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INDIANA
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March 12, 1996

AEP:NRC:1218A

Docket Nos.: 50-315
50-316

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D. C. 20555

Gentlemen:

Donald C. Cook Nuclear Plant Units 1 and 2
REACTOR VESSEL HEAD PENETRATION ALTERNATE REPAIR TECHNIQUE

References

(1) Letter AEP:NRC:1218, E. E. Fitzpatrick to W. T. Russell, "CRDM Reactor Vessel Head Penetration Assessment", dated October 26, 1994, and its attachments:

1. Westinghouse "Assessment of Indications in Donald C. Cook Unit 2 Head Penetration TS", October 24, 1994.

2. WCAP 14118, Revision 1 "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support continued operation: D. C. Cook Unit 2", October 1994.

(2) Letter, J. P. O'Hanlon (VEPCO) to USNRC Document Control Desk, "Virginia Electric and Power Company, North Anna Power Station Unit 1 - Reactor Vessel Head Penetrations, use of an alternate repair technique" (serial No. 95-605), dated November 22, 1995, and its attachments:

1. WCAP-13998, Rev. 1, "RV Closure Head Penetration Tube ID Weld Overlay Repair" (Proprietary)

2. WCAP-14519, "RV Closure Head Penetration Tube ID Weld Overlay Repair" (Non-Proprietary)

3. USNRC letter, W. T. Russell to W. Rasin, NUMARC, "Safety Evaluation for Potential Reactor Vessel Head Adapter Tube Cracking," November 19, 1993.

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4. USNRC letter, A. G. Hansen to R. E. Link, "Acceptance Criteria for Control Rod Drive Mechanism Penetrations at Point Beach Nuclear Plant, Unit 1," March 9, 1994.

(3) Letter, D. B. Matthews (NRC) to J. P. O'Hanlon (VEPCO), North Anna Unit 1 - Use Of An Alternative Repair Technique For Reactor Vessel Head Penetrations" (serial No. 95-606) (TAC NO. M94138), dated February 5, 1996.

Inspections at pressurized water reactors have shown the presence of cracking in some reactor vessel head penetration tubes. This phenomenon has been followed closely by the Nuclear Energy Institute (NEI) and the owners groups. Because of the slow rate of crack growth and the relative ease of detection, the issue appears to have a low safety significance but potential economic risk.

During the last Cook Nuclear Plant unit 2 refueling outage, the reactor vessel head penetrations were inspected and indications of flaw were found in head penetration 75. An evaluation performed by Westinghouse determined that, despite the presence of the indications, continued reactor operation was acceptable for one cycle (Reference 1).

We plan to inspect some Cook Nuclear Plant unit 2 reactor vessel head penetrations again during the 1996 refueling outage. In the event that repairs are required as a result of that inspection, pursuant to 10 CFR 50.55(a)(3) we request approval to use a Westinghouse repair procedure as an alternative to the ASME Code requirements. The alternate repair procedure is described in the Attachment to this letter and is the same as that previously transmitted in Reference 2, except as noted in the Westinghouse annotated letter on embedded flaw repair for Cook Nuclear Plant. These exceptions are necessary to reflect our plant configuration, flaw orientation, and repair preferences, but otherwise this is the same procedure that was approved for use by Virginia Power at the North Anna power plant (Reference 3).

The use of the embedded flaw repair will provide an acceptable level of safety. The embedded flaw repair technique involves an excavation at the inside surface of the penetration. This excavation will be sufficient to remove the portion of the flaw which is exposed to the reactor coolant at the inside surface of the penetration. The depth of the excavation is sized such that following application of a weld overlay, the remaining portion of the flaw will qualify as "embedded" according to the rules of ASME Section XI paragraph IWA 3310(b). This approach will prevent exposure of the flaw to the reactor coolant environment thereby stopping further flaw growth.

Approval to use the alternate procedure is requested prior to April 9, 1996, when we anticipate performing the reactor vessel head inspections. The unit 2 refueling outage is currently scheduled to begin March 23, 1996.

