DATA REPORT FOR NUCLEAR VESSEL

ATTACHMENT SHEET

Nozzles

| PURPOSE | NO. | DIAMETER OR SIZE | TYPE | MATERIAL | THICKNESS | REINFORCEMENT MATERIAL | HOW ATTACHED |
|---|---|---|---|---|---|---|---|
| Surge Assembly | | | | | | | |
| Body | 1 | 11-13/16"ID | Forging | A-508-64 Cl. 2 | 1" | Integral | Welded |
| Extension | 1 | 10-1/2" I.D. | Forging | SB-166 Inconel | 1-1/8" | Integral | Welded |
| Spray Assembly | | | | | | | |
| Body | 1 | 4-1/2" I.D. | Forging | A-508-64 Cl. 2 | 59/64" | Integral | Welded |
| Extension | 1 | 3-5/8" I.D. | Forging | SB-166 Inconel | 19/32" | Integral | Welded |
| | | | | | | | |
| Relief Valve | | | | | | | |
| Body | 1 | 3" I.D. | Forging | A-508-64 Cl. 2 | 1-17/32" | Integral | Welded |
| Extension | 1 | 3" I.D. | Forging | SB-166 Inconel | 1-1/2" | Integral | Welded |
| Level Assembly | | | | | | | |
| Body | 8 | 1-7/16" I.D. | Forging | A-508-64 Cl. 2 | 1/2" | Integral | Welded |
| Body Ext. | 8 | .957" I.D. | Bar | SB-166 Inconel | 13/64" | Integral | Welded. |
| Extension | 8 | .957" I.D. | Bar | SA-132 Type F-316 | 13/64" | Integral | [illegible] |
| Temperature | | | | | | | |
| Body | 2 | .815" I.D. | Bar | SB-166 Inconel | .250" | In Head/Shell | Welded |
| Extension | 2 | .815" I.D. | Bar | SA-182 Type F-316 | .250" | N/A | Welded |
| Heater Assembly | | | | | | | |
| Sleeves | 120 | 1.158" O.D. | Tubing | SB-167 Inconel | .172" | In Head | Welded |
| Heaters | 120 | .875" O.D. | Tubing | SB-163 Inconel | .130" | N/A | Screwed & Seal Weld |


COMBUSTION ENGINEERING, INC.
NEW YORK
CE
PRESSURIZER

## NB-3300 VESSEL DESIGN

## NB-3310 GENERAL REQUIREMENTS

### NB-3311 Acceptability

The requirements for acceptability of a vessel design are as follows.

*(a)* The design shall be such that the requirements of NB-3100 and NB-3200 shall be satisfied.

*(b)* The rules of this Subarticle shall be met. In cases of conflict between NB-3200 and NB-3300 the requirements of NB-3300 shall govern.

## NB-3320 DESIGN CONSIDERATIONS

### NB-3321 Design and Service Loadings

The provisions of NB-3110 apply.

### NB-3322 Special Considerations

The provisions of NB-3120 apply.

### NB-3323 General Design Rules

The provisions of NB-3130 apply except when they conflict with rules of this Subarticle. In case of conflict, this Subarticle governs in the design of vessels.

### NB-3324 Tentative Pressure Thickness

The following formulas are given as an aid to the designer for determining a tentative thickness for use in the design. They are not to be construed as formulas for acceptable thicknesses. However, except in local regions (NB-3221.2), the wall thickness of a vessel shall never be less than that obtained from the formulas in NB-3324.1 and NB-3324.2, in which:

$t$ = thickness of shell or head, in.
$P$ = Design Pressure, psi
$R$ = inside radius of shell or head, in.
$R_o$ = outside radius of shell or head, in.
$S_m$ = design stress intensity values (Section II, Part D, Subpart 1, Tables 2A and 2B), psi

#### NB-3324.1 Cylindrical Shells

$$t = \frac{PR}{S_m - 0.5P} \quad \text{or} \quad t = \frac{PR_o}{S_m + 0.5P}$$

#### NB-3324.2 Spherical Shells

$$t = \frac{PR}{2S_m - P} \quad \text{or} \quad t = \frac{PR_o}{2S_m}$$

## NB-3330 OPENINGS AND REINFORCEMENT

### NB-3331 General Requirements for Openings

*(a)* For vessels or parts thereof which meet the requirements of NB-3222.4(d), analysis showing satisfaction of the requirements of NB-3221.1, NB-3221.2, NB-3221.3, and NB-3222.2 in the immediate vicinity of the openings is not required for pressure loading if the rules of NB-3330 are met.

*(b)* For vessels or parts thereof that do not meet the requirements of NB-3222.4(d) so that a fatigue analysis is required, the rules contained in NB-3330 ensure satisfaction of the requirements of NB-3221.1, NB-3221.2, and NB-3221.3 in the vicinity of openings, and no specific analysis showing satisfaction of those stress limits is required for pressure loading. The requirements of NB-3222.2 may also be considered to be satisfied if, in the vicinity of the nozzle, the stress intensity resulting from external nozzle loads and thermal effects, including gross but not local structural discontinuities, is shown by analysis to be less than $1.5S_m$. In this case, when evaluating the requirements of NB-3222.4(e), the peak stress intensity resulting from pressure loadings may be obtained by application of the stress index method of NB-3338 or NB-3339.

*(c)* The provisions of (a) and (b) above are not intended to restrict the design to any specified section thicknesses or other design details, provided the basic stress limits are satisfied. If it is shown by analysis that all the stress requirements have been met, the rules of NB-3330 are waived.

*(d)* Openings shall be circular, elliptical, or of any other shape which results from the intersection of a circular or elliptical cylinder with a vessel of the shapes permitted by this Subsection. Additional restrictions given in NB-3338.2(d) are applicable if the Stress Index Method is used. If fatigue analysis is not required, the restrictions on hole spacing are applicable unless there will be essentially no pipe reactions.

*(e)* Openings are not limited as to size except to the extent provided in NB-3338.2(d).

*(f)* All references to dimensions apply to the finished dimensions excluding material added as corrosion allowance. Rules regarding metal available for reinforcement are given in NB-3335.

*(g)* Any type of opening permitted in these rules may be located in a welded joint.

# EA-SC-93-087-01

# ATTACHMENT 11

# Code Reconciliation

ABB
ASEA BROWN BOVERI

October 19, 1993
Southeast Nuclear Service Center
CSE-93-381

Consumers Power Co.
Palisades Nuclear Plant
27780 Blue Star Memorial Highway
Covert, MI 49043

Attention:

SUBJECT: **CONSTRUCTION CODE RECONCILIATION FOR THE REPAIR/MODIFICATION OF TWO (2) PRESSURIZER TEMPERATURE NOZZLES**

Enclosure (1) Construction Code Reconciliation for Consumers Power Company Pressurizer Upper and Lower Temperature Nozzle Repairs/Modification

Dear Mr. Overway,

The Original Construction Code associated with the original CE supplied Consumers Power Pressurizer is the 1965 Edition through Winter 1966 Addendum of the ASME Boiler and Pressure Vessel Code, Section III.

