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Docket Number 50-346

License Number NPF-3

Serial Number 1-1271

April 25, 2002

Mr. J.E. Dyer, Administrator
United States Nuclear Regulatory Commission
Region III
801 Warrenville Road
Lisle, IL 60532-4351

Subject: Partial Response to Confirmatory Action Letter No. 3-02-001 - Repair Plans for the Davis-Besse Nuclear Power Station, Unit 1 Reactor Pressure Vessel Head

Ladies and Gentlemen:

On March 13, 2002, the Nuclear Regulatory Commission (NRC) issued the subject Confirmatory Action Letter (CAL) regarding the Reactor Pressure Vessel (RPV) head at the Davis-Besse Nuclear Power Station, Unit 1 (DBNPS). The CAL requires FirstEnergy Nuclear Operating Company (FENOC) to obtain review and approval of the repair or modification and testing plans for the RPV head prior to implementation. The purpose of this letter is to provide the NRC with repair plans for the Control Rod Drive Mechanism (CRDM) nozzle #2 location and the CRDM nozzle #3 and #11 location of the RPV head.

The attached repair plans discuss the considerations and associated activities, including pre-repair mockup details and activities, necessary to repair the RPV head as were discussed with the NRC Staff on April 10, 2002. The complete repair packages that include the detailed instructions to personnel for performing the activities required for the repair will be available for NRC Staff review at the DBNPS prior to and during repair implementation.

As stated in the repair plans, the NRC Staff will be informed of the schedule for mockup activities to provide the staff with an opportunity for witnessing these activities as they occur. The mockup activities are an essential part of the repair process and will provide the necessary verification of equipment fitup techniques, accessibility, equipment checkout, and procedural adequacy, and will provide personnel training.

Approval of the repairs plans is requested by May 16, 2002. In addition, approval of activities following scheduled mockup demonstration will ensure repair of the DBNPS RPV head can be accomplished in a timely yet controlled manner.

If you have any questions or require further information, please contact Mr. David H. Lockwood, Manager – Regulatory Affairs, at (419) 321-8450.

Very truly yours,

Attachments

cc: USNRC Document Control Desk
S.P Sands, DB-1 NRC/NRR Project Manager
D.V. Picket, DB-1 NRC/NRR Backup Project Manager
C.S. Thomas, DB-1 Senior Resident Inspector
Utility Radiological Safety Board

Repair Plan Description
Davis-Besse Nuclear Power Station, Unit 1
Control Rod Drive Mechanism Nozzle #2

(12 Pages Follow)

Repair Plan Description
Davis-Besse Nuclear Power Station, Unit 1
Control Rod Drive Mechanism Nozzle #2

Introduction

Inspections of the Reactor Vessel Closure Head (RVCH) performed in accordance with the Davis-Besse response to NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," identified conditions that required Control Rod Drive Mechanism (CRDM) nozzle #2 to be removed from service. This nozzle will be removed from service by welding an Alloy 690 welded plug into the nozzle penetration. The repair is intended to be acceptable for service for the remaining current licensed life of the DBNPS (i.e., approximately 15 years). A summary of the repair plan for installing the Alloy 690 welded plug into the nozzle penetration is provided in the following. The repair plan description identifies several issues that require NRC concurrence and/or approval under the provisions of the Confirmatory Action Letter No. 3-02-001 and the requirements of 10CFR50.55a. Figure 1 shows the location of CRDM nozzle #2 on the RVCH.

Summary of Current Condition

Degradation was observed in the RVCH penetration bore of CRDM nozzle #2 during the repair efforts for this nozzle. Figure 2 represents the corrosion area, size and profile. The overall degraded volume has been characterized based on the video examination and approximate measurements from an impression mold. These dimensions are as follows:

- 3-1/2 to 4 inches in length starting from the top of the RPV head
- about 3/8 inch deep (at the deepest location approximately 1-3/4 inches from the top of the RPV head)
- between 1-3/4 to 2 inches at it's widest location.

The extent of corrosion was less near the annulus opening.

Repair Codes and Standards

The repair of CRDM nozzle #2 will be performed in accordance with the requirements of the FirstEnergy Nuclear Operating Company Quality Assurance Program Manual and the FENOC ASME Quality Assurance Manual for the Davis-Besse Nuclear Power Station. In accordance with these FENOC Quality Assurance Manuals, Framatome ANP, Inc. (FRA-ANP) has been contracted to perform the necessary repair services. The repair services will be performed using FRA-ANP's National Board Certificate of Authorization No. NR-64 that authorizes FRA-ANP to perform repair/replacement activities in accordance with the requirements of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME B&PV Code).

All operational details of the individual processes to be used in RVCH repair are controlled by a number of documents including the Process Traveler, Drawings, Welding Procedure Specifications, Equipment Operating Instructions, etc. All control documents are referenced in the Process Traveler at the appropriate sequence of work activity.

The CRDM nozzle #2 repairs will be performed in accordance with the requirements of the 1995 Edition through the 1996 Addenda of ASME B&PV Code Section XI (ASME Section XI) except where alternatives have been granted in accordance with 10 CFR 50.55a or alternatives specified in ASME B&PV Code Cases endorsed by NRC Regulatory Guide 1.147 are applicable. As permitted by IWA-4220, the design of the CRDM nozzle #2 repair is in accordance with ASME B&PV Code Division 1 Section III, 1989 Edition, No Addenda. The original Construction Code for the RVCH was ASME B&PV Code Section III, 1968 Edition, Summer 1968 Addenda. The 1989 Edition of ASME B&PV Code Section III is used for design as this Code edition was the edition first used for mid-wall CRDM nozzle repair. Reconciliation of the 1989 Edition of ASME B&PV Code Section III with the original Construction Code has been performed in accordance with the requirements of IWA-4220 of ASME Section XI.

Non-destructive examination of the welding will be performed in accordance with ASME B&PV Code Section III, 1992 Edition as specified in Code Case N-416-1.

10 CFR 50.55a Requests for Alternative RR-A23 and RR-A24 have been submitted by FirstEnergy Nuclear Operating Company letter Serial Number 2783 to address alternatives to ASME Section XI requirements.

Material for Repairs

The material to be used for the plug at CRDM nozzle #2 will be ASME SB-564 UNS-N06690 forged disk (Alloy 690). The plug will be welded to the P-No. 3 Group No. 3 SA-533 Gr. B, Class 1 low alloy steel RVCH using F-No. 43 Alloy52/152 filler metal. The ASME SB-564 forged disk was solution annealed and thermally treated in compliance with FRA-ANP specifications to provide a metallurgical structure known to improve corrosion resistance. Alloy 690 thermally treated in this manner is resistant to Primary Water Stress Corrosion Cracking (PWSCC) under PWR operating conditions.

The Alloy 690 plug will be machined to fit the as-machined nozzle #2 bore. Appropriate machining and grinding practices will be used on the Alloy 690 forged disk during shop and field activities to ensure dimensions and limit cold working of the Alloy 690 material surfaces. The machining drawing will specify a maximum surface roughness of 3.2 Ra (equivalent to 125 RMS) for the portion of the finished part exposed to the reactor coolant during service. FRA-ANP approved cutting fluids will be used to avoid excessive surface heating and harmful contaminants.

The controls described above ensure that the machining and grinding processes will not jeopardize the PWSCC resistance of the material.

There is no interference fit between the repair plug and the nozzle penetration. The plug-to-bore weld is the structural reactor coolant pressure boundary weld, and no credit is taken for lateral restraint in the stress analysis. This is similar to the other CRDM nozzles where the interference fit is used to maintain alignment, but no credit is taken for this restraint in the stress analysis.

The proposed repair is suitable for the restoration of CRDM nozzle #2 since the root cause of the degradation has been determined to be boric acid corrosion resulting from moisture introduced due to PWSCC cracking of CRDM nozzle #2. The repair materials are resistant to both PWSCC and boric acid corrosion.

Repair Process

CRDM nozzle #2 has been removed from the RVCH as part of the discovery portion of the root cause plan. A semi-automated machining tool operating from underneath the RVCH was used to remove the entire lower portion of the CRDM nozzle to a predetermined position above the existing J-groove partial penetration weld. This operation severs the nozzle from the existing J-groove weld. The nozzle was then further machined as shown in Figure 3 to facilitate extraction while preserving the degradation area for root cause evaluation. Following machining the nozzle was removed.

The following activities will be performed to install the Alloy 690 plug into the CRDM nozzle #2 bore to restore integrity to the penetration. The major steps for the installation of the CRDM nozzle penetration plug are illustrated in Figures 3 through 5. The repair welding method does not differ significantly from the other repair welds that previously have been made to nozzles having flaws that required repair (e.g., USNRC to AmerGen Energy Co., Safety Evaluation Report for Three Mile Island, Unit 1 Third Ten-Year ISI Interval, Relief Request RR-01-18 (TAC MB3177), dated 12/4/2001; USNRC to AmerGen Energy Co., Safety Evaluation Report for Three Mile Island, Unit 1 Third Ten-Year ISI Interval, Relief Request RR-01-14 through 01-17 (TAC MB2323), dated 11/7/2001).

a) The degraded area will be blended by abrasive grinding and then the surfaces examined using liquid penetrant (PT). As left dimensions will be taken of the blended area.

b) The entire RVCH nozzle bore, with the exception of the J-groove weld, will then be examined using PT.

c) The Alloy 690 plug will then be machined to fit and inserted into the RVCH nozzle bore.

d) The Alloy 690 plug will be welded to the RVCH nozzle bore using a remotely operated machine GTAW weld head. The ambient temperature GTAW temper bead repair process will apply ERNiCrFe-7 (Alloy 52) filler metal at a 50°F minimum preheat temperature. No post-weld hydrogen bake will be used.

e) The final weld face, not including the taper transition, will be machined and/or ground suitable for inspection.

f) Following a Code-required 48 hour hold period, the final weld will be PT and ultrasonically (UT) examined.

g) A 1/8 inch minimum chamfer will be ground at the bottom end of the RVCH nozzle bore in the remnant of the original CRDM nozzle to RVCH J- groove weld. The original J-groove weld is chamfered to assure that the thickness of the remaining weld metal will be no greater than the maximum Code allowable flaw size.

Welding Process

Welding the plug to the CRDM nozzle #2 bore on the RVCH low-alloy steel base material will be done with a remotely operated GTAW weld head. An ambient temperature temper bead welding technique will be applied using Alloy 52 filler metal and 50°F minimum preheat with no post-weld hydrogen bake. Temper bead welding will be performed according to the methodology of Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature GTAW Temper Bead Technique", as described in 10 CFR 50.55a Request for Alternative RR-A23. Code Case N-638 is listed as acceptable for implementation in NRC Draft Regulatory Guide DG-1091, December 2001.

The area to be welded will be buttered with a deposit having at least three layers to achieve a minimum 1/8 inch thickness. The heat input for each layer will be controlled to within a Code-specified ± 10% of that used in the procedure qualification test. Particular care will be taken in placement of the weld layers at the weld toe area of ferritic material to ensure that the heat affected zone (HAZ) and ferritic weld metal are tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

Care will be given to ensure that the weld region is free from potential sources of diffusable hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be suitably controlled.

