PERMANENT REPAIR PLAN

FOR THE

ANO-2 PRESSURIZER

04/21/88

BACKGROUND:

In late April, 1987, a small Reactor Coolant System leak was detected, and through containment entries was determined to be coming from the pressurizer high point vent and the pressurizer lower head. As a result the plant was shutdown in accordance with Technical Specifications and the event was reported in accordance with 10CFR50.72 and 50.73. The leakage source at the lower head was determined to be the X-1 heater sleeve. Further inspections via video camera from inside the pressurizer revealed that the X-1 and T-4 heaters had failed. A temporary repair was made by drilling out both heaters and welding low alloy steel plugs into the holes using the temper bead process. The temporary repair was reviewed and approved by the NRC.

In the NRC's Safety Evaluation Report for the temporary repair Arkansas Power and Light Co. was requested to submit its plans for a permanent repair by November 1, 1987. The preliminary repair plan was presented to the NRC in a meeting in Bethesda, Md. on October 26, 1987. As a result of the October 26, meeting the NRC requested that the final repair plan be submitted to them after completion of the mockup testing. This report is to provide the final repair plan to the NRC. The final repair plan has not changed from the preliminary plan, as presented to the NRC, with the exception of some minor design details.

PERMANENT REPAIR - APPLICABLE CODES:

All codes used are NRC approved per 10CFR50.55a. The following table summarizes the applicable codes used for the design of the permanent repair.

Original Design Code:

> ASME Section III, 1968 edition,
> through 1970 addenda for Class A
> vessels.

Design Code:

> ASME Section III, 1980 edition,
> through Winter 1981 addenda,
> reconciled to the original design code.

Repair Code:

ASME Section XI, 1980 edition,
through Winter 1981 addenda,
reconciled to the original design code.

PERMANENT REPAIR PROCESS OUTLINE:

The following is a general outline of the repair process. A detailed description of the repair process is contained in the Field Construction Procedures and other specific procedures for the project.

1. Install temporary support structure.

2. Removal of the Temporary Plug:

   a. Mark the penetration to be removed.

   b. Layout and mark a 10" band around the repair area.

   c. Perform informational UT and MT in the marked area.

   d. Drill out the existing plug.

   e. Grind weld prep area to specification.

3. Preparation and Pre-inspection:

   a. Measure and record the dimensions of the final weld prep cavity.

   b. MT the weld prep in accordance with NB-5000.

   c. Install heaters and thermocouples as required for pre-heating the vessel head.

   d. Preheat the repair area, perform the buttering weld in accordance with the half bead technique to 1/4" minimum thickness and perform PT and UT in accordance with ASME Code requirements.

   e. Grind or ream the penetration to remove any weld metal covering the edge of the penetration.

   f. Measure and record the dimensions of the buttered cavity and the penetration.

4. Nozzle Installation:

   a. Machine the nozzle as required to achieve the desired fit.

   b. Align nozzle insertion tooling using dummy nozzle.

   c. Shrink fit nozzle int penetration and verify proper position.

   d. Install automatic weld head and verify proper position. Perform the seal weld.

   e. Perform VT on the seal weld using a borescope.

   f. Perform the structural weld with progressive PT every 1/4" of deposited thickness.

   g. Final grind the structural weld to the required contour. UT and MT the base material and PT the structual weld. Repeat the VT on the seal weld.

   h. Install the plug into the nozzle and weld. PT the plug weld.

   i. Remove the temporary support structure. MT ground areas.

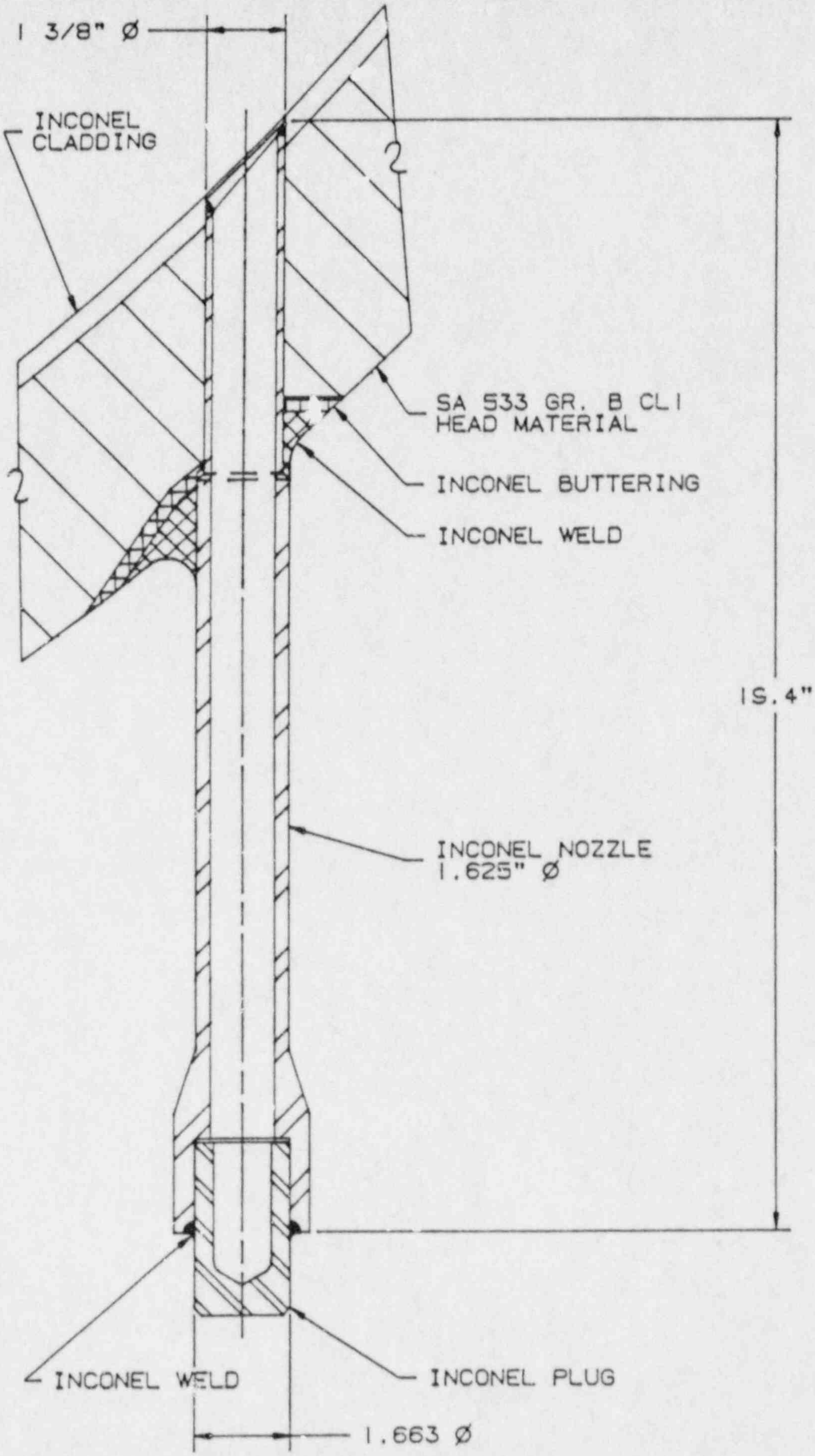
   j. Perform the system pressure test as required by ASME Section XI, IWB-5000.