A code reconciliation is provided as Enclosure 1 to meet code requirements in accordance with your Section XI program.

Sincerely,

ABB COMBUSTION ENGINEERING

Keith Coe

K. E. Coe
SNSC Engineering

KEC:gt

ABB Combustion Engineering Nuclear Services

Combustion Engineering, Inc
1201 Riverfront Parkway
Chattanooga, Tennessee 37402
Telephone (615) 752-2590
Toll Free 1-800-872-8836
Fax (615) 752-2449

ENCLOSURE 1

# CONSTRUCTION CODE RECONCILIATION FOR CONSUMERS POWER COMPANY - PALISADES PRESSURIZER UPPER AND LOWER TEMPERATURE NOZZLE REPAIR/MODIFICATION

In accordance with the Owners Specification "Engineering Specification for a Pressurizer Assembly, CE Specification No. 70P-001, Revision 2," the original construction code for the Palisades Pressurizer is the 1965 Edition through the winter 1966 Addendum of Section III of the ASME Boiler and Pressure Vessel Code (herein after referred to as the Original Construction Code). The ASME Section XI Program at Consumers Power is governed by the 1983 Edition through Summer '83 Addendum of Section XI (herein after referred to as the Section XI Code). This modification will be designed under ASME Section III rules and implemented under ASME Section XI, 1983 edition with Summer '83 Addenda.

Two instrumentation nozzles of (1.3) inch diameter located in the pressurizer require modification to prevent leak paths due to axial cracks in the nozzle base material.

The subject nozzles are temperature nozzles, one located in the top head and the other located in the lower shell of the Pressurizer. These nozzles provide a pressure boundary and structural support for thermowells and RTD devices. The nozzles will be modified by welding to prevent leakage of reactor coolant. The original nozzles will remain in place. The repair/modification activities will be done in accordance with ASME Section XI Code and provides for a weld buildup on the vessel outside diameter

(OD) surface. No repair of the original nozzle attachment weld (partial penetration) on the inside of the vessel will be made. The weld buildup will be made to incorporate the nozzle OD surface and the OD surface of the Pressurizer to provide the aforementioned new pressure boundary. After the temporary repair weld is completed, the top head temperature nozzle will be severed between the original weld and the temporary repair weld to allow thermal expansion during heatup and cooldown during normal operations. This modification/weld buildup will become the vessel pressure boundary for each nozzle.

This modification involves a repair activity in accordance with the ASME Section XI 1983 Edition with Summer '83 Addenda. Article IWA-4120 states that repairs may be performed in accordance with "later editions of the Construction Code, or Section III, either in its entirety or portions thereof" or the rules of Section XI, IWB-4000 for Class 1 Components may be used alternatively.

The Section XI Code (Article IWA-7210) specifies that replacements shall meet the requirements of the edition of the Construction Code to which the original component or part was constructed, unless the following alternative is adopted Article IWA-7210 (c):

> "(c) Alternatively, replacements may meet all or portions of the requirements of later editions of the Construction Code, provided that the following requirements are met.

(1) The requirements affecting the design, fabrication and examination of the replacement are reconciled with the Owner's Specification.

(2) Mechanical interfaces, fits and tolerances that provide satisfactory performance are not changed by the later edition of the Construction Code.

(3) Modified or altered designs are reconciled with the Owner's Specification through the Stress Analysis Report, Design Report, or other suitable method which demonstrates the satisfactory use for the specified design and operating conditions, whichever is applicable.

(4) Materials are compatible with the installation and system requirements."

The discussion below addresses each of the requirements:

1. Requirement

"(1) the requirements affecting the design, fabrication and examination of the replacement (modification) are reconciled with the Owner's Specification".

## Discussion

The Owner's Specification specifies the Original Construction Code as the 1965 Edition with Summer '66 Addendum of Section III of the ASME Code. The design, fabrication and examination requirements are specified in NB-3000[1], NB-4000[1], and NB-5000[1] respectively.

A comparison of each of these requirements is provided below:

## Design

The design of the modification is consistent with the Original Construction Code, i.e., the rules of NB-3000 (N-400). The "Requirements for Acceptability" (NB-3211) for the design are met for this modification in ABB/CE Engineering Calculation No. CR-9417 - CSE93 - 1121, Rev. 1, "Structural Analysis of Temperature Nozzle Weld Repairs For Consumers Power Palisades Pressurizer".

## Fabrication

There are no fabrication activities associated with this modification activity.

---

[1] The sections of the 1965 Code for design are Article 4 (N-400), Article 5 (N-500) and Article 6 (N-600). The Articles correlate to NB-3000, NB-4000, and NB-5000 respectively in current editions of Section III.

Examination

The examination of the Replacement Nozzles is being performed under the 1986 edition of ASME Section III, NB-5000 which provides current industry acceptance criteria. This criteria is at least as restrictive as the requirements in the 1965 ASME Section III.

In light of the above, the requirements affecting the design, fabrication and examination of this modification are considered reconciled with the Owner's Specification.

2. Requirement

"(2) Mechanical interfaces, fits, and tolerances that provide satisfactory performance are not changed by the later Edition of the Construction Code."

Discussion

Mechanical interfaces, fits, and tolerances are not changed by the use of Section XI.

3. Requirement

"(3) Modification or altered designs are reconciled with the Owner's Specification through the Stress Analysis Report, Design Report, or other suitable method which demonstrates the satisfactory use for the specified design and operating conditions, whichever is applicable".

Discussion

The Design Report associated with this project is ABB/CE Engineering Calculation No. CR-9417 - CSE93 - 1121, Rev. 1, "Structural Analysis of Temperature Nozzle Weld Repairs for Consumer's Power Palisades Pressurizer". This design report has analyzed and found acceptable this specific modification for the specified design and operating conditions of the Owner's Specification. The modified design is therefore reconciled with the Owner's Specification.

4. Requirement

"(4) Materials are compatible with the installation and system requirements".

Discussion

The weld, pad is deposited with SFA 5.11 ENiCrFe-3 welding electrodes as specified in ASME Section II, Part C. This filler material (F-43) is compatible with both the alloy 600 (P43) nozzle and the vessel base material, SA-533 Grade B Class 1 for the top head nozzle and the A-10 composition weld pad of the side shell nozzle.

The welding filler material, SFA 5.11 ENiCrFe-3, conforms to the requirements of Section II and III 1986 Edition and is compatible with the materials being joined. This weld material (ENiCrFe-3) provides corrosion resistance in the primary water environment and meets the strength requirements for design under ASME Section III.

The repair welds will be made in accordance with the requirements of IWA-4300 of Section XI.