Sincerely,

E. E. Fitzpatrick
Vice President

plt

Attachment

cc: A. A. Blind
G. Charnoff
H. J. Miller
NFEM Section Chief
NRC Resident Inspector - Bridgman
J. R. Padgett

Attachment to AEP:NRC:1218A

ALTERNATIVE REPAIR PROCEDURE

ALTERNATIVE TO CODE REQUIREMENTS

I. IDENTIFICATION OF COMPONENTS

1A Inspection

DRAWING 68-3262		
Ring	Penetration Nos.	Description
Initial Sample Group (1)		
Outer Most	74, 75, 76, 77 & 78	4" Thermocouple Column (non-sleeved)
Expanded Group (2)		
Select Inner Penetrations	66, 60, 58	4" Control Rod Drive (sleeved)
	64	4" Head Adapter Plug (non-sleeved)

(1) Selection of penetrations is in accordance with WCAP 14588, "Final Report Documenting the Development and Use of Simple Economic Decision Risk Tools for Managing PWSCC in Reactor Vessel Head Penetrations."

(2) If flaws are detected during the initial sample group, the inspection will be expanded to include four additional penetrations as indicated. If flaws are detected in the expanded group inspection, additional penetrations will be selected for inspection. Penetration selection will be based upon WCAP 14588.

1B. Repair

AEPSC and Westinghouse have developed repair techniques for penetration no. 75 in the event that the flaw acceptance criteria is exceeded.

II. IMPRACTICAL CODE REQUIREMENTS

Reinspection of the Cook Nuclear Plant unit 2 reactor vessel head penetration no. 75 is scheduled for U2R96. Additionally, penetration nos. 74, 76, 77 and 78 will be reinspected. The reinspection will be performed using the same techniques used during U2R94; i.e., eddy current for flaw detection and ultrasonic inspection for flaw characterization. The Cook Nuclear Plant unit 2 acceptance criteria previously provided under WCAP

14118, Revision 1, will be utilized for this inspection. Industry acceptance criteria have been established by Westinghouse and reported in WCAP 14024, "Inspection Plan Guidelines for Industry/Plant Inspection of Reactor Vessel Closure Head Penetration Tubes." The acceptance criteria have been reviewed and accepted by the NRC[1] [2], with comments. The NRC comments have been incorporated in WCAP 14024. AEPSC and Westinghouse have developed repair techniques in the event repairs are required. The code requires flaws exceeding the acceptance criteria to be removed or reduced to an acceptable size, as stated in subparagraph IWB-3112(c), "Components whose examination (IWB-2200) reveals flaw indications, other than the indications of (b) above, that exceed the standards of Table IWB-3410-1 shall be unacceptable for service unless such flaws are removed or repaired to the extent necessary to meet the allowable flaw indication standards prior to placement of the component in service."

Thermal sleeves are installed in 18 of the 78 unit 2 reactor vessel head penetration tubes. Due to the penetration configuration and the available tooling, complete removal of flaws greater than 0.25 inch deep requires the removal of the thermal sleeve. Removal and reinstallation of the thermal sleeve is a very difficult process. Any removal and reinstallation method involves special tooling, a significant amount of remote machining/welding, radiation exposure and uncertainty.

III. BASIS FOR ALTERNATIVE TO CODE REQUIREMENTS

An alternative to removing the thermal sleeve and totally removing the flaw is to partially remove the flaw and weld overlay to the original wall thickness. This technique is referred to as an "embedded flaw repair." This repair technique is described in the Westinghouse annotated letter dated March 6, 1996 (attached), and WCAP 13998, entitled "RV Closure Head Penetration Tube ID Weld Overlay Repair," and can be applied to penetrations with or without thermal sleeves.

The weld overlay eliminates the exposure of the flaw to the reactor coolant environment and results in a subsurface (i,.e., "embedded") flaw as defined by ASME Section XI, IWA-3320. Flaw evaluation standards will be based on the industry acceptance criteria applied to Cook Nuclear Plant in WCAP 14118, Revision 1. The penetration tube is sufficiently stiff and constrained by the vessel head, so the integrity of the tube will be maintained by the weld overlay regardless of the location and extent of the flaw.

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[1]USNRC Letter, W.T. Russell to Rasin, NUMARC, "Safety Evaluation for Potential Reactor Vessel Head Adapter Tube Cracking," November 19, 1993.