The GTAW welding process is inherently free from trapped diffusable hydrogen. This is because the process applies bare filler wire and uses no flux. An inert gas blanket shields the molten puddle and surrounding material from the atmosphere and any moisture it may contain. To further reduce the likelihood of any hydrogen evolution or absorption, the welding procedure requires care to ensure the weld region is free of potential sources of hydrogen. The GTAW process will be shielded with welding grade argon that typically produces porosity free welds. Argon flow rates will be adjusted to assure adequate shielding of the weld without creating a venturi effect that might draw oxygen or water vapor from the ambient atmosphere into the weld.

Each of the processes have been qualified previously in accordance with ASME B&PV Section IX.

Nondestructive Examination (NDE)

Nondestructive Examination (NDE) personnel will be qualified in accordance with IWA-2300 or NB-5500.

The methods and acceptance criteria of the 1992 Edition of ASME B&PV Code Section III, as modified by 10 CFR 50.55a Requests for Alternative RR-A23 and RR-A24 will be used for nondestructive examinations. The 1992 Edition of ASME B&PV Code Section III is used in accordance with the requirements of Code Case N-416-1, "Alternative Pressure Test Requirement for Welded Repairs or Installation of Replacement Items by Welding, Class 1, 2 and 3 Section XI, Division 1". Accordingly, the surface examination acceptance criteria will be in accordance with NB-5350 of the 1992 Edition of ASME Section III and the ultrasonic examination acceptance criteria will be in accordance with NB-5330 of the 1992 Edition of ASME Section III.

Prior to plug installation, a PT examination will be performed on the machined bore. Upon completion of welding, PT and UT examinations will be performed after the weld has been ground and after the weld has been at ambient temperature for at least 48 hours.

Pressure Testing

Prior to reactor startup with the plant in Mode 3 (Hot Standby) at full temperature and pressure, a visual examination (VT-2) will be performed in conjunction with the system leakage test required by IWA-5000 of the 1992 Edition of ASME Section XI. This pressure test is in accordance with the requirements of Code Case N-416-1. Code Case N-416-1 is listed in NRC Regulatory Guide 1.147 Revision 12.

Stress Analysis of Repair

The CRDM nozzle #2 repair is designed in accordance with ASME B&PV Code Division 1 Section III, 1989 Edition, No Addenda. Design analyses will demonstrate the acceptability of the repair for the remaining service life of the RVCH.

The repair will be analyzed using a 3-dimensional finite element model. The model will encompass a 45-degree segment of the RVCH, using symmetry boundary conditions to include the effect of the remainder of the head. The model will include the RVCH base material and cladding, the #2 repair plug and Inner Diameter Temper Bead (IDTB) repair weld, the chamfer on the original attachment weld for CRDM nozzle #2, adjacent CRDM penetrations, housings, and attachment welds.

A volume enveloping the field measurements of the degraded area in the bore will be removed from the solid model so that the structural effects of the degradation will be included in the analysis. As applicable, stress concentration factor(s) may be applied to the finite element analysis (FEA) results in the subsequent analyses to account for the possible irregular contour of the actual as-left degraded surface.

The model will be used to calculate stresses throughout the structure for the Design Specification temperature and pressure transients. Thermal expansion and conductivity properties of all materials are included and accounted for in the model. The analysis will account for the material loss resulting from the corrosion of the exposed low-alloy steel. Stresses will also be provided at key locations for use in fracture mechanics calculations needed to support the repair design and to justify leaving flaws in the original structural weld.

In response to specific issues raised during the April 10, 2002, meeting between FENOC and NRR, the following is provided:

1. Fatigue history

The fatigue evaluation at nozzle #2 will include both past and future operations. Design condition transients and cycles will be used in the stress and fatigue analysis for the repair at nozzle #2.

2. Strength reduction factors

The strength reduction factors used in the fatigue analysis will be determined in one of two ways:

- The finite element model is determined to be accurate. This is determined by using a classical approach to determine the strength reduction factor, which is multiplied times the linearized stresses from the finite element model. This result is compared to the direct output from the finite element model and the higher of the two is used in the fatigue usage factor calculation.

- A strength reduction factor of 4.0 is used for geometries such as the root of the J-groove weld according to ASME Section III requirements.

3. Material differences (Thermal expansion, thermal conductivity, etc.)

Material properties including thermal expansion and conductivity of all materials are included in the FEA model.

<u>Post Repair Inspection</u>

The UT performed during the repair will provide a baseline of the CRDM nozzle #2 structural weld. After all repairs are completed, the top outer surface of the RVCH will be cleaned to remove residual debris. The area around the cavity repair and CRDM nozzle #2 will be visually inspected. The visual inspection will be video taped to provide a historical record to be used as a baseline for future bare head visual examinations. Ten 12 inch diameter inspection access ports have been placed in the service structure to facilitate cleaning and inspection of the RVCH.

Records

Records of the repair activity will be maintained in accordance with IWA-6000. Records will include:

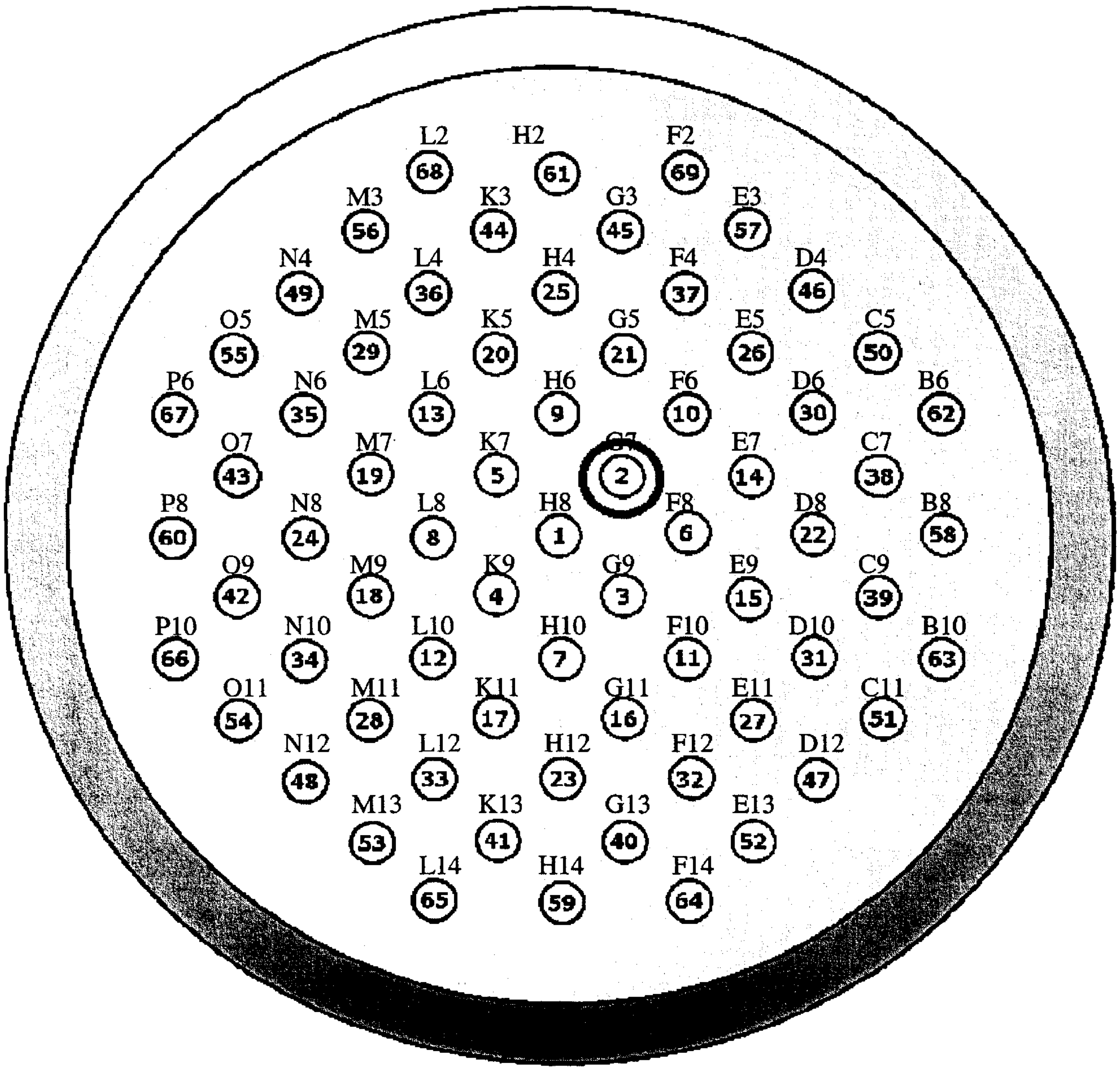
- Weld Procedure Specifications
- Form NIS-2
- Work Orders including Weld Travelers
- Inprocess and final NDE reports.

Approvals Required

As stated in the foregoing, approval of 10 CFR 50.55a Requests for Alternative RR-A23 and RR-A24 is required for the welding and flaw evaluation aspects of the repair.