Conclusion

The preceding discussions show the requirements for reconciliation to the Original Construction Code have been met for this modification.

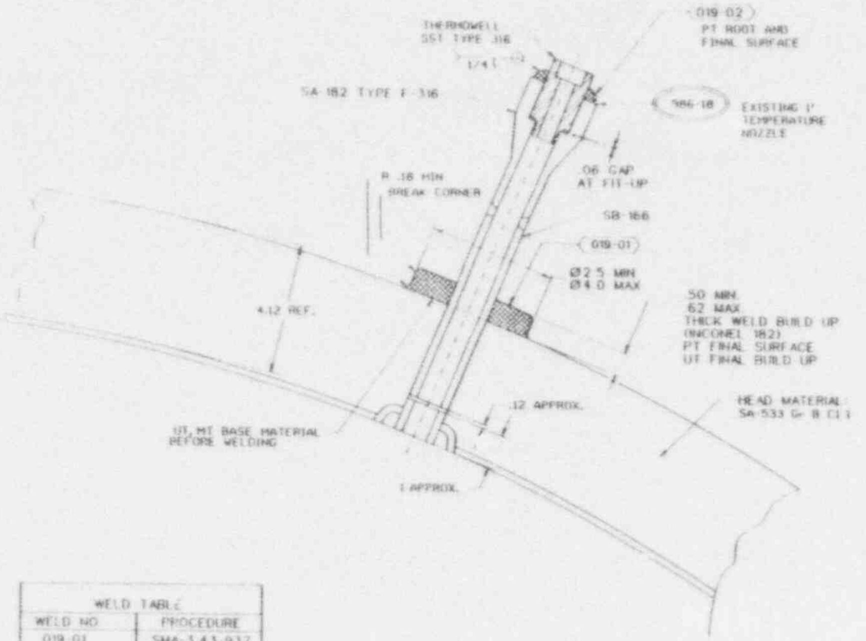
# EA-SC-93-087-01

# ATTACHMENT 12

# TE-0101 Drawing

D-9417-C093-019 1

| | | | |
|---|---|---|---|
| 01 | Added sever between welds<br>SMA 3.43.937 was SMA 3.43.918<br>Added materials<br>Added .06 gap dimension<br>FDCR No C093-037 | 10/15/93<br>DR SULTAN<br>WF DRIGO | J.A. [illegible]<br>10/15/93 |
| 02 | PER FDCR NO C093-038<br>.50 MIN/.62 MAX WAS .25MIN/.38 MAX | 10/18/93<br>DRD<br>J.S. McGuire | J.A. [illegible]<br>10/18/93 |



WELD TABLE

| WELD NO. | PROCEDURE |
|---|---|
| 019-01 | SMA-3.43-937 |
| 019-02 | GTA-8.8-910 |

CERTIFIED FOR
CONSTRUCTION

VERIFICATION STATUS: COMPLETE

The Saftey Related design information contained in this document has been verified to be correct by means of Design Review using Checklist(s) 3 of QAM 101.

Name [illegible] Signature [illegible] Date 10/18/93
Independent Reviewer

UNLESS OTHERWISE SPECIFIED:
1. TOLERANCES
   .X - ±.1"
   .XX - ±.01"
   .XXX - ±.003"
   ANGLES - ±10'
   CHAMFERS - ± 3°
2. BREAK ALL INTERNAL AND EXTERNAL CORNERS WITH APPROX. .03" RADIUS OR CHAMFER
3. MACHINED SURFACES TO BE 125 AA OR BETTER
4. ALL DIMENSIONS ARE IN INCHES

EA-SC-93-087-01
Attachment 12

PRESSURIZER HEAD TEMPERATURE
NOZZLE WELD REPAIR

THIS DRAWING IS THE PROPERTY OF [illegible]

ASEA BROWN BOVERI

SCALE: NONE
DRAWN BY: MALLIN DATE: 10/12/93
CHECKED BY: [illegible] DATE: 10/14/93
APPROVED BY: J.A. [illegible] DATE: 10/14/93
TASK NO: 2003067
FILE NAME: [illegible]
DRAWING NO. D-9417-C093-019
REV. 02

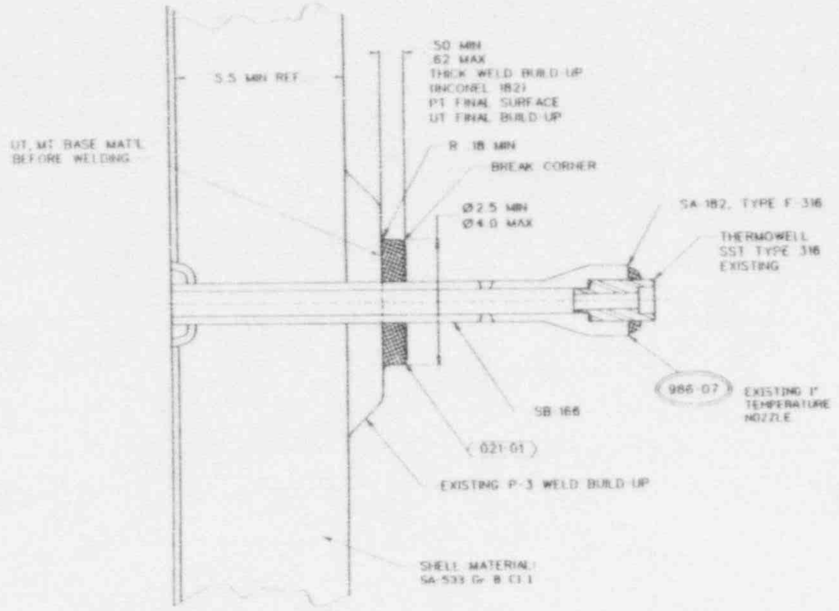
# EA-SC-93-087-01

# ATTACHMENT 13

# TE-0102 Drawing

D-9417-C093-021 1

| | DESCRIPTION | DATE | APPROVED |
|---|---|---|---|
| 01 | PER EIDCR NO. C093-039:<br>.50 MIN/.62 MAX WAS .25 MIN/.38 MAX | 10/18/93<br>DRD<br>J.G. McCALLUM | |



# CERTIFIED FOR CONSTRUCTION

VERIFICATION STATUS: COMPLETE

The Safety Related design information contained in this document has been verified to be correct by means of Design Review using Checklist(s) 3 of QAM-101.