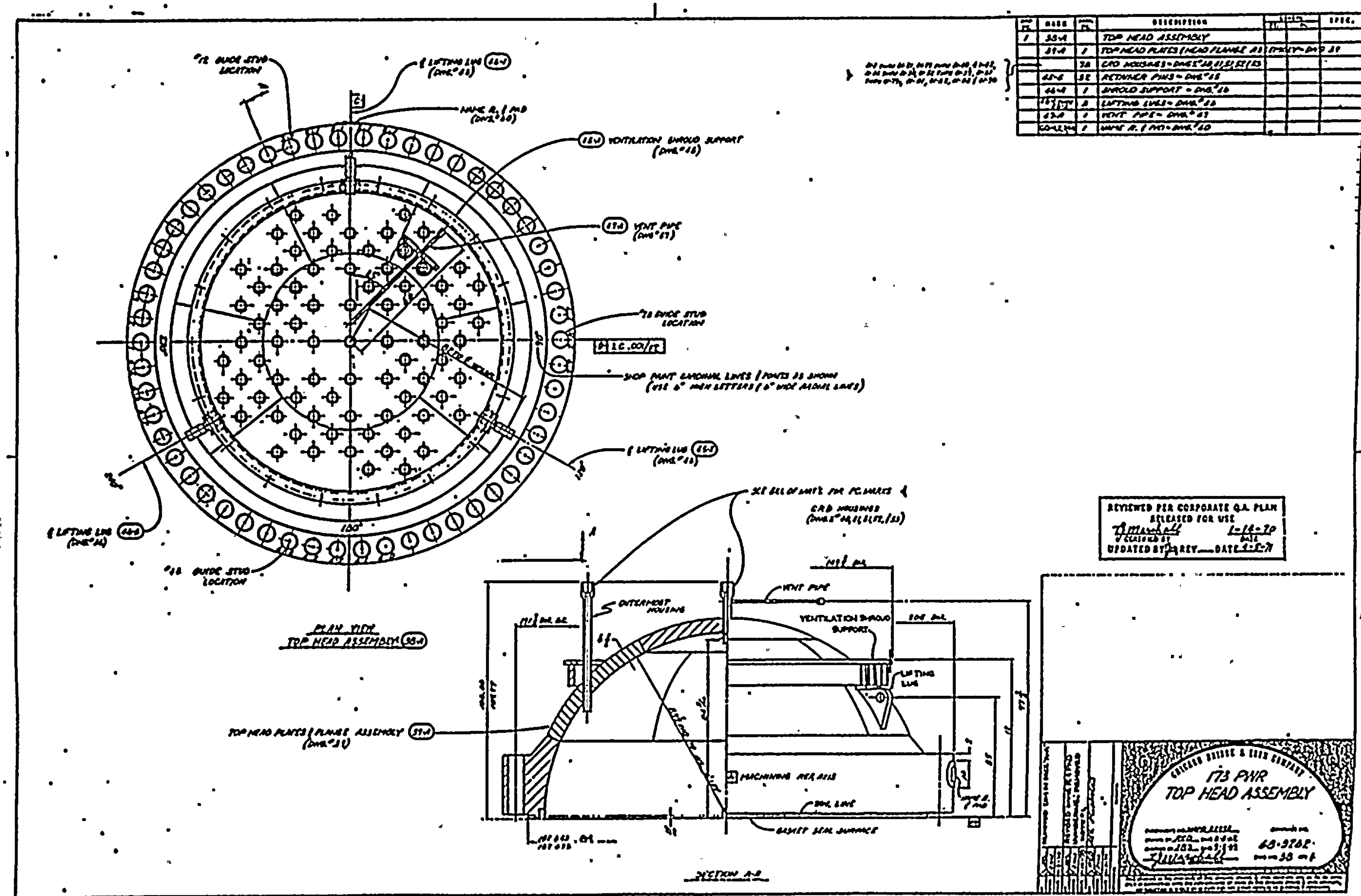
[2]USNRC Letter, A.G. Hansen to R.E. Link, "Acceptance Criteria for Control Rod Drive Mechanism Penetrations at Point Beach Nuclear Plant, Unit 1," March 9, 1994.

The other advantages to this type of repair versus a code repair is that this technique results in lower residual stress than a complete excavation with a full weld build up and a better inside diameter surface than a complete excavation and a partial weld build up.