FIGURE 1
Nozzle 2 Location

Reactor Head



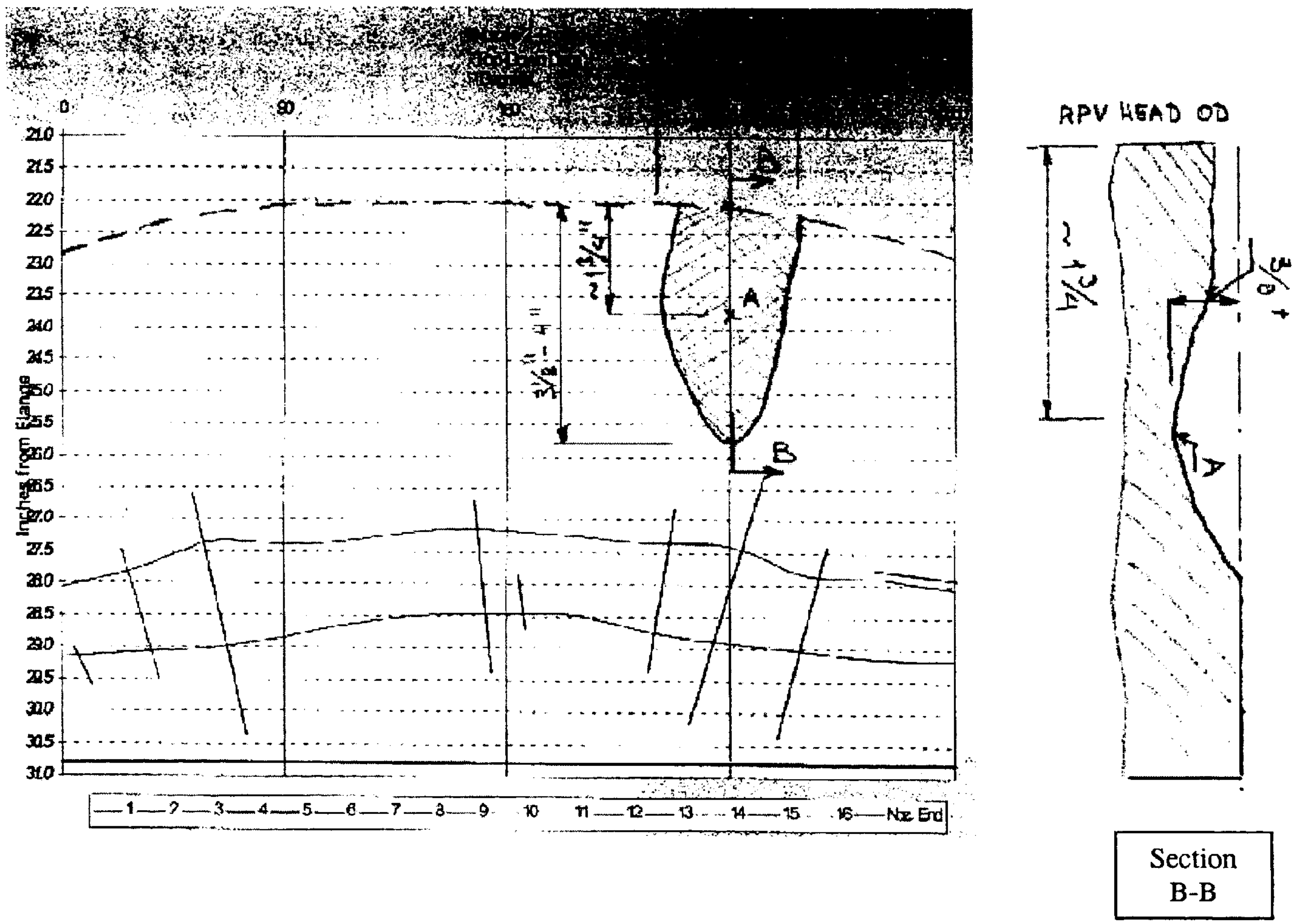


Figure 2
Nozzle 2 Corrosion Area
Location, Size, and Profile.