Name B.A. Beck Signature B.A. Beck Date 10/18/93
Independent Reviewer

UNLESS OTHERWISE SPECIFIED:

1. TOLERANCES
   - .X - ± .1"
   - .XX - ± .01"
   - .XXX - ± .003"
   - ANGLES - ±10'
   - CHAMFERS - ± 3°
2. BREAK ALL INTERNAL AND EXTERNAL CORNERS WITH APPROX. .03" RADIUS OR CHAMFER
3. MACHINED SURFACES TO BE 125 AA OR BETTER
4. ALL DIMENSIONS ARE IN INCHES

| WELD TABLE | |
|---|---|
| WELD NO. | PROCEDURE |
| 021-01 | SMA-3.43.937 |

EA-SC-93-087-01
Attachment 13

## PRESSURIZER SHELL TEMPERATURE NOZZLE WELD REPAIR

ASEA BROWN BOVERI

SCALE: NONE
DRAWN BY: D.R. [illegible] DATE: 10/15/93
CHECKED BY: W.F. [illegible] DATE: 10/15/93
APPROVED BY: J.A. [illegible] DATE: 10/15/93
TASK NO. 2003067
FILE NAME: (CFS) 93040.dgn
DRAWING NO. D-9417-C093-021 REV 01

# EA-SC-93-087-01

# ATTACHMENT 14

# Traveler 2003067-002

EA-SC-93-087-01
Attachment 14
Page 1 of 9

Proc No 10.41
Attachment 4
Revision 17
Page 1 of 2

# PROCEDURE TRAVELER

Procedure Title ABB/COMBUSTION ENGINEERING NUCLEAR SERVICES TRAVELER NO. 2003C67-002 ? WELD REPAIR/MODIFICATION OF PRESSURIZER NOZZLES - EDM PROCESS

Procedure No 2003067-002 Revision No 0 Date Initiated 10/22/93

Sponsor Chad Main Return to Initiator By 10/22/93

| Assigned Activity (✓) | Activity | Reviewer | Activity Person Hours | Activity Completed By Print Name & Initial |
|---|---|---|---|---|
| ✓ | ☒ Urgent Revision<br>☐ Urgent Editorial | | | Chad Main CWM<br>Chad W. Main 10/22/93 |
| N/A | Applicability Review<br>☐ Inactivate ☐ Retain-Revise ☐ Retain-No Revision ☐ Cancel<br>☐ Cancel - Replaced by: ______ ☐ Retain-Editorial | | | |
| ✓ | Draft Development<br>Start Date: / /<br>Completion Date: 10/22/93 | | | |
| ✓ | Technical Review*<br>Comments: ☐ Yes ☒ No<br>Review Completed: 10/22/93<br>Comment Resolution: / / | Jerry Nordby | .1 | JC Nordby, JCN |
| N/A | ALARA Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| N/A | Environmental Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| ✓ | User Review*<br>Comments: ☐ Yes ☒ No<br>Validation Performed: ☐ Yes ☒ No<br>Review Completed: 10/22/93<br>Comment Resolution: / / | Colin Grady | | Approved by Colin Grady per telecon 10/22/93<br>Chad W. Main 10/22/93 |
| ✓ | PS&L Review*<br>Comments: ☐ Yes ☒ No<br>Safety Evaluation # 93-1233<br>Review Completed: 10/22/93<br>Comment Resolution: / / | Jeff Erickson contacted per telecon 10/22/93<br>Chad W Main 10/22/93 | | Jeff agreed that Safety Review had not been affected by changes to procedure/traveler |
| ✓ | Sponsor Review<br>Review Completed: 10/22/93<br>Comment Resolution: / / | | | |
| ✓ | Manager Approval<br>Completed: 10/22/93 | Colin Grady for RB Kasper | | Colin Grady approved per telecon 10/22/93 Chad W. Main |
| N/A | Typing<br>In: / /<br>Out: / / | | | |
| ✓ | Sponsor Approval<br>Completed: 10/22/93 | | | Chad Main 10/22/93 |
| ✓ | DCC Control & Distribution<br>In: / /<br>Out: / / | | | |
| | | | | |
| | | | | |

Procedure No. 2003067-002
Revision No. 0
Issued Date 10/21/93

# PALISADES NUCLEAR PLANT
# MAINTENANCE PROCEDURE

## TITLE:

ABB-COMBUSTION ENGINEERING NUCLEAR SERVICES
TRAVELER NO. 2003067-002

WELD REPAIR/MODIFICATION OF PRESSURIZER NOZZLE(S)

ELECTRICAL DISCHARGE MACHINING (EDM) PROCESS

Chad W. , 10/22/93
Procedure Sponsor Date

, 10/22/93
Technical Reviewer Date

Colin Grady , 10/22/93 , 0
User Reviewer Date Rev #

# PALISADES NUCLEAR PLANT
## SAFETY REVIEW

PS&L Log No 93-1233

Item Identification: No 2003067-002 Rev 0 Title ABB/CE NUCLEAR SERVICES TRAVELER: WELD REPAIR/MODIFICATION OF PRESSURIZER NOZZLE -- EDM PROCEDURE

SE Rev

Describe Issue/Change: PRESSURIZER NOZZLE REPAIRS BY COMBUSTION ENGINEERING

Reason for Issue/Change: PROCEDURE REQUIREMENT BY ADMINISTRATIVE PROC. 10.41

| | Yes | No |
|---|---|---|
| 1. Does the item involve a change to procedures as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 2. Does the item involve a change to the facility as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 3. Does the item involve a test or experiment not described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 4. Should the Technical Specifications or any of their Bases be changed in conjunction with this item?<br>TS Sections affected NONE<br>TS Sections reviewed 3.0, 4.0 | | X |

Justify No Answers below if logic is not obvious:

Although material removal under the ASME code is discussed in general terms in the FSAR, the EDM process does not deviate from code acceptable practices.

If any Safety Review question listed above is answered "YES", perform a written USQ Evaluation according to Section 5.3.

If all Safety Review questions listed above are answered NO, written USQ Evaluation is not required. However, this Attachment shall accompany other review materials for the item to document that a Safety Evaluation was not required.

10/21/93
Prepared By Date

10/21/93
Reviewed By Date

ABB
ASEA BROWN BOVERI
Combustion Engineering Nuclear Power

## FIELD CHANGE NOTICE

FCN NO. 200306700**5** DATE 10-22-93

DOCUMENT NO. D-9417-C093-019 REV. NO. 02

PAGE 1 of 1 STEP / PARA. NO. ZONE B-6

**DESCRIPTION OF REQUESTED CHANGE:**

Add: "Note: Requires a NOT TO exceed ligament thickness of .055" MAX. AND A groove depth of .200" MIN." Do NOT SEVER.