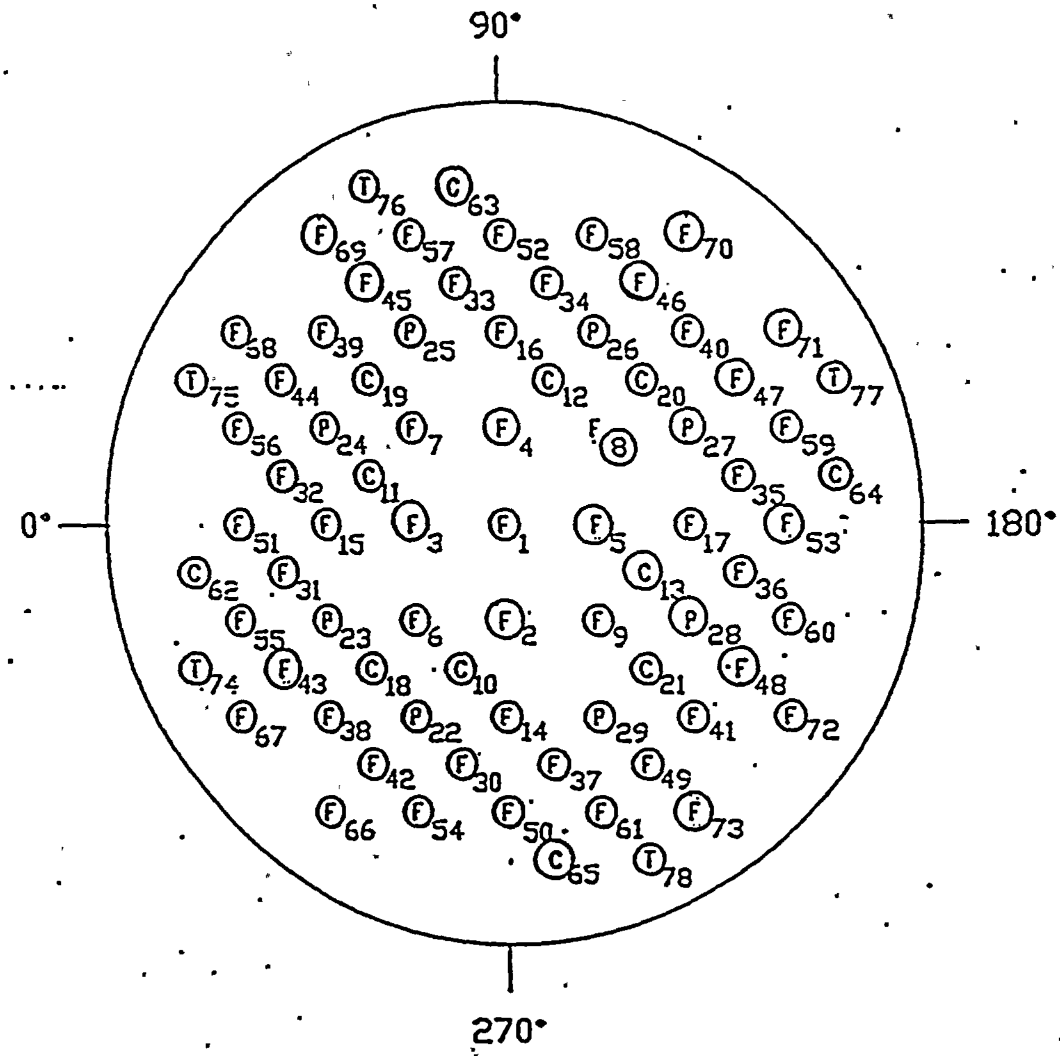
Therefore, it is also advantageous to use this technique for unsleeved penetrations. Additionally, the development of analysis and tooling for a single versatile repair technique is preferred.

IV. ALTERNATIVE TO CODE REQUIREMENTS

The embedded flaw repair method, proposed and supported by the stated Westinghouse documentation, will be used as an alternative to the code requirements if repairs are required, for axial flaws up to through-wall in reactor vessel head penetration tubes. The flaw will be partially removed using electric discharge machining. The excavation will be based on the depth of the measured flaw and will range from 0.090 to 0.125 inch. The extremities of the flaw relative to the boundaries of the excavated area must be examined by the appropriate NDE methods or otherwise evaluated to ensure that the excavation has covered the full length of the flaw. A weld overlay will be performed to completely fill the excavation and restore the inside diameter surface of the penetration. The final weld surface will be examined using liquid penetrant and either eddy current or ultrasonics as appropriate. The reactor vessel head will be VT-2 examined without removing the insulation during startup at nominal operating pressure.