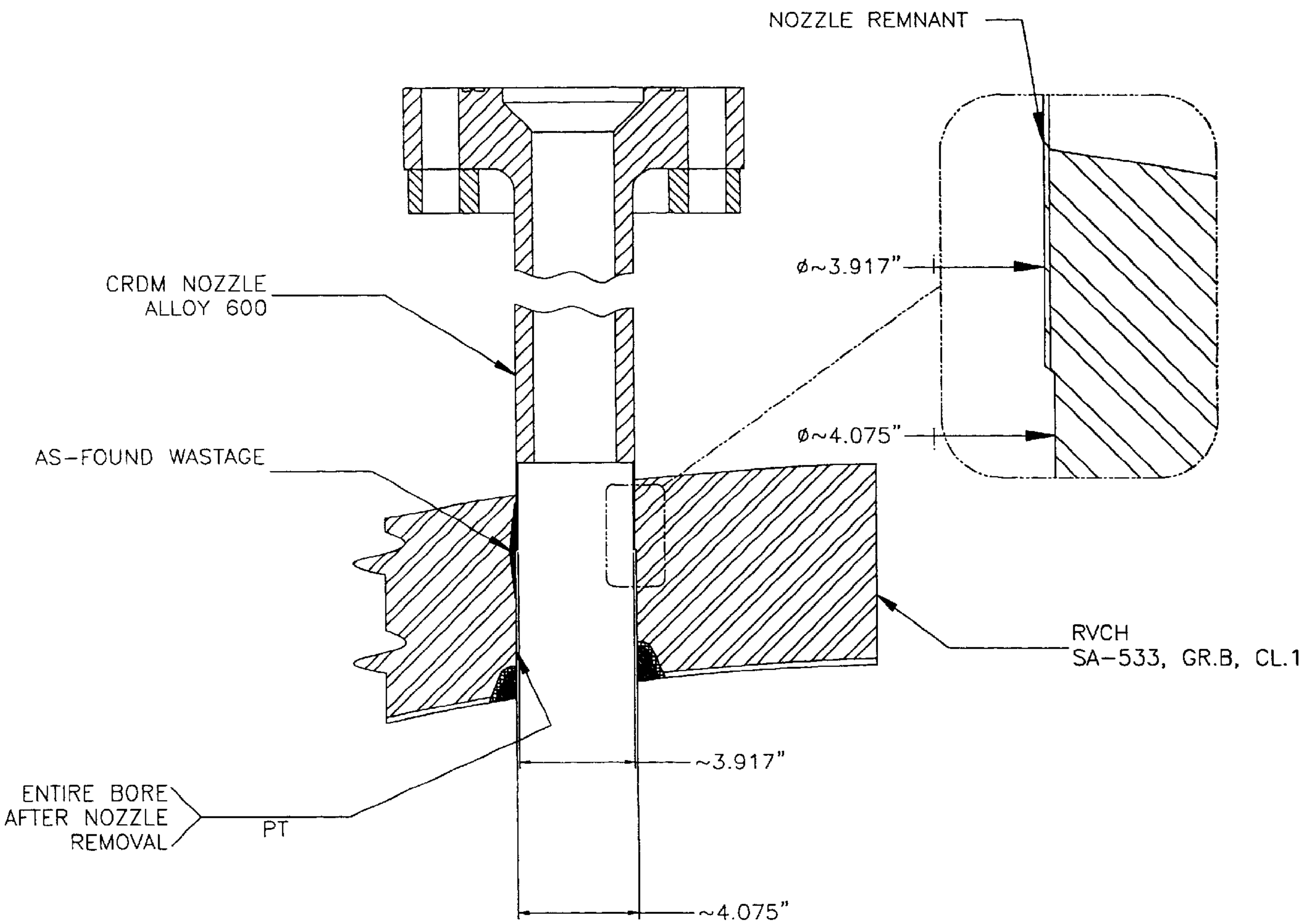


Figure 3

BORE AND REMOVE NOZZLE

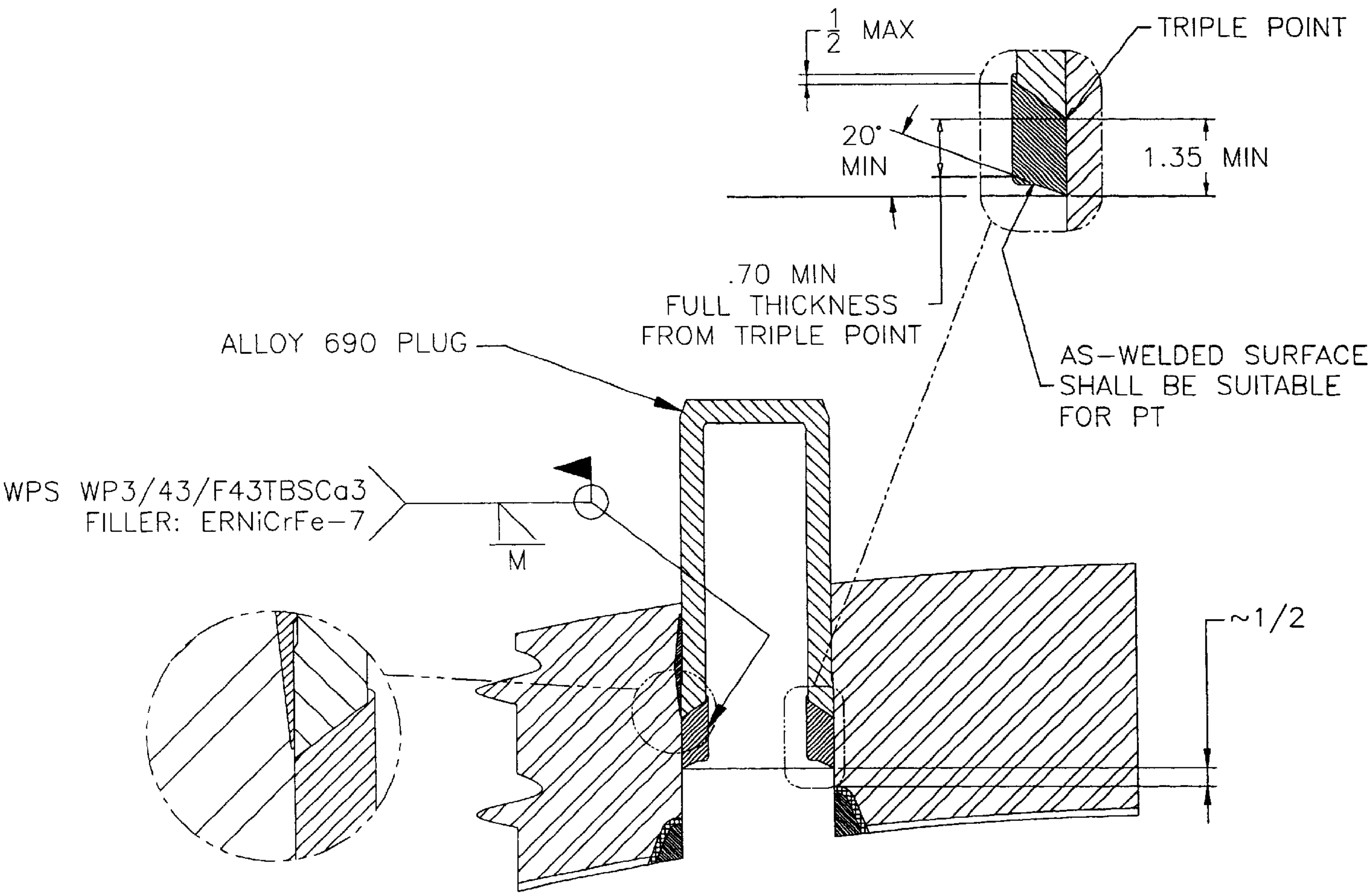


Figure 4

INSERT PLUG, TEMPERBEAD WELD

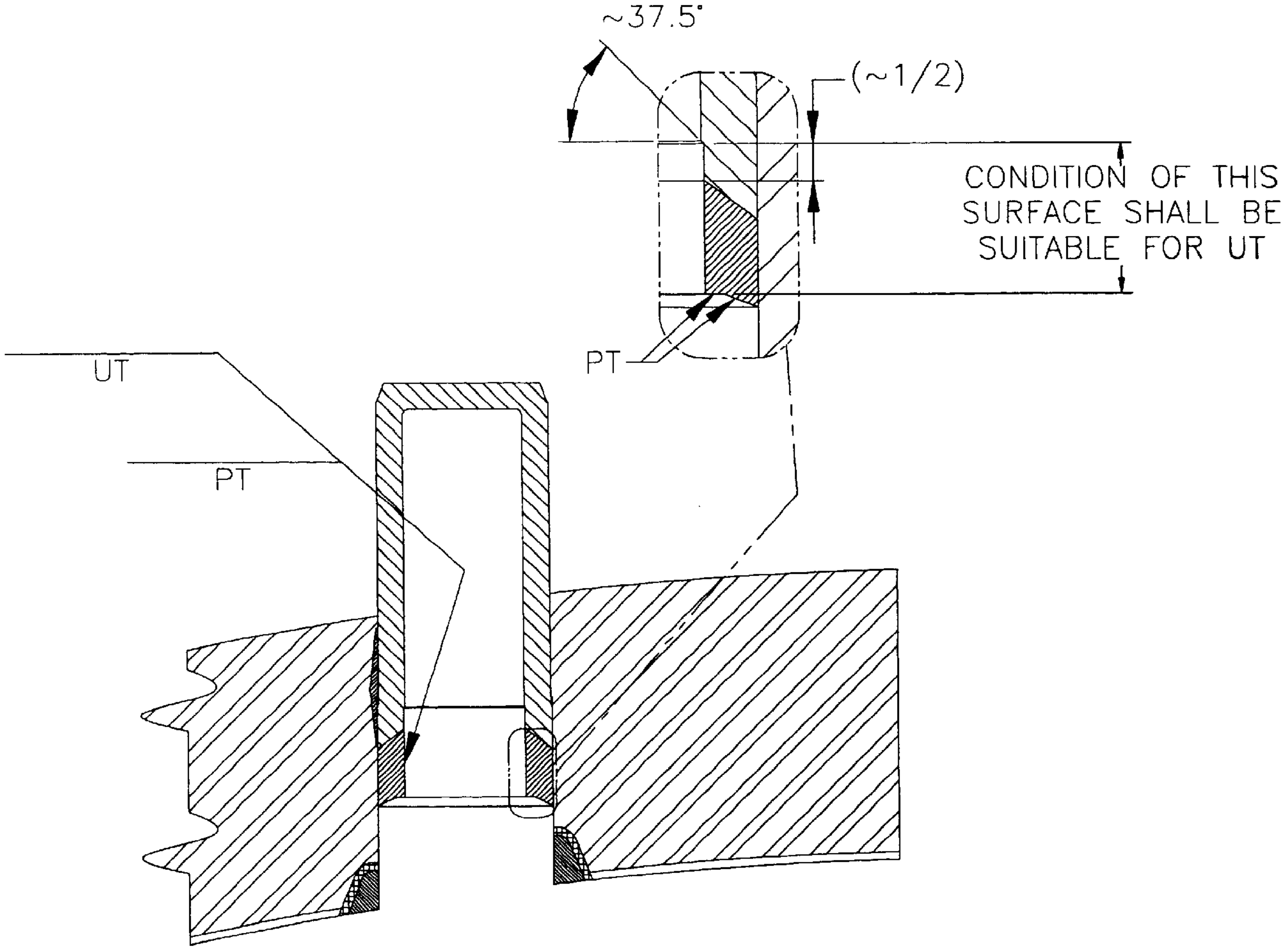


Figure 5

GRINDING AND NDE

Repair Plan Description
Davis-Besse Nuclear Power Station, Unit 1
Control Rod Drive Mechanism Nozzles #3 and #11

(20 Pages Follow)

Repair Plan Description
Davis-Besse Nuclear Power Station, Unit 1
Control Rod Drive Mechanism Nozzles #3 and #11

Introduction

Inspections have been performed of the Reactor Vessel Closure Head (RVCH) in accordance with the Davis-Besse Nuclear Power Station, Unit 1 (DBNPS) response to NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles." These inspections have identified conditions that require repair of the Control Rod Drive Mechanism (CRDM) nozzles #3 and #11 and a degraded portion of the RVCH. These nozzles previously were removed from their penetrations atop the RVCH for investigation of the RVCH degradation. It is planned to remove the areas of significant degradation of the RVCH using abrasive water jet methods. These areas include those previously occupied by CRDM nozzles #3 and #11. The abrasive water jet cutting method was selected in order to preserve evidence for investigation of the RVCH degradation mechanism. The repair will consist of welding an Alloy 690 forged disk into the through-wall bore created by the removal of the degraded area. The repair is intended to be acceptable for service for the remaining current licensed life of the DBNPS (i.e., approximately 15 years). A summary of the repair plan for inserting this Alloy 690 forged disk is provided in the following. The repair plan description identifies several issues that require NRC concurrence and/or approval under the provisions of the Confirmatory Action Letter No. 3-02-001 and the requirements of 10CFR50.55a. Figure 1 shows the location of CRDM nozzles #3 and #11 on the RVCH and Figure 2 provides a plan view of the repair area.

Summary of Current Condition

The results of inspections performed in response to NRC Bulletin 2001-01 required repair to CRDM nozzle #3. During those repairs additional degradation was observed in the RVCH penetration bore at CRDM nozzle #3. Investigation determined that the degradation was a result of boric acid corrosion. Figure 3 shows a plan view of the degradation area and the post repair surface area. The 180° (uphill toward nozzle #1) location exhibits little or no degradation. However, the 0° (downhill toward nozzle #11) location exhibits extensive degradation, with the low-alloy steel material corroded away, down to the stainless steel cladding (average of approximately 0.30 inches remaining thickness). The extent of the corrosion is approximately 6.6 inches in length and 4 to 5 inches at the widest part. From the 270° location to the 0° location (counterclockwise looking down from the top of the RVCH), there is an undercut area.

Repair Codes and Standards

The through-wall bore created by the removal of area encompassing CRDM nozzles #3 and #11 (hereinafter referred to as the CRDM nozzle #3 bore) will be repaired in accordance with the requirements of the FirstEnergy Nuclear Operating Company (FENOC) Quality Assurance Program Manual and the FENOC ASME Quality Assurance

Manual for the Davis-Besse Nuclear Power Station. Framatome ANP, Inc. (FRA-ANP) has been contracted to perform the necessary repair services consistent with the FENOC QA Manuals. These repair services will be performed using FRA-ANP's National Board Certificate of Authorization No. NR-64 that authorizes FRA-ANP to perform repair/replacement activities in accordance with the requirements of Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME B&PV Code). FRA-ANP has subcontracted Welding Services, Inc. to apply the closure weld for the forged disk, and TMP Worldwide, Inc. to perform nondestructive examinations of the repair.

All operational details of the individual processes to be used in RVCH repair are controlled by a number of documents including the Process Traveler, Drawings, Welding Procedure Specifications, Equipment Operating Instructions, etc. All control documents are referenced in the Process Traveler at the appropriate sequence of work activity.

The CRDM nozzle #3 bore repairs will be performed in accordance with the requirements of the 1995 Edition through the 1996 Addenda of ASME B&PV Code Section XI (ASME Section XI) except where alternatives have been granted in accordance with 10 CFR 50.55a or alternatives specified in ASME B&PV Code Cases endorsed by NRC Regulatory Guide 1.147 are applicable. As permitted by IWA-4220, the design of the CRDM nozzle #3 bore repair is in accordance with ASME B&PV Code Division 1 Section III, 1989 Edition, No Addenda. The original Construction Code for the RVCH was ASME B&PV Code Section III, 1968 Edition, Summer 1968 Addenda. The 1989 Edition of ASME B&PV Code Section III is used for design of the repair. The basis for this selection is that this Code edition was the edition first used for mid-wall CRDM nozzle repair. Reconciliation of the 1989 Edition of ASME B&PV Code Section III with the original Construction Code has been performed in accordance with the requirements of IWA-4220 of ASME Section XI.

10 CFR 50.55a Request for Alternative RR-A25 has been submitted by FirstEnergy Nuclear Operating Company letter Serial Number 2785 to address alternatives to ASME Section XI requirements.

Material for Repairs

The material to be used for the forged disk at CRDM nozzle #3 bore will be P-No. 43 SB-564 (UNS N06690) Alloy 690 material. The CRDM nozzle #3 bore will be buttered with F-No. 43 ERNiCrFe-7 filler metal (Alloy 52). The forged disk will be welded to the buttering using F-No. 43 Alloy 52 filler metal. Alternatively, consideration is being given to using Alloy 52 for the first half inch deposit exposed to reactor coolant, with the balance of fill being deposited with Alloy 82. The ASME SB-564 forged disk was solution annealed and thermally treated in compliance with FRA-ANP specifications to provide a metallurgical structure known to improve corrosion resistance. Alloy 690 thermally treated in this manner is resistant to Primary Water Stress Corrosion Cracking (PWSCC) under PWR operating conditions.

The Alloy 690 forged disk will be machined to fit the CRDM nozzle #3 bore. Appropriate machining and grinding practices will be used on the Alloy 690 forged disk during shop and field activities to limit cold working of the Alloy 690 material surface. The machining drawing will specify a maximum surface roughness of 3.2 Ra (equivalent to 125 RMS) for the portion of the finished part exposed to the reactor coolant during service. FRA-ANP approved cutting fluids will be used to avoid excessive surface heating and harmful contamination.

Grinding on the forged disk, after final welding in the RVCH, will be performed using either carbide burrs or aluminum oxide, silicon carbide or zirconia alumina grinding wheels bonded with a resin, silicate or other FRA-ANP or FENOC approved burrs/wheels. Burrs or grinding wheels shall be clean and not previously used on materials other than NiCrFe or stainless steel. Final grinding passes will be performed using 60 to 80 grit wheels to minimize surface roughness and cold work.

The controls described above ensure that the machining and grinding processes will not jeopardize the PWSCC resistance of the material.

The proposed repair is suitable for the restoration of the RVCH cavity since the probable cause of the cavity formation has been determined to be boric acid corrosion resulting from moisture introduced due to PWSCC cracking of CRDM nozzle #3. The repair materials are resistant to PWSCC and are resistant to boric acid corrosion.

Repair Process

The CRDM nozzle #3 bore will be removed from the RVCH as part of the investigative portion of the root cause plan. An automated abrasive water jet tool operating from above the RVCH will be used to remove the degraded volume of the RVCH including CRDM nozzles #3 and #11 to create an approximate 17-1/4 inch circular through-wall penetration in the RVCH.

During the testing of the abrasive water jet cutting system, the minimum and maximum allowable standoff distances between the nozzle jet and work piece will be determined. A desired distance to be used during qualification mockup cut and removal of the wastage area will be determined based on these minimum and maximum values.

The standoff distance is a function of the rotational (azimuthal) and Z-axis (up and down) position of the tool. It is expected that a large allowable standoff range exists and therefore manual manipulation of the Z-axis position will be acceptable. Rotational position will be controlled automatically. A chart will be created that will direct tooling operators on the appropriate Z-axis positions to be used with relation to rotational position to achieve the desired standoff distance. The abrasive water jet system is also equipped with a camera that allows for viewing of the nozzle jet and work piece simultaneously providing a visual verification of the standoff distance.