SEE pg 2 of 2 this FCN

Drawing will be revised -

**REASON FOR CHANGE:**

To Reflect Requirements of Palisades Nuclear PLANT Specification Change Package #93087

---

APPROVED BY: Per Tecon with J.A. Ambona

10-22-93
Task Manager Date

10-22-93
Quality Representative Date

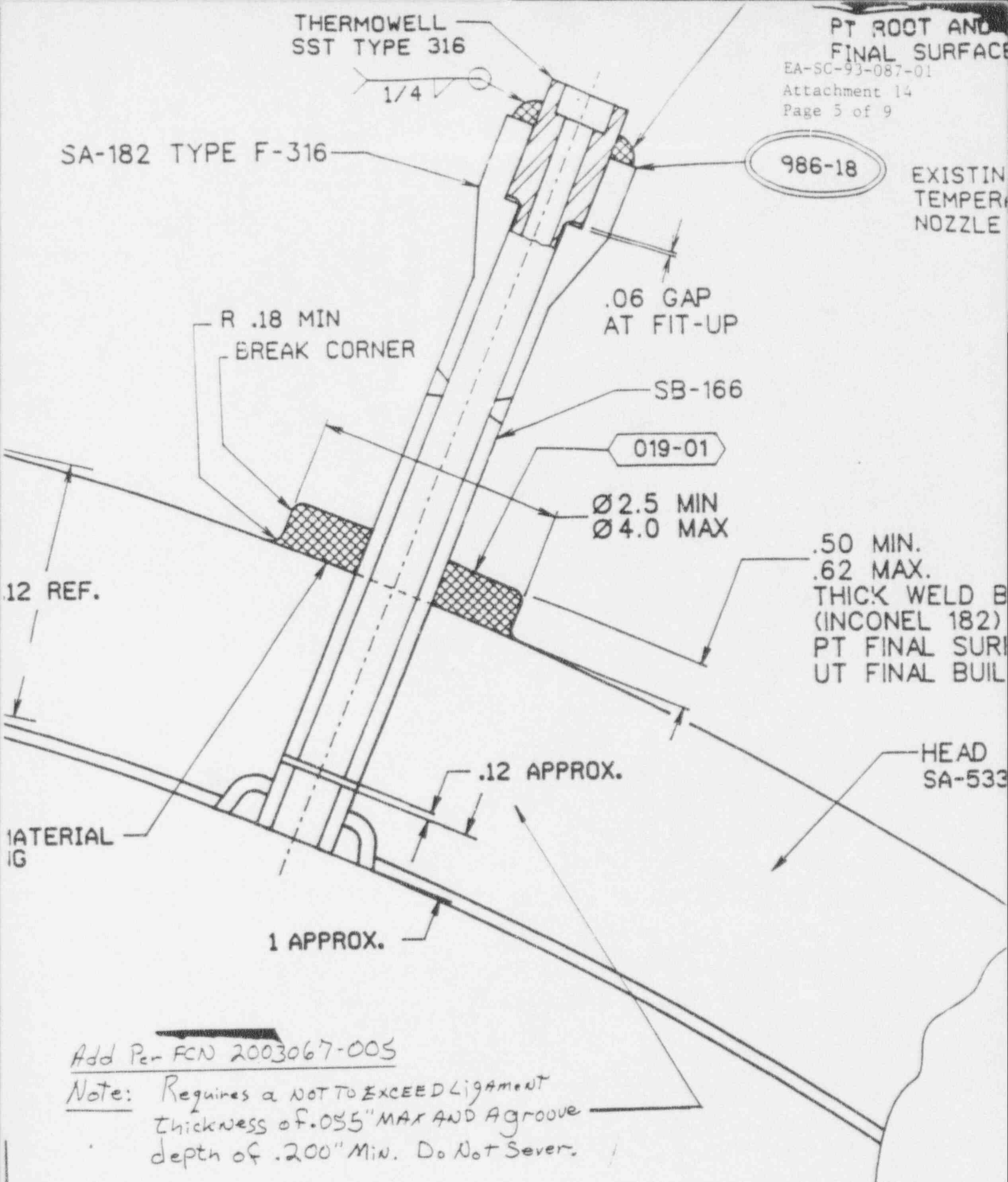
REVIEWED AND RELEASED BY:

10/22/93
Client Representative Date

Approved per telecon with KL Blake
10/22/93
Authorized Inspection Agency Date

FQO FCN (2/91)

pg 1 of 2



Add Per FCN 2003067-005
Note: Requires a NOT TO EXCEED Ligament thickness of .055" MAX AND A groove depth of .200" Min. Do Not Sever.

Pg 2 of 2
FCN 200~~6037~~3067-005
AD 10-22-93

ABB-COMBUSTION ENGINEERING
NUCLEAR SERVICES
TRAVELER NO. 2003067-002

PAGE 1 OF 4
REVISION 0
DATE 10/20/93

# WELD REPAIR/MODIFICATION OF PRESSURIZER NOZZLE

UTILITY: CONSUMERS POWER COMPANY

SITE: PALISADES

NOZZLE NO.: PRESSURIZER NOZZLE REPAIR

1.0 TABLE OF CONTENTS AND LIST OF EFFECTIVE PAGES:

APPROVED BY:

Paul E Reynolds 10-20-93
TASK MANAGER DATE

Chad W. [illegible] 10/21/93
OWNER REPRESENTATIVE DATE

10-20-93
QUALITY REPRESENTATIVE DATE

Approved per telecon with KL Blake
AUTHORIZED INSPECTION AGENCY DATE
Chad W. [illegible] 10/22/93

10-20-93
ENGINEERING DATE

## 2.0 REFERENCES

2.1 ABB/Combustion Engineering Dwg. No. D-9417-C093-019, Rev. 02.
Reference FCN # 2003067-005 for actual nozzle cut requirements
10/22/93

2.2 ABB/Combustion Engineering Nuclear Services Quality Assurance Manual, QAM-100, Fourth Edition, Rev. 1.

2.3 Instruction Manual: Pressurizer; Consumers Power Company - Palisades Plant.

2.4 ASME Code Seccion XI, 1983 Edition, Summer 1983 Addenda.

2.5 ASME Code Section II and III, 1986 Edition with no Addenda. (Materials)

2.6 ABB/Combustion Engineering STD-100-207, Rev.0.

2.7 ABB/Combustion Engineering O.P-9.5. Rev. 9.

2.8 Designated sign-offs/abbreviations in this traveler shall be in accordance with the following legend.

S - Supervisor/Worker
Q - Quality Operations
O - Owner/Client
A - Authorized Nuclear Inspector
W - Witness
I - Inspect
H - Hold
MPE - Magnetic Particle Examination
UT - Ultrasonic Test
WIR - Weld Inspection Record
LPE - Liquid Penetrant Examination
UTE - Ultrasonic Test Examination
ROI - Report of Inspection

## 3.0 PREREQUISITES

3.1 All required personnel have received training in Quality Control, Radiation Control, and ALARA procedures and have been trained in the work tasks to be performed.

3.3 Special tooling is on hand in sufficient quantity for the intended program.

3.4 Scaffolding at the pressurizer where work is to be performed has been erected, if required.

3.5 Insulation has been removed.

3.6 Provide a system of tool and material accountability for all items entering the primary system, if applicable.

3.7 Install water plug,if required.

STEP NO.