DESCRIPTION
TOP HEAD ASSEMBLY
TOP HEAD PLATES & HEAD FLANGE ASSEMBLY
CRD HOUSINGS
RETAINER PINS
SHROUD SUPPORT
LIFTING LUGS
VENT PIPE
NAME PL. & PAD
VENTILATION SHROUD SUPPORT
VENT PIPE
GUIDE STUD LOCATION
LIFTING LUG
PLAN VIEW
TOP HEAD ASSEMBLY
OUTERMOST HOUSING
VENTILATION SHROUD SUPPORT
LIFTING LUG
MACHINING REF. AXIS
GASKET SEAL SURFACE
TOP HEAD PLATES & FLANGE ASSEMBLY
SECTION A-A
REVIEWED PER CORPORATE Q.A. PLAN
RELEASED FOR USE
CHICAGO BRIDGE & IRON COMPANY
173 PWR
TOP HEAD ASSEMBLY
68-9262

SUPPLEMENT TO DRAWING 68-3262 PENETRATION NUMBERS



COOK UNIT 2

Symbol	Component	Number	Thermal Sleeve
F	Full Length CRDM	53	Yes
P	Part Length CRDM	8	No
T	Thermocouple Column	5	No
C	Head Adapter Plug	12	No

AEP-96-051, Rev. 1

Westinghouse Electric Corporation
Energy Systems
Nuclear Technology Division
Box 355
Pittsburgh Pennsylvania 15230-0355

Mr. David Powell
American Electric Power Service Corporation
One Riverside Plaza
Columbus, Ohio 43216-6631

NSD-NT-OPL-96-084, Rev. 1
March 6, 1996

AMERICAN ELECTRIC POWER SERVICE CORPORATION
DONALD C. COOK NUCLEAR PLANT
Embedded Flaw Repair

Dear Mr.Powell:

Attached for your information and use is the revised version of the annotated letter on the embedded flaw repair for Cook Nuclear Plant. The letter incorporates comments received from AEPSC. The embedded flaw approach is one method that can be used to repair a crack in a reactor vessel head penetration. The embedded flaw repair consists of partial removal of the flaw by excavation followed by a weld overlay.

A similar effort was also recently performed for Virginia Power. Below is a summary of the technical differences between the Donald C. Cook Nuclear Plant annotated letter and the letter that was prepared for the application of the embedded flaw repair for Virginia Power.

1. The Virginia Power letter imposes a limitation that the embedded flaw repair technique may be used for flaws with depths up to 75% of the wall thickness. For Cook Nuclear Plant, the embedded flaw technique is being recommended for flaws up to through wall in depth. The known flaw at Cook Nuclear Plant Unit 2 for which this repair technique may be applied is below the head penetration weld. There are no pressure boundary concerns with flaws that are at or below elevation of the weld. Therefore, the ASME Code minimum wall requirement is not a consideration for the known flaw at Cook Nuclear Plant Unit 2. Further, structural evaluations performed by Westinghouse have identified that there are no concerns with the structural stability of the tubes with through wall flaws, including flaws above the weld, until the flaws become excessively long (several inches in length).

2. The Virginia Power annotated letter includes description of an alignment collar on the thermal sleeves that provide for a small clearance with the head penetration tube ID. This description was not included in the Donald C. Cook Nuclear Plant annotated letter as the thermal sleeves in the Cook Nuclear Plant head penetrations contain no such collar.

3. The Virginia Power letter states that the excavated area will be dye penetrant inspected prior to application of the weld overlay to verify that the excavation covers the full extent of the flaw. The requirement to perform this dye penetrant examination was not included in the Cook Nuclear Plant letter to eliminate concerns of contamination of the area to be welded with the dye penetrant chemicals.

If you have any questions, please call Ms. Robin Lapides (412-374-5683) or me.

Very Truly Yours,

Robert L. Goldberg
Senior Sales Engineer
North American Field Sales

RSL/bbp

Attachment

cc: T. Georgantis - AEPSC
B. Mickatavage - AEPSC

EMBEDDED FLAW REPAIR FOR COOK NUCLEAR PLANT

A. Background

Inspections have shown the presence of cracking in reactor vessel head penetration tubes in a number of pressurized water reactors. The cause of this cracking has been attributed to primary water stress corrosion cracking (PWSCC). Several methods are available for performing repairs to the penetration tubes should cracking be significant enough to warrant repair. These methods include excavation of the penetration tube to remove shallow flaws and, for deeper flaws, excavation and weld repair. With respect to excavation and weld repair, two methods are available. These methods would be to 1) completely remove the crack by excavation followed by a full or partial weld build-up, and 2) partial removal of the flaw by excavation followed by a weld overlay ("embedded flaw" repair).