The following activities will be performed to install the Alloy 690 forged disk into the CRDM nozzle #3 bore. The major steps are illustrated in Figures 4 through 8.

a) The CRDM nozzle #3 bore will be machined to its final 17-1/2 inch dimension and PT examined. (Figure 4)

b) Stainless steel (Type 304) gas shield cover and runoff rings will be seal welded with Alloy 52 filler metal on the RVCH inner surface at the CRDM nozzle #3 bore and a stainless steel runoff ring similarly will be welded on the outer surface of the RVCH at the bore to facilitate buttering of the bore. (Figure 5)

c) The face of the CRDM nozzle #3 bore will be buttered with a remotely operated machine Gas Tungsten Arc Welding (GTAW) process weld head, using the ambient temperature temper bead process with ERNiCrFe-7 (Alloy 52) filler metal and 50°F minimum preheat temperature. (Figure 6)

d) The final buttering will be machined and/or ground to obtain a minimum of 3/8 inch deposit. (Figure 7)

e) A Code-required 48-hour hold period will be implemented to identify any hydrogen delayed cracking, although considered unlikely. Following the hold period, the final butter will be PT and UT examined.

f) The stainless steel OD runoff ring and seal weld, including the heat affected zone of P-No. 3 Group 3 base metal, will be removed by machining or grinding.

g) The Alloy 690 forged disk will be welded to the butter using a remotely operated machine GTAW weld head, using ERNiCrFe-7 (Alloy 52) filler metal. (Figure 8)

h) The closure weld will be surfaced finished to support NDE of the weld (PT and RT). Grinding of the surrounding opening will be performed to blend any remaining localized OD surface degradation.

i) The closure weld will be examined using PT and RT methods.

<u>Welding Process</u>

Two distinct welds will be used for the repair process. Both will be made using a remotely operated GTAW process. The first weld will butter the face of the CRDM nozzle #3 bore with the Alloy 52 weld material. The second weld provides the closure weld of the Alloy 690 forged disk to the buttered CRDM nozzle #3 bore.

Care will be given to ensure that the weld region is free of potential sources of hydrogen. The surfaces to be welded, filler metal, and shielding gas shall be controlled by procedure. This GTAW welding process is inherently free of hydrogen. The process applies bare filler wire and uses no flux to trap moisture. An inert gas blanket shields the weld and surrounding material from the atmosphere and any moisture it may contain. To further reduce the likelihood of any hydrogen evolution or absorption, the welding procedure requires care to ensure that all surfaces and materials in near proximity to the weld are free of potential sources of hydrogen. The GTAW process will be shielded with welding grade argon that typically produces porosity free welds. Argon flow rates will be adjusted to assure adequate shielding of the weld without creating a venturi effect that might draw oxygen or water vapor from the ambient atmosphere into the weld.

Buttering

The buttering on the RVCH low-alloy steel base material will be done with a remotely operated weld head, utilizing ambient temperature GTAW temper bead technique using Alloy 52 filler metal and 50°F minimum preheat with no post weld hydrogen bake. The welding will be performed using the methodology of Code Case N-638, "Similar and Dissimilar Metal Welding Using Ambient Temperature GTAW Temper Bead Technique", as described in 10 CFR 50.55a Request for Alternative RR-A25. Code Case N-638 is listed as acceptable for implementation in NRC Draft Regulatory Guide DG-1091, December 2001.

The CRDM nozzle #3 bore will be buttered with a deposit of at least three layers to achieve a minimum 1/8 inch overlay deposit with the heat input for each layer controlled to within the Code-specified ± 10% of that used in the procedure qualification test. Care will be taken in placement of the weld layers at the weld toe area of ferritic material to ensure that the heat affected zone (HAZ) is tempered. Subsequent layers will be deposited with a heat input not exceeding that used for layers beyond the third layer in the procedure qualification.

Weld Torch to Workpiece Distance (Buttering)

A single control system is used to control rotational movement of the head. The distance from the welding torch to the work surface is controlled by precise Arc Voltage Control (AVC). A slide mechanism is used to control vertical positioning of the welding head.

Forged Disk to CRDM Nozzle #3 Bore Weld

The forged disk will be welded to the buttering applied to the CRDM nozzle #3 bore using a remotely operated GTAW weld head. The similar metal weld will be made in accordance with the requirements of NB-4000 of the ASME B&PV Code Section III, 1989 Edition, as permitted by IWA-4200 of ASME B&PV Code Section XI.

Weld Torch to Workpiece Distance and Angle (Closure Weld)

The forged disk weld head uses programmed circumferential and vertical axis motion control to accommodate the rise and fall during any single 360 degree weld bead. Additionally, a linear vertical axis is used to provide precise Arc Voltage Control (AVC). Cross seam adjustments are accomplished using a radial axis slide and a rotary axis (wrist) is used for torch tilt. The welding operator can remotely control all motion functions.

Nondestructive Examination (NDE)

Nondestructive Examination (NDE) personnel will be qualified in accordance with IWA-2300 and NB-5500.

The methods and acceptance criteria of the 1992 Edition of ASME B&PV Code Section III will be used for nondestructive examinations. The 1992 Edition of ASME B&PV Code Section III is used in accordance with the requirements of Code Case N-416-1, "Alternative Pressure Test Requirement for Welded Repairs or Installation of Replacement Items by Welding, Class 1, 2 and 3 Section XI, Division 1". Accordingly, the surface examination acceptance criteria will be in accordance with NB-5350 of the 1992 Edition of ASME Section III, the ultrasonic examination (UT) acceptance criteria will be in accordance with NB-5330 of the 1992 Edition of ASME Section III, and the radiographic examination (RT) acceptance criteria will be in accordance with NB-5320 of the 1992 Edition of the ASME Section III.

Examination by PT will be performed on the machined opening of the CRDM nozzle #3 bore prior to weld buttering.

After the buttering has been completed, the butter will be machined to final dimension then PT and UT will be performed after the weld has been at ambient temperature for a minimum period of 48 hours.

Ultrasonic examination of the buttering for the nozzle #3 location will be performed using a combination of straight beam and angle beam transducers. The examination areas will include the weld material, the fusion zone, and heat affected zone beneath the weld. The UT techniques used will search for lack of fusion, underbead cracking, laminar and planar defects within the buttering layer. The scanning will be performed manually with a person positioned above the head reaching down into the repair area. The full area of the buttering will be scanned using 0°, 60°, and OD creeping wave transducers with the 60° and creeping wave transducers aimed in four directions; two opposed directions parallel to the weld beads and two opposed directions perpendicular to the weld beads. ASME Section III, NB-5000 standards will be used.

Subsequently, the final closure weld, which includes the buttering in the CRDM nozzle #3 bore, will be examined by PT and RT.

There is no ASME B&PV Code Section XI Table IWB-2500-1 Examination Category which is applicable to this weld configuration. The DBNPS has conservatively classified this weld as a circumferential weld, Examination Category B1.21. In accordance with IWA-4530, a pre-service inspection will be performed in accordance with IWB-2000. Category B1.21 circumferential welds require volumetric examination per Table IWB-2500-1, with volumetric examinations defined in paragraph IWA-2230 as RT or UT.

Since the post-repair NDE examination will be performed to ASME B&PV Code Section V, Article 2, this examination is acceptable as the pre-service examination as well. The acceptance standards of ASME B&PV Code Section III, 1992 Edition, NB-5300 will be used for acceptance of the weld for pre-service examination. As permitted by IWA-4530, this pre-service examination will be performed prior to the pressure test required by IWA-4540.

After all repairs are completed, the top outer surface of the RVCH will be cleaned to remove residual debris. The area around the cavity repair and CRDM nozzle #2 will be visually inspected. The visual inspection will be video taped to provide a historical record to be used as a baseline for future bare head visual examinations. Ten 12 inch diameter inspection access ports have been placed in the service structure to facilitate cleaning and inspection of the RVCH.

Future inspections will be performed in accordance with ASME Section XI. During each refueling outage, a bare head qualified visual inspection will be performed. The closure weld for the CRDM nozzle #3 bore will be examined by RT at least once every ten year interval. This is consistent with ASME Section XI requirements for weldments in reactor heads fabricated from plate segments and a dollar piece, which is comparable with the proposed repair at DBNPS.

Pressure Testing

Prior to reactor startup with the plant in Mode 3 at full temperature and pressure, a visual examination (VT-2) of the top head will be performed in conjunction with the system leakage test required by IWA-5000 of the 1992 Edition of ASME Section XI. This pressure test is in accordance with the requirements of Code Case N-416-1. Code Case N-416-1 is accepted by NRC Regulatory Guide 1.147 Revision 12.

Surrounding Nozzle Distortion

The new weld has been evaluated analytically and it has been determined that there is sufficient distance from the surrounding penetrations to ensure that any distortion at these penetrations due to welding will be limited to acceptable levels. As a confirmation, photometric measurements will be made on both the mockup and the RVCH to verify that CRDM distortion is within acceptable limits.

Stress Analysis of Repair

The CRDM nozzle #3 bore repair has been designed in accordance with ASME B&PV Code Division 1 Section III, 1989 Edition, No Addenda. The design analyses will demonstrate the acceptability of the repair in accordance with ASME B&PV Section III for the remaining service life of the RVCH.

The repair will be analyzed by FRA-ANP using a 3-dimensional finite element model. The model will encompass a 90-degree segment of the RVCH, using symmetry boundary conditions to include the effect of the remainder of the head. The model will include the RVCH base material and cladding, the forged disk and repair weld, adjacent CRDM penetrations, housings, and attachment welds. The results of field measurements of the outer surface of the head will be used to refine the model so that the effects of the remaining topography (including remaining areas of degradation) will be included in the analysis. A chamfer also will be applied analytically to the perimeter of the repair hole at the head outer surface to add conservatism to the degradation modeled.

The model will be used to calculate stresses throughout the structure for the Design Specification temperature and pressure transients. Thermal expansion and conductivity properties of all materials are included in the model. Stresses also will be provided at key locations for use in fracture mechanics calculations needed to support the repair design and to justify any small flaws left in the original structural J-groove weld.

Structural Integrity Associates (SI) will perform an independent ASME B&PV Code Section III evaluation of the repair to ensure code stress and fatigue limits are met. This will involve development of an independent three-dimensional finite element analysis of the RVCH, the repairs and as left local contours. The model will be subjected to all the loadings and transients in the Design Specification for the RVCH.

In response to specific issues raised during the April 10, 2002, meeting between FENOC and NRR, the following is provided:

1. Fatigue history

The area removed via abrasive water jet to accommodate the repair forged disk will eliminate the areas of the RVCH that would have any significant fatigue usage factor resulting from past operations except the portion of the original structural J-groove weld remaining at the penetration #11 location. The stress calculation will address this condition quantitatively for the remaining original structural weld portion and will address other areas in a quantitative/qualitative fashion. Design condition transients and cycles will be used in this calculation for both past and future operating transient conditions.