Figure 1 shows the configuration of an installed nozzle (typical of both X-1 and T-4).

MOCKUP TESTING:

A full scale mockup was constructed to simulate the lower pressurizer head area, including the surrounding heater nozzles. The mockup was used for demonstrating the actual repair techniques to be used in the field, for welder qualification in accordance with ASME Section IX and XI, and for training of the welders and the machinists who will actually perform the repair. All mockup qualification was performed in appropriate protective clothing, including respirators.

The mockup was also used to quantify the amount and size of the debris which will be generated inside the pressurizer, primarily during the drilling and reaming process of removing the temporary plug. It was also used to develop techniques to minimize the amount of debris left in the pressurizer. (Note that the debris to be left in the pressurizer is very



1 3/8" Ø
INCONEL
CLADDING
SA 533 GR. B CL1
HEAD MATERIAL
INCONEL BUTTERING
INCONEL WELD
15.4"
INCONEL NOZZLE
1.625" Ø
INCONEL WELD
INCONEL PLUG
1.663 Ø

Figure 1

minimal and was addressed in the 10CFR50.59 safety evaluation included in the Design Change Package.)

MATERIAL CONSIDERATIONS:

The permanent repair process addresses all material concerns with the existing repair as follows:

1. The seal weld joining the nozzle to the vessel cladding will preclude exposure of the SA-533 Gr B Cl 1 vessel shell to borated water.

2. The use of Inconel weld material will eliminate concern with hydrogen embrittlement and stress corrosion cracking of existing low alloy (E8018) weldment on the pressurizer shell outside surface.

WELDING AND MATERIALS:

The ASME Section XI half bead welding technique for dissimilar materials (IWB-4340) will be used for making the buttering weld layer on the prepared cavity. The structural weld joining the buttering layer to the nozzle will be made per ASME Section III. The weld material for the half bead buttering weld will be ENiCrFe-3 (Inconel 182). The weld material for the structural weld will be ERNiCr-3 (Inconel 82) for the first pass and ENiCrFe-3 (Inconel 182) for the subsequent passes.

The nozzle will be Inconel 600 thermally treated at 1300 degrees Fahrenheit plus or minus 25 degrees Fahrenheit for 16 hours.

HALF BEAD AND STRUCTURAL WELD:

The following is an outline of the weld procedure. This outline is not intended to be a detailed description of the weld procedure, but is to provide a general description of the welding process. A detailed description of the weld procedures are contained in the specific procedures for the project.

1. Preheat the weld area to 300 degrees Fahrenheit for 30 minutes.

2. Butter the cavity surface with one weld layer, using 3/32" diameter ENiCrFe-3 electrodes.

3. Remove one-half of the first weld layer by grinding.

4. Continue welding until the buttered thickness is 1/4".

5. Increase preheat to 450 - 550 degrees Fahrenheit for a minimum of 4 hours.

6. Cool to ambient temperature and hold for 48 hours. UT and PT the buttering layer.

7. Remove thermocouples, grind surface, and perform MT or PT of ground areas.

8. Install the nozzle and perform the seal weld. Complete the structural weld joining the nozzle to the buttering layer. Perform progressive PT examination during the deposition of the structural weld.

9. PT the completed structural weld.

WELDING PROCEDURE QUALIFICATIONS:

The welding procedures for the temporary attachment of the drill support fixture to the pressurizer skirt, and for the structural weld joining the buttering layer to the nozzle, used previously qualified and approved B&W procedures.

The welding process for the seal weld was specifically developed and qualified for this repair by B&W. The seal weld is done using a computer controlled weld head inserted through the nozzle. The weld is autogenous and the process is qualified to produce a minimum throat thickness of 1/16", although the actual throat achieved is consistently greater than the 1/16" minimum which is required by the analysis.

The welding process for the half bead buttering was also specifically developed and qualified for this repair by B&W. Microstructural tests performed by B&W on the weld qualification coupons have demonstrated that the half bead technique used will not leave untempered martensite in the heat affected zone.