B. Introduction

1. Weld Build-up Repair Technique

Several issues are associated with the case of complete removal of the flaw followed by a weld build-up that have an undesirable affect on personnel exposure, site schedule, and component adequacy for continued operation. These are discussed in the following paragraphs. The repair of a head penetration tube in which there is a thermal sleeve is included within the issues that are discussed below. Although there is a known flaw in an unsleeved penetration, additional inspections are planned, and repair of a sleeved penetration is therefore discussed as a contingency.

a. Penetration Residual Stress/inspection Following Repair

One method for the application of the weld buildup is to completely fill the excavation and restore the ID of the penetration. While this method provides a surface that can be readily inspected following repair, it will require the application of a larger amount of weld material which can result in increases in penetration residual stress. This could adversely affect the susceptibility of the penetration to PWSCC. An alternate method for repair is to apply a smaller amount of weld material and thereby minimize the amount of additional penetration residual stress and deformation. However, this method has the drawback of not restoring the penetration ID and would result in a much more difficult surface for post repair inspection.

b. Thermal Sleeve Removal

Due to the spatial constraints associated with the design of the vessel penetration and thermal sleeve (refer to attached figure entitled "Thermal Sleeve Guides"), thermal sleeve removal is necessary to completely eliminate a flaw that is deeper than 0.25 inch for those penetrations which contain thermal sleeves. Removal of the thermal sleeve can be achieved by two methods.

The first method removes a portion of the thermal sleeve through the bottom of the penetration. To accomplish this, first the thermal sleeve is cut at an elevation above the crack in the penetration. However, the distortion and ovality of the penetration produced by the original attachment weld may not permit removal of the thermal sleeve. The thermal sleeve contains alignment features that have a small clearance to the penetration ID. Following this cutting and removal, the repair is made to the penetration and the thermal sleeve subsequently reinstalled. This installation requires remote welding of the thermal sleeve followed by inspection to verify an acceptable weld as well as correct alignment. Although the technique for cutting and rewelding of the thermal sleeve has been developed in Europe, additional development and qualification of this process by Westinghouse would be required prior to its use at Cook Nuclear Plant.

For those penetrations with ovality and distortion that will not permit thermal sleeve removal through the bottom end, the second method is to remove the thermal sleeve through the top of the penetration. This method requires removal of the CRDM rod travel housing by cutting the canopy seal weld and threading the rod travel housing out of the CRDM latch housing, cutting the thermal sleeve above the thermal sleeve guide, and removal of the remaining thermal sleeve out of the top of the penetration. Following the repair, it is necessary to install a new thermal sleeve through the top of the penetration. The guide is installed from the underside of the vessel head to the bottom of the thermal sleeve via threads. A locking weld between the guide and the sleeve completes this part of the installation. The rod travel housing and canopy seal weld are re-installed.

Both of these methods involve a significant amount of remote machining/welding and radiation exposure associated with the removal and installation of the thermal sleeve.

2. Embedded Flaw Repair

The embedded flaw repair technique involves an excavation at the inside surface of the penetration. This excavation would be sufficient to remove the portion of the crack which is exposed to the reactor coolant at the inside surface of the penetration. The depth of the excavation, 0.125 inch or smaller, is established such that, following application of a weld overlay, the remaining portion of the flaw qualifies as an embedded flaw according to the rules of ASME Section XI paragraph IWA 3310(b). The depth of the excavation is controlled by utilizing

"hard stops" which are incorporated into the tooling to limit travel of the EDM electrode. The extremities of the flaw relative to the boundaries of the excavated area must be examined by appropriate NDE methods or otherwise evaluated to ensure that the excavation has covered the full length of the flaw. The weld is applied and examined with dye penetrant and either eddy current or ultrasonics to verify an acceptable weld. This approach eliminates exposure of the flaw to the reactor coolant environment, and stops further flaw growth due to PWSCC. See attached figure entitled "