4.0 PERFORMANCE

4.1 Verify satisfactory completion of prerequisites.

S W ________
Q W________
O _
A

REMARKS: ______________________________

4.2 Setup EDM equipment per the requirements of Ref.
Ref. 2.6.
EDM machine settings shall not exceed the following:
Amperage= Shall not exceed 30 Amps.

S W ________
Q
O -
A _

CAUTION: Any time the EDM equipment is not operational make sure the D.I. water source is shut off to minumize the dilution of the primary water.

NOTIFY SHIFT SUPERVISOR PRIOR TO PUTTING WATER IN PRIMARY SYSTEM AT EXT. 0225/0252; SS.________________
name/date

REMARKS: ______________________________

4.3 EDM the groove in the nozzle approximately 1" (one) inch from the vessel I.D. per ref. 2.6. and 2.1.
Reference FCN # 2003067-005 for actual nozzle cut requirements.

S W________
Q W ________
O _
A _

10/22/93

REMARKS: ______________________________

4.4 Verify nozzle groove by VT-3, per Ref. 2.7. and Drawing Ref. 2.1.

S W
Q I ________
O _
A _
ROI__________

REMARKS: ______________________________

RETURN TO TRAVELER
2003067-001 STEP 4.22
FOR INSTALLATION OF THE THERMOWELL

# EA-SC-93-087-01

# ATTACHMENT 15

# EDM Procedure

Proc No 10.41
Attachment 4
Revision 17
Page 1 of 2

# PROCEDURE TRAVELER

Procedure Title PROCEDURE FOR ELECTRICAL DISCHARGE MACHINING PZR NOZZLE

Procedure No SED-100-207 Revision No 0 Date Initiated 10/22/93

Sponsor Chad Main Return to Initiator By 10/22/93

| Assigned Activity (√) | Activity | Reviewer | Activity Person Hours | Activity Completed By Print Name & Initial |
|---|---|---|---|---|
| ✓ | ☑ Urgent Revision<br>☐ Urgent Editorial | | | Chad Main CWM<br>Chad W Main 10/22/93 |
| N/A | Applicability Review<br>☐ Inactivate ☐ Retain-Revise ☐ Retain-No Revision ☐ Cancel<br>☐ Cancel - Replaced by: ________ ☐ Retain-Editorial | | | |
| ✓ | Draft Development<br>Start Date: / /<br>Completion Date: 10/22/93 | | | |
| ✓ | Technical Review*<br>Comments: ☐ Yes ☒ No<br>Review Completed: 10/22/93<br>Comment Resolution: / / | Jerry Nordby | .1 | J Nordby, JN |
| N/A | ALARA Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| N/A | Environmental Review*<br>Comments: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | | | |
| ✓ | User Review*<br>Comments: ☐ Yes ☐ No<br>Validation Performed: ☐ Yes ☐ No<br>Review Completed: / /<br>Comment Resolution: / / | Paul Reynolds | | PAUL Reynolds PKR<br>Paul Reynolds 10-22-93<br>? |
| ✓ | PS&L Review*<br>Comments: ☐ Yes ☒ No<br>Safety Evaluation # 93-1234<br>Review Completed: 10/22/93<br>Comment Resolution: / / | Jeff Erickson contacted per telecon 10/22/93 | CW M<br>Chad 10/29/93 | Jeff agreed that Safety Review had not been affected by changes to procedure/special process |
| ✓ | Sponsor Review<br>Review Completed: 10/22/93<br>Comment Resolution: / / | | | |
| ✓ | Manager Approval<br>Completed: 10/22/93 | RB Kasper for Colin Grady | | Colin Grady approved per telecon 10/22/93 Chad W Main |
| N/A | Typing<br>In: / /<br>Out: / / | | | |
| ✓ | Sponsor Approval<br>Completed: 10/22/93 | | | Chad Main, 10/22/93 |
| ✓ | DCC Control & Distribution<br>In: / /<br>Out: / / | | | |
| | | | | |
| | | | | |

# PALISADES NUCLEAR PLANT
# SAFETY REVIEW

PS&L Log No 93-1234

Item Identification: No STD-100-207 Rev 0 Title PROCEDURE FOR LECTRICAL DISCHARGE MACHINING (EDM) PRESSURIZER NOZZLE SEVERING

SE Rev

Describe Issue/Change: PRESSURIZER NOZZLE REPAIRS BY COMBUSTION ENGINEERING

Reason for Issue/Change: PROCEDURE REQUIREMENT BY ADMINISTRATIVE PROC. 5.06

| | Yes | No |
|---|---|---|
| 1. Does the item involve a change to procedures as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 2. Does the item involve a change to the facility as described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 3. Does the item involve a test or experiment not described in the FSAR?<br>FSAR Sections affected NONE<br>FSAR Sections reviewed 4.3, 4.4, 5.1, 5.6, 5.8, 5.10, 6.9, 7.4, 9.1, TABLE 4-21, TABLE 4-22 | | X |
| 4. Should the Technical Specifications or any of their Bases be changed in conjunction with this item?<br>TS Sections affected NONE<br>TS Sections reviewed 3.0, 4.0 | | X |

Justify No Answers below if logic is not obvious:

Although material removal under the ASME code is discussed in general terms in the FSAR, the EDM process does not deviate from code acceptable practices.

If any Safety Review question listed above is answered "YES", perform a written USQ Evaluation according to Section 5.3.

If all Safety Review questions listed above are answered NO, written USQ Evaluation is not required. However, this Attachment shall accompany other review materials for the item to document that a Safety Evaluation was not required.

| | |
|---|---|
| , 10/21/93<br>Prepared By Date | , 10/21/93<br>Reviewed By Date |

Procedure No. STD-100-207
Revision No. 0
Issued Date 10/21/93

# PALISADES NUCLEAR PLANT
# SPECIAL PROCESS PROCEDURES

## TITLE:

PROCEDURE FOR ELECTRICAL DISCHARGE MACHINING (EDM)
PRESSURIZER NOZZLE SEVERING

Chad W. [illegible], 10/22/93
Procedure Sponsor Date

, 10/22/93
Technical Reviewer Date

Colin Grady, 10/22/93, 0
User Reviewer Date Rev #

ABB
ASEA BROWN BOVERI
Combustion Engineering Nuclear Power

## FIELD CHANGE NOTICE

FCN NO. 2003067005

DATE 10-22-93

DOCUMENT NO. D-9417-C093-019

REV. NO. 02

PAGE 1 of 1

STEP/PARA. NO. ZONE B-6

**DESCRIPTION OF REQUESTED CHANGE:**

Add: Note: Requires a NOT TO exceed ligament thickness of .055" MAX. AND A groove depth of .200" MIN." Do NOT SEVER.