2. Strength reduction factors

The strength reduction factors used in the fatigue analysis will be determined in one of two ways:

- The finite element model will be determined to be accurate. This will be determined by using a classical approach to determine the strength reduction factor, which is multiplied times the linearized stresses from the finite element model. This result will be compared to the direct output from the finite element model and the higher of the two will be used in the fatigue usage factor calculation.
- For geometries such as the root of the J-groove weld, the ASME Section III requirement to use a strength reduction factor of 4.0 will be followed.

3. Material differences (Thermal expansion, thermal conductivity, etc.).

As stated in the foregoing, thermal expansion and conductivity properties of all materials are included in the model.

Mockup Configuration, Demonstration Activities and Locations

The objective of the mockup is to demonstrate each of the major steps of the repair to the RVCH including abrasive water jet removal of the corrosion cavity as part of the root cause plan, buttering and machining of the bore, closure weld of the forged disk, and associated PT, UT and RT examinations.

In addition to mockups used for the purpose of equipment set-up and initial procedure establishment for each process, the following mockups will be performed as a minimum:

Abrasive Water Jet: Two (2) process/personnel qualification coupons, one (1) Design Review Board demonstration coupon, and one (1) pre-production coupon.

Boring: Two(2) full thickness carbon steel coupons, one (1) weld deposited buttering coupon, two (2) full thickness low alloy steel demonstration coupons both initial bore and subsequent weld buttering.

Buttering: One (1) filler material weldability coupon, two (2) full thickness carbon steel personnel training coupons, and two (2) final demonstration full thickness low alloy steel coupons.

Forged Insert Welding: One (1) full diameter, 5 inch thick Alloy 690 forged insert to buttering proof-of-process coupon that will be subjected to PT and RT. One (1) full thickness, full diameter Alloy 690 forged insert to buttering weld that will be subjected to all described NDE, mechanical testing, distortion and temperature monitoring evaluations.

Mockup Materials

The materials selected for the mockup are representative of the actual RVCH materials.

- The RVCH base material coupon will be quenched and tempered P-No. 3 Group No. 3 in accordance with a Code-specified minimum tensile strength of 80 ksi and specified minimum yield strength of 50 ksi. The coupon will be subjected to PWHT at 1125F±25F for 12 hours minimum.

- The cladding shall be SFA-5.4 E309L 1st layer and E308L balance (using Shielded Metal Arc Welding) or SFA-5.9 ER309L 1st layer and ER308L balance (using GTAW).

Mockup Configuration

- The RVCH base material coupon will be flat and at least 48 inches long and 36 inches wide and 7 +1/8, -0 inches thick.

- The bottom side of the RVCH base material coupon shall have 2 inches minimum width by 5/16 ± 1/16 inch clad band area extending radially outward from inside the AWJ cutting kerf to outside the bottom runoff ring.

- The hillside location on the RVCH will be simulated by inclining the mockup RVCH plate within the fixture approximately 12 degrees from horizontal prior to machining the CRDM nozzle penetrations that corresponds to a tangent plane at the 17-½ inch hole centerline. The large spherical head radius of the actual RVCH is inconsequential regarding rise and fall when compared to the demonstration plate. The abrasive water jet and welding processes have sufficient control to work in either case.

- The CRDM nozzle penetrations shall be machined to 4.00 +/-0.03 inches diameter through wall.

- The RVCH plate at a minimum shall contain simulations of CRDM nozzle penetration numbers 1, 6, 7, 15, 16 and 27 with CRDM nozzle mockups installed therein.

- CRDM nozzle penetration spacing (pitch) shall be the same as the actual spacing in the RVCH.

- The CRDM nozzle mockup assembly portion extending above the RVCH coupon shall simulate the actual CRDM nozzle exterior configuration.

- The final primary opening size shall be 17-1/2 inches diameter through wall with its centerline essentially parallel to the vertical centerline of the RVCH.

- The RVCH coupon top surface shall simulate the remaining external surface degradation contour (outside the 17-1/2 inch opening) to the extent practical after final machining and prior to attachment of welding runoff tabs.

Mockup Instrumentation

The instrumentation used in the mockup demonstrations will be treated as safety related instrumentation in accordance with the FRA-ANP QA Program to ensure reliability of the instrumentation and data collected.

Distortion

Targets will be installed on each CRDM nozzle flange mockup for precision metrology measurements that will be taken and recorded prior to and after welding the forged disc to the RVCH coupon.

Temperature

Thermocouples (TC) will be installed within 1 inch of the edge of the opening on both the top face and bottom face on the high hillside and low hillside of the RVCH coupon and recorders attached for interpass temperature measurements and recording during buttering and groove welding (4 TCs total).

Mockup Mechanical Testing

Following post-weld NDE, the demonstration mockup will be subjected to mechanical testing to verify that required ASME Code mechanical properties have been met. The mechanical testing will include the types of tests used for Welding Procedure Qualifications similar to the methodology provided in Code Case N-638, Ambient Temperature Machine Gas Tungsten Arc Welding (GTAW) Temper Bead Technique. These tests will include two (2) transverse tensiles, four (4) transverse guided side bends, six (6) charpy v-notch impact specimens, with three (3) from the weld heat-affected-zone compared to three (3) in the unaffected base material of the low alloy steel.

The property tests are confirmatory relative to the existing procedure qualification test results for the full scale mockup weld. This testing will be done in parallel with closure welding on the RVCH. Results will be available prior to final RVCH weld acceptance, with a written report available in 30 days.

Mockup Location

The abrasive water jet cutting demonstration will be performed at DBNPS site inside of containment.

Machining, buttering and NDE of the 17-1/2 inch opening in the coupon will be performed in Lynchburg, Virginia at the FRA-ANP Old Forest Road Shop. Machining of the buttering weld, and subsequent PT and UT of the coupon will also be performed at the FRA-ANP Lynchburg Old Forest Road Shop.

The mockup will then be shipped to Welding Services, Inc. in Norcross, Georgia, where the forged Alloy 690 insert welding into the 17-1/2 inch opening will be performed. Closure weld RT and PT will be performed in Norcross at Welding Services, Inc. by FRA-ANP and FRA-ANP's subcontractor for NDE, TMP Worldwide, Inc. for RT.

Mockup Evaluation

The acceptability of cutting and welding on the mockup for repair of the RVCH will be as follows:

1. Abrasive Water Jet cutting will be deemed acceptable if the portion of the mockup removed is in the planned location and the opening is within the specified tolerances. The removed portion will be examined to ensure the outer surface remains unaffected.

2. Surface and volumetric NDE test results will be evaluated to ensure that ASME Code requirements are satisfied.

3. Mechanical testing, metallography and hardness testing results will be evaluated to ensure that ASME Code and other pre-established acceptance parameters have been satisfied.

4. Dimensional position of the CRDMs adjacent to the repair will be measured to ensure that any distortion is within acceptable limits.

Records

Records of the repair activity will be maintained in accordance with IWA-6000. Records will include:

- Weld Procedure Specifications
- Form NIS-2
- Work Orders including Weld Travelers
- Inprocess and final NDE reports.

Approvals Required

During mockup testing, the DBNPS will notify the NRC in advance of each planned demonstration in order to provide the NRC with the opportunity for witnessing the demonstration, and to review and discuss the results. Following NRC approval of each of the completed mockup activities as shown below, corresponding activities in the plant will proceed.

1. Abrasive Water Jet Mockup
2. CRDM Nozzle #3 Bore Buttering Mockup
3. Final Closure Weld, RT and PT Mockup

Additionally, as stated in the foregoing, approval of 10 CFR 50.55a Request for Alternative RR-A25 is required for the welding and flaw evaluation aspects of the repair.