SEE pg 2 of 2 this FCN

Drawing will be revised - Pex -

**REASON FOR CHANGE:**

TO Reflect Requirements of Palisades Nuclear PLANT Specification Change Package #93087

---

APPROVED BY: Per Tecon with J.A Ambona

Paul E. 10-22-93
Task Manager Date

10-22-93
Quality Representative Date

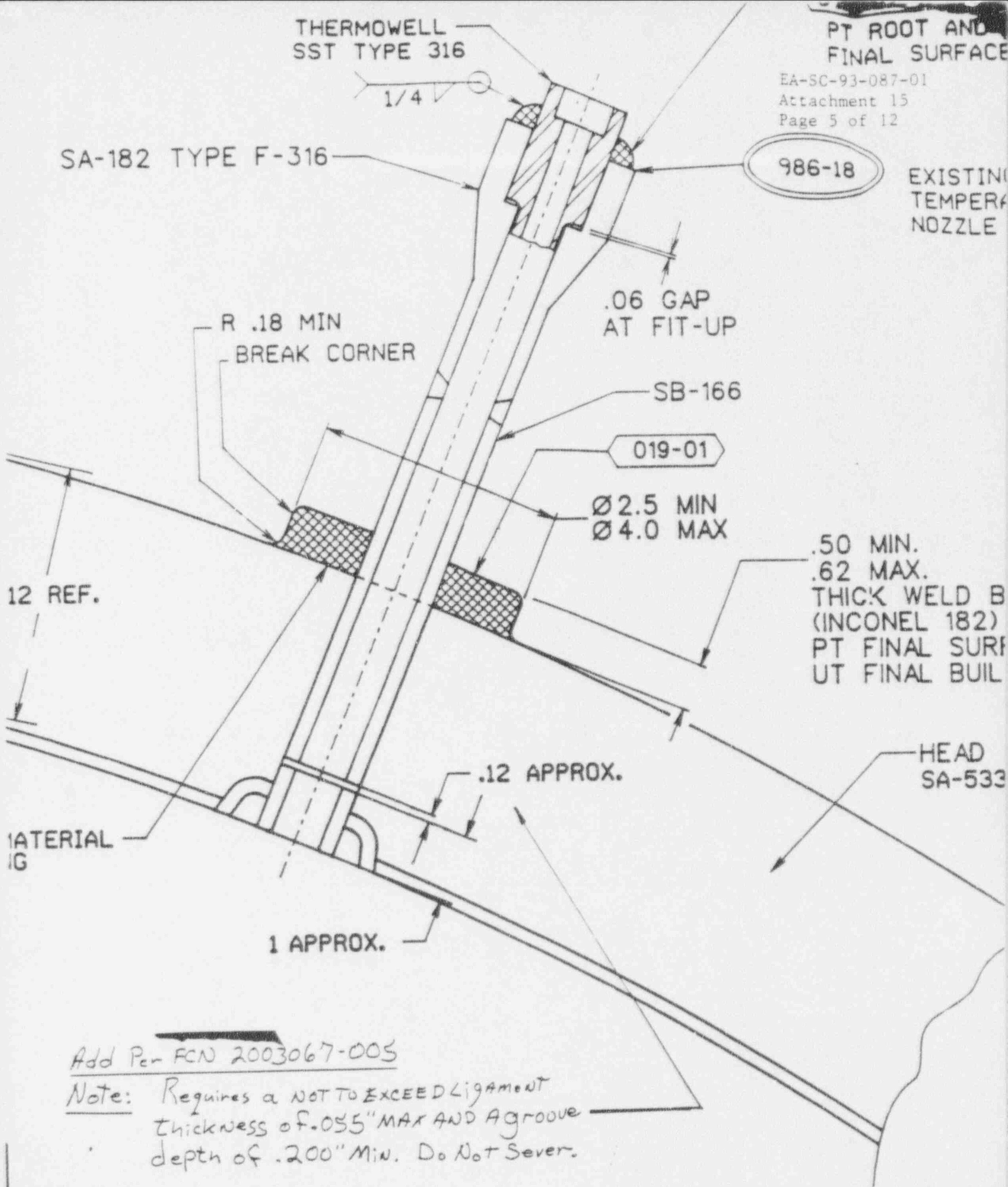
REVIEWED AND RELEASED BY:

Chad W. Ma 10/22/93
Client Representative Date

Approved per telecon with KL Blake
Chad W. Ma 10/22/93
Authorized Inspection Agency Date

FOO FCN (2/91)

pg 1 of 2



Add Per FCN 2003067-005

Note: Requires a NOT TO EXCEED Ligament thickness of .055" MAX AND A groove depth of .200" Min. Do Not Sever.

Pg 2 of 2
FCN 200~~6037~~3067-005
10-22-93

ABB
ASEA BROWN BOVERI
Combustion Engineering Nuclear Power

## FIELD CHANGE NOTICE

FCN NO. 20030ᵹ 004 DATE 11-22-93

DOCUMENT NO. STD-100-207 REV. NO. 0

PAGE 5 STEP / PARA. NO. 5.33

**DESCRIPTION OF REQUESTED CHANGE:**

Delete step 5.33.

**REASON FOR CHANGE:**

Palisades Nuclear Plant specification change Package #93087 Requires a not to exceed ligament thickness of .055" max. And a groove depth of .200" min.

---

APPROVED BY: Per telecon K. Coe 10-22-93

Paul Reynolds 10-22-93
Task Manager Date

J. O'Neill 10-22-93
Quality Representative Date

REVIEWED AND RELEASED BY:

Chad W. Mason 10/22/93
Client Representative Date

K Blake 10-22-93
Authorized Inspection Agency Date

QO FCN (2/91)

ABB
ASEA BROWN BOVERI
Combustion Engineering Nuclear Power

## FIELD CHANGE NOTICE

FCN NO. 2003067-006

DATE 11-22-93

DOCUMENT NO. STD-100-207

REV. NO. 0

PAGE 4 & 5

STEP / PARA. NO. 5.19 ; 5.30

**DESCRIPTION OF REQUESTED CHANGE:**

Step 5.19; 5.30 change note to read.
Note: Do not cut above 30 Amps:

**REASON FOR CHANGE:**

Monetary peaks may exceed 24 Amps.

---

APPROVED BY: Per telecon J. Wallin 10.22.93

Paul Reynolds 11-22-93
Task Manager Date

O'Neill 10-22-93
Quality Representative Date

REVIEWED AND RELEASED BY:

Chad W. Main 10/22/93
Client Representative Date

Approved per telecon with
KL Blake 10/22/93
Authorized Inspection Agency Date

Chad W. Main
10/22/93

FQO FCN (2/91)

# PROCEDURE FOR
# ELECTRICAL DISCHARGE MACHINING (EDM)
# PRESSURIZER NOZZLE SEVERING

STD-100-207, REV. 0

PREPARED BY: John Wallace DATE: 10/19/93

COGNIZANT SUPERVISOR APPROVAL: DATE: 10/19/93

FIELD OPERATIONS APPROVAL: Jack L. Moseley DATE: 10/19/93

Q.A. APPROVAL: DATE: 10/19/93

## 1.0 OBJECTIVES

1.1 This document sequences the steps required for electrical discharge machining (EDM) of 1" pressurizer nozzle in the area of the nozzle between the I.D. and O.D. of the pressurizer shell. This allows for the removal of material in a manner so as to limit the debris from entering the pressurizer and reduce the total manrem for the project by controlling the process remotely. Both copper tungsten and graphite electrodes may be used for this process.

## 2.0 REFERENCES

LuM 10/22/93

2.1 Drawing No. D-9417-C093-019, Rev. 2. Reference FCN # 2003067-005 for actual requirements of nozzle cut.

## 3.0 DEFINITIONS

3.1 The following services are available:

A. 480 VAC 3 phase (30 amp lines).

B. Demineralized water 60 psi minimum.

C. 110 VAC 20 amp

## 4.0 PROCEDURE

4.1 The EDM Control Cabinet and Power Supply should never be left unattended in the energized mode.

4.2 Ensure that the "Ram Mode" switch is in the "Edge" position any time the tool is not in use.

4.3 Do not operate the EDM tool without operating DI water flush system.

4.4 If any step cannot be completed because of equipment failure, or some other cause, inform the CE shift supervisor.

## 5.0 OPERATIONAL PROCEDURE

5.1 Visually check the cables, fixtures, and hoses for any obvious damage and be sure all connections are secure.

5.2 Install a new electrode in the EDM Tooling Head.

NOTE: Electrode is to be positioned such that the electrode is centered in Delrin wand and the D.I. water connection is rotated to its outermost position referenced to the Delrin wand. This is 0° Ref.

5.3 Install the tooling holder such that the two 1/4" holes are facing the center line of the pressurizer.

5.4 Install the Delrin wand into the nozzle with 0° Ref. aligned with the pressurizer and center line.

5.5 Adjust the tooling holder such that the two 1/4" holes are centered in line with the two set screws which are used to lock the electrode shaft.

5.6 Install eccentric coupling on electrode shaft.

5.7 Install eccentric motor mount to the tooling holder.

5.8 Rotate the eccentric coupling such that the coupling is aligned to the center of the motor mount.

5.9 Install motor to motor mount and eccentric coupling.

NOTE: Motor shaft and electrode shaft must not be in contact.

5.10 Tighten set screws in the eccentric coupling to the motor shaft and the electrode shaft.

5.11 Recheck connections at the tooling head.

5.12 Suggested EDM parameters.

| | |
|---|---|
| Servo | Up |
| Mode | Auto retract (during cut)<br>Edge (stand by) |
| Servo Speed | 3-9 |
| Gap Adjust | 3-9 |
| Ram Cycler | Off |
| Ram Feed | Neutral |
| Gap Initiation | 150 |
| Leads | 1 or 2 |
| Electrode | Metallic - 2 |
| Polarity | Neg. |
| Peak Current | Full |

| | |
|---|---|
| % On Time | 20-90 |
| Arc Duration | 128 |
| Capacitor Mode | Off |

5.13 Turn the EDM machine on while the Ram Mode switch is in the edge position.

5.14 Start D.I. water flow to the electrode.

5.15 Check Edge Mode by shorting between negative and positive, alarm on power supply should sound.

5.16 If the electrode is in contact with the nozzle, the edge alarm will sound. Do not turn to auto retract until no alarm sounds.

5.17 If edge alarm is sounded due to electrode contact, adjust electrode to a position that does not cause an alarm.

5.18 Turn mode to Auto Retract, press machine on and check that electrode is not shorted.

5.19 Open hydraulic line valve to begin cut and adjust control parameters for best cut.

See FCN # 2003067-006

NOTE: Do not cut above ~~24~~ 30 amps. CWM 10/22/93

5.20 Continue cut until complete or operator deems it necessary to change to new electrode. If new electrode is needed, repeat steps for electrode installation.

5.21 After eccentric cut is complete, remove electrode tooling and install new electrode which is approximately .20" thinner. Installation steps are same as for 1st electrode up to Step 5.6.

5.22 Install concentric coupling to the electrode shaft. Do not tighten set screws.

5.23 Install concentric motor mount to the tooling holder.

5.24 Rotate electrode shaft approx. 135° in a clockwise direction. This should move electrode into the eccentric slot.

5.25 Tighten 2 set screws through Delrin wand to fix electrode shaft at 135°.

5.26 Install motor to the concentric motor mount and the concentric coupling. Tighten coupling set screws.

5.27 Recheck connections at the tooling head.

5.28 If the edge alarm sounds, slight adjustment of the electrode may be necessary before beginning cut.

5.29 Turn mode to Auto Retract, press machine on and check that the electrode is not shorted.

5.30 Open hydraulic valve to begin cut and adjust control parameters for best cut.

NOTE: Do not cut above ~~24~~ 30 amps. CwM 10/22/93 See FCN#-2003067-006

5.31 Continue until cut is complete or operator deems it necessary to change electrode. If a new electrode is needed, repeat steps for electrode installation.

5.32 If another concentric cut is required repeat steps for concentric cutting but use an electrode .20" thinner than the electrodes used for previous concentric cut.

CwM 10/22/93 See FCN# 2003067-004

~~5.33 If small ligaments remain after concentric cuts they may be removed by cutting with the eccentric process.~~

NOTE: Graphite cutters may be used for last cuts.

5.34 After cut verification disassemble and remove equipment from containment.

# EA-SC-93-087-01

# ATTACHMENT 16

# ASME Code Interpretation

# IX-1-89-70

**Interpretation: XI-1-89-69**

Subject: Section XI, IWF-1300 and Table IWF-2500-1; Component Support Examination Boundaries (1980 Edition With Addenda Through Winter 1981)

Date Issued: February 15, 1991

File: IN90-027

Question: For a nonintegral support whose boundary is identified in IWF-1300(c) with no mechanical connections buried within the insulation, is it a requirement of Section XI that the examination be extended from a mechanical connection to the surface of the pipe, therefore, requiring removal of the insulation to complete the visual examination?

Reply: No, if there are no examinations required per Section XI, Table IWF-2500-1, then removal of the insulation is not required.

**Interpretation: XI-1-89-70**

Subject: Section XI, IWB-4212; Material Removal Process – Nonwelded (1983 Edition With Summer 1983 Addenda)

Date Issued: February 15, 1991

File: IN91-005

Question: If electric discharge machining (EDM) or metal disintegration machining (MDM) are used on P-8 or P-43 materials, in an area where defect removal or repair welding is not required, does the requirement of Section XI, IWB-4212, for additional material removal apply?

Reply: No.