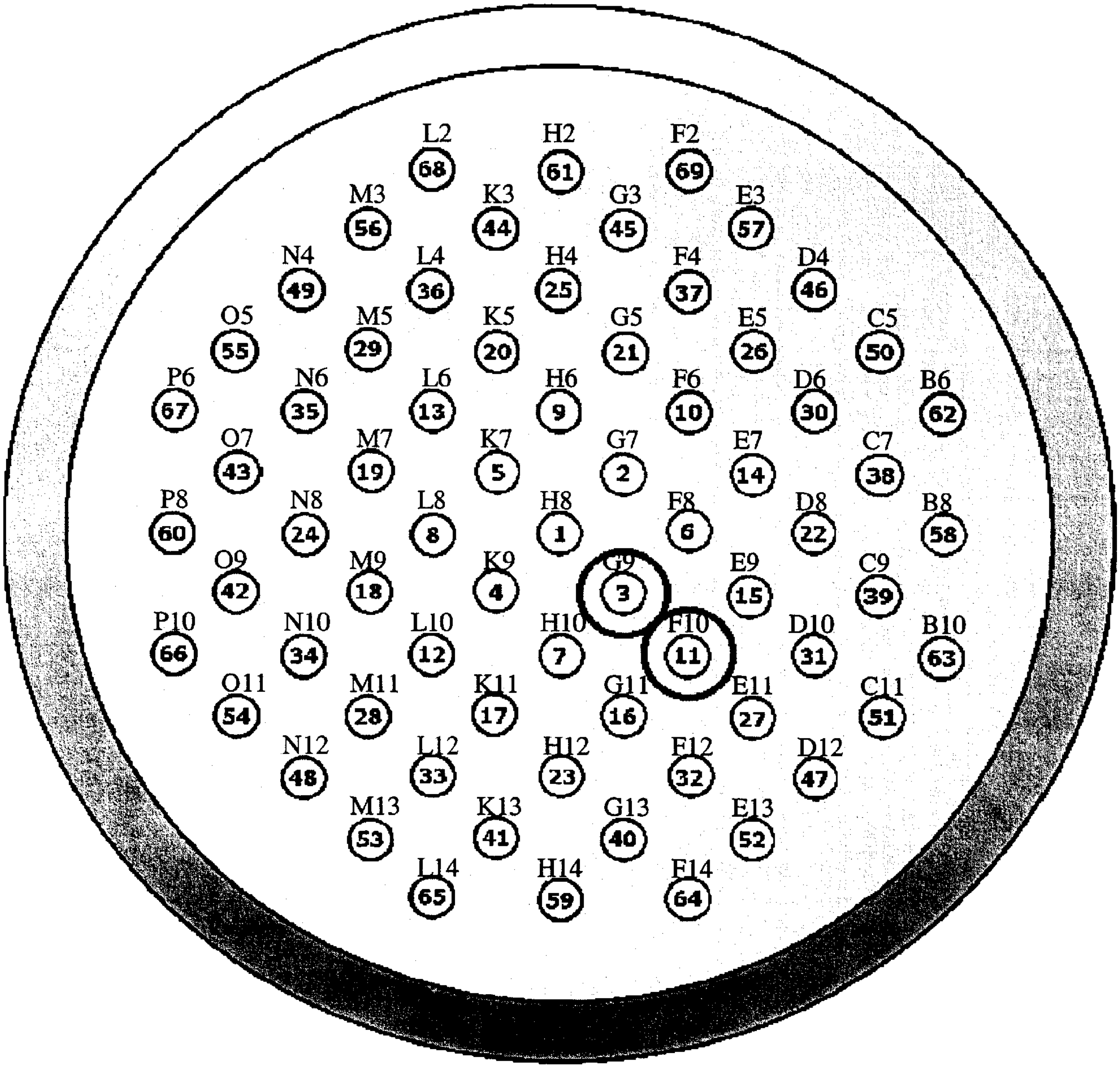
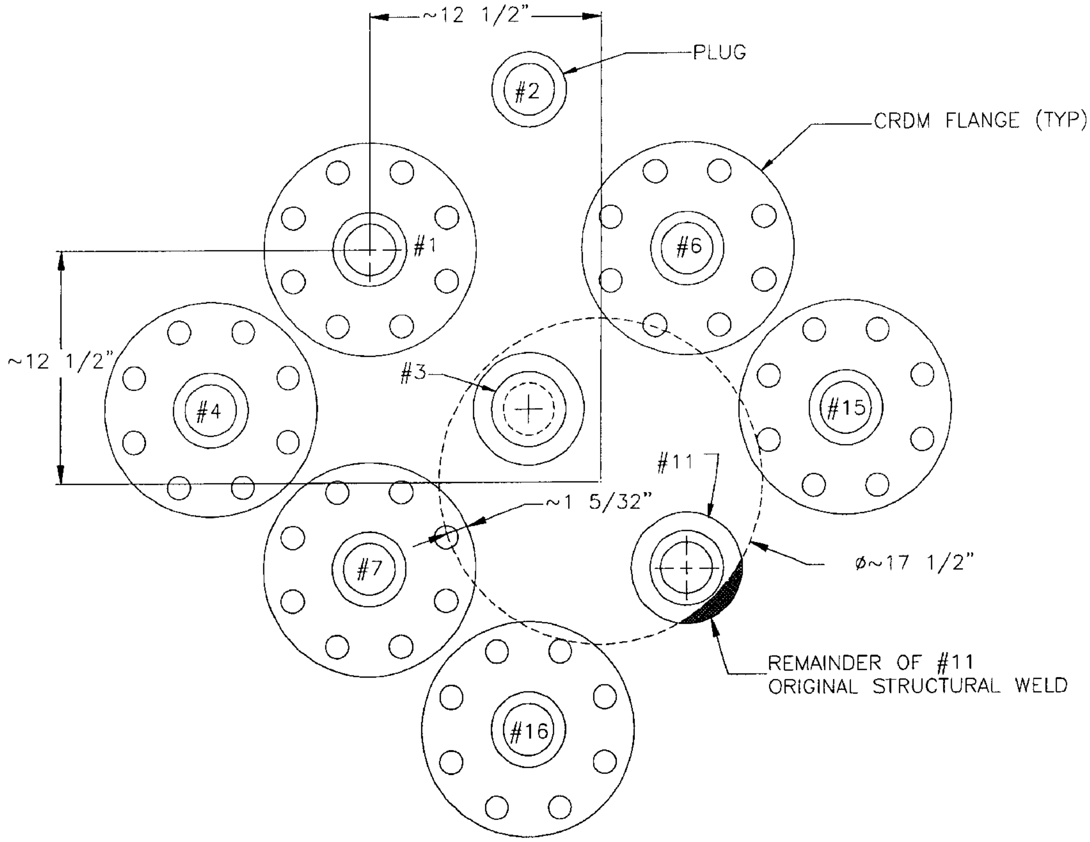
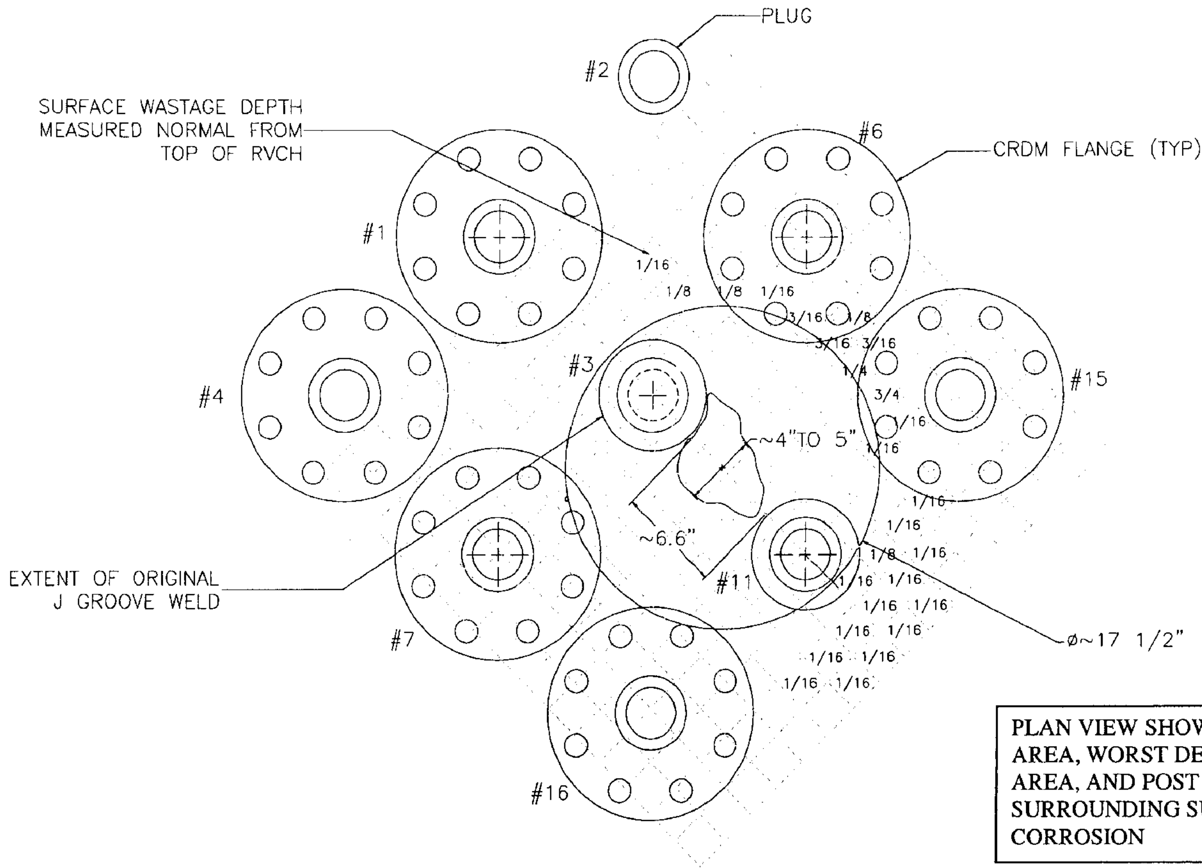


Figure 1
Nozzle 3 & 11 Location



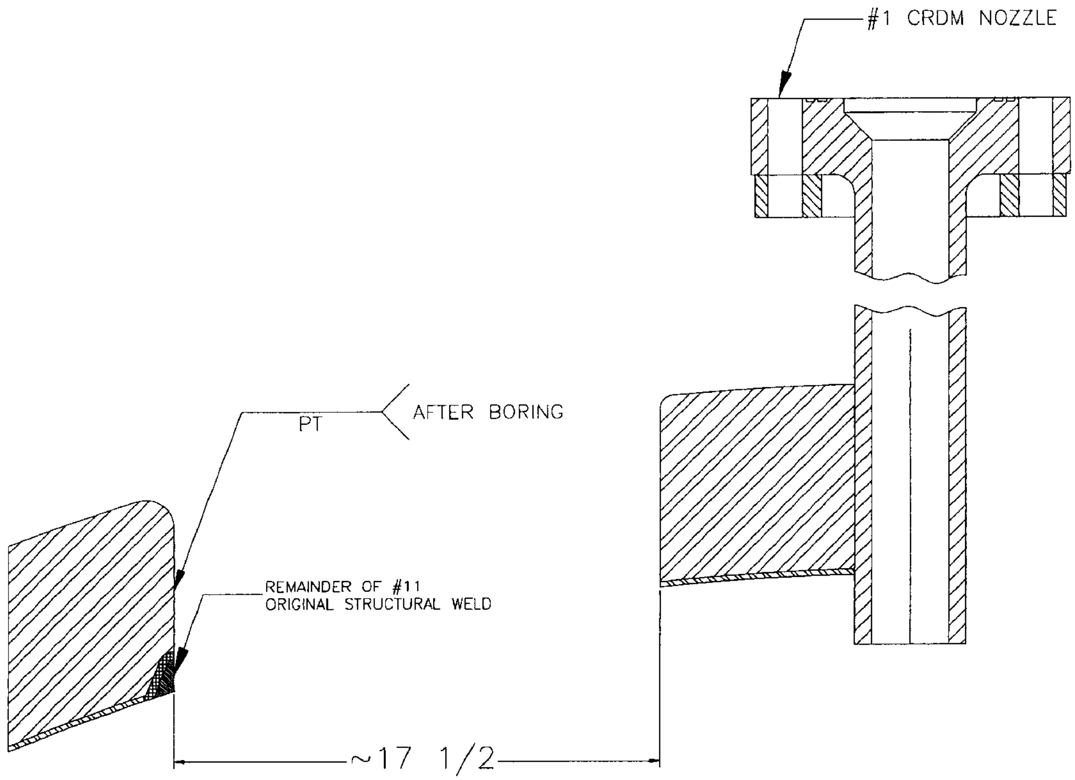
PLAN VIEW OF REPAIR AREA

Figure 2



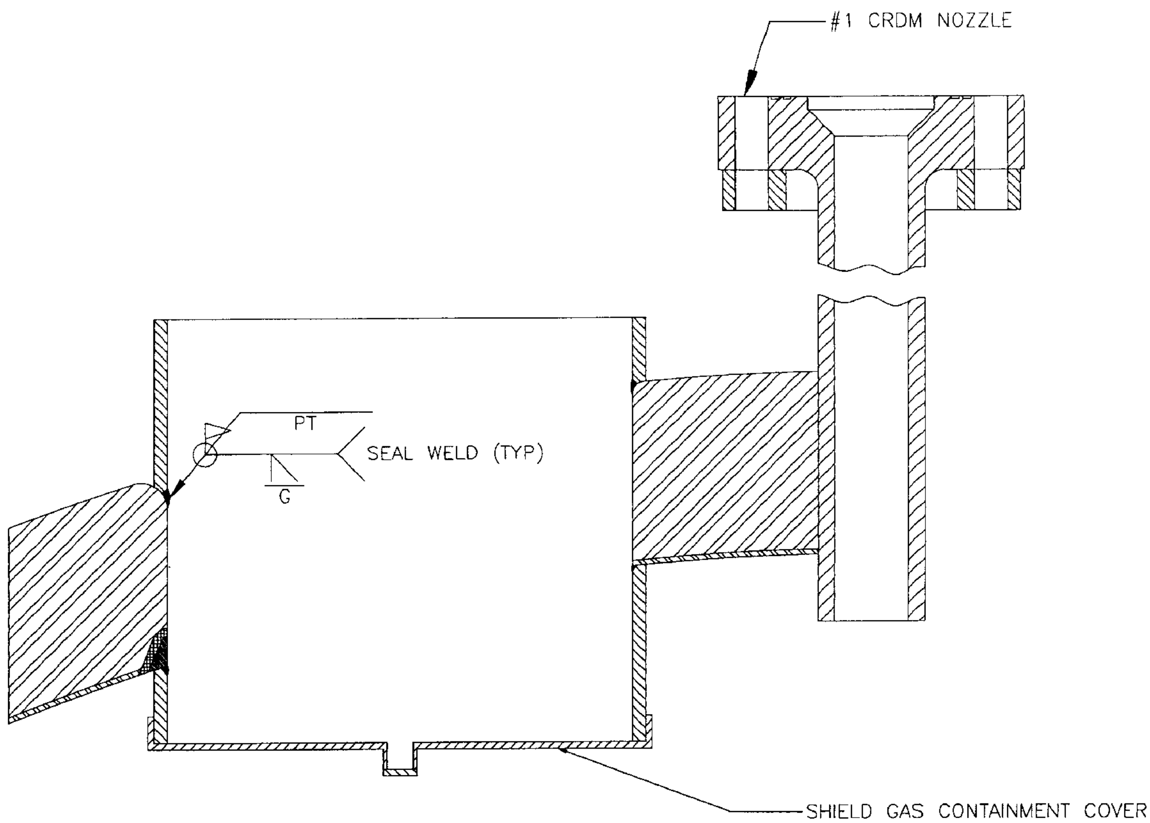
PLAN VIEW SHOWING REPAIR AREA, WORST DEGRADATION AREA, AND POST REPAIR SURROUNDING SURFACE CORROSION

Figure 3



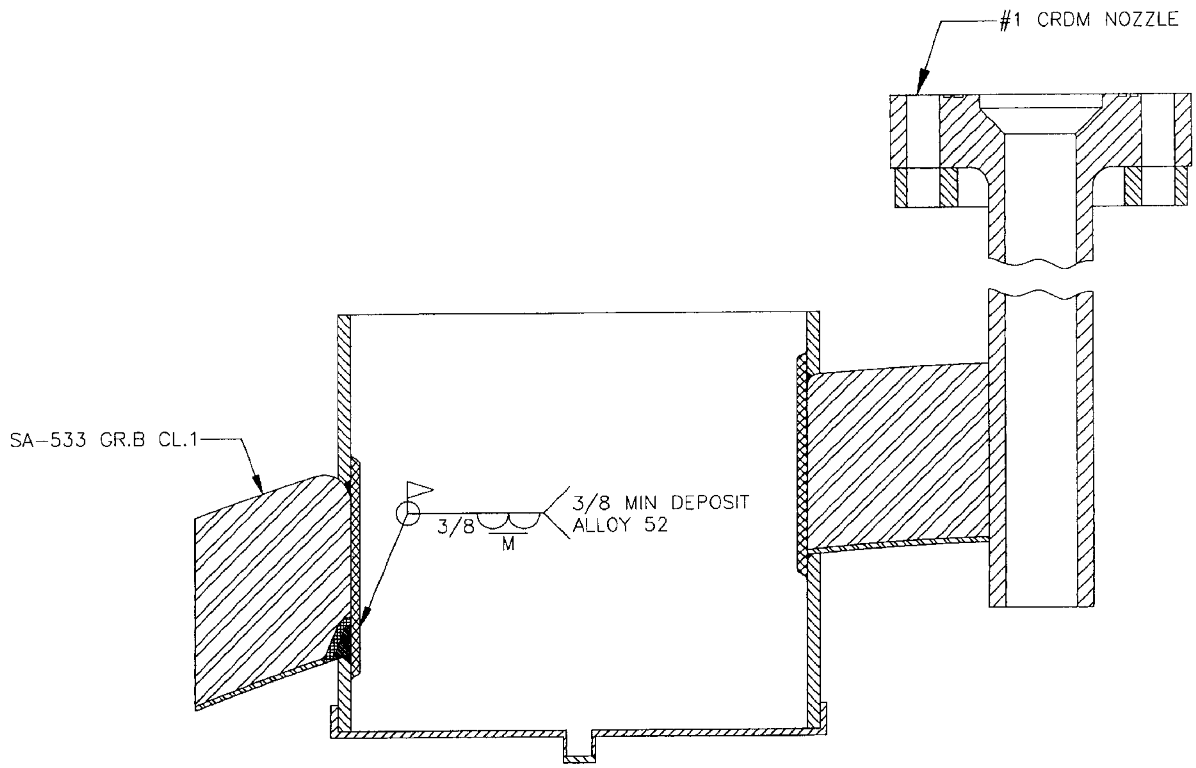
ABRASIVE WATERJET CUT TO
APPROXIMATELY 17 1/4" AND
FINISH BORE REPAIR AREA

Figure 4



INSTALL OD AND ID RUNOFF RINGS

Figure 5



DEPOSIT BUTTER
REMOTE MACHINE GTAW

Figure 6

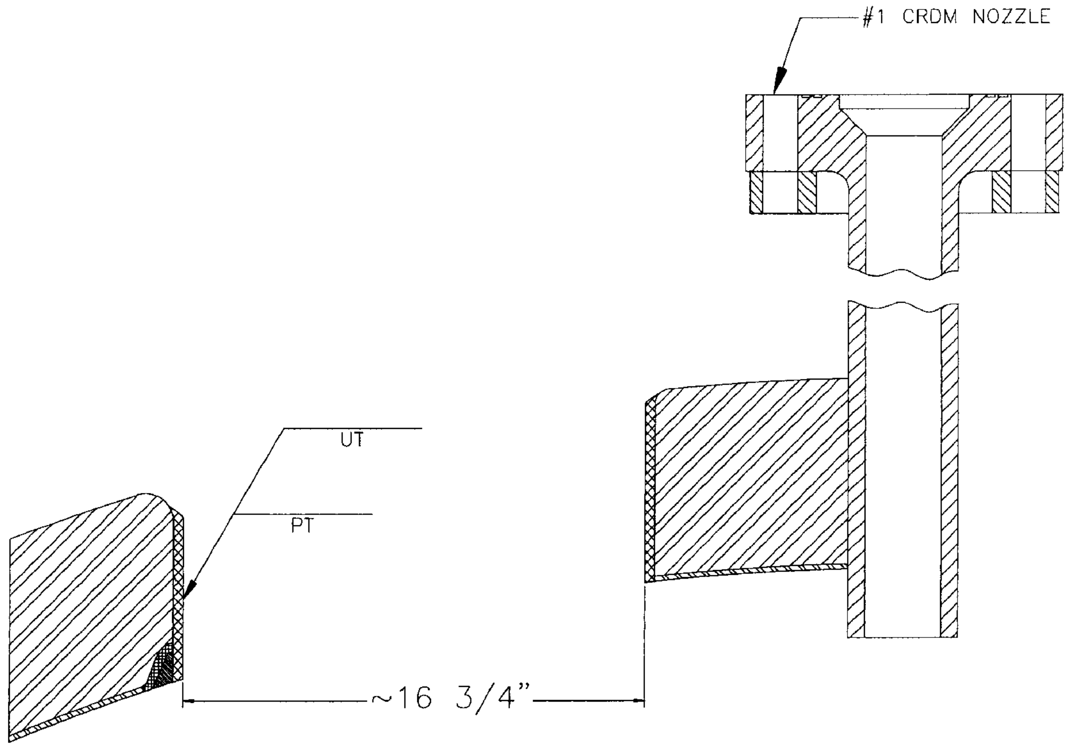


Figure 7

MACHINE BORE & INSPECT

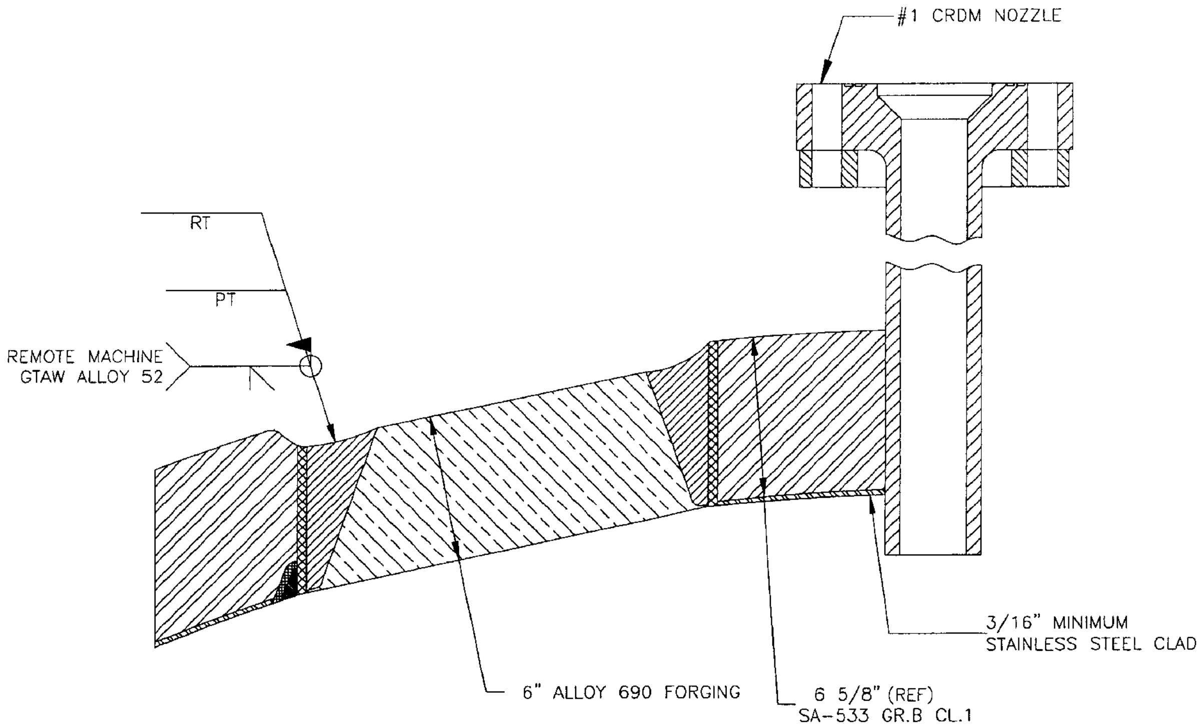


Figure 8

WELD, BLEND GRIND & INSPECT

COMMITMENT LIST

The following list identifies those actions committed to by the Davis-Besse Nuclear Power Station (DBNPS) in this document. Any other actions discussed in the submittal represent intended or planned actions the DBNPS. They are described only for information and are not regulatory commitments. Please notify the Manager - Regulatory Affairs (419-321-8450) at the DBNPS of any questions regarding this document or associated regulatory commitments.

COMMITMENTS	DUE DATE
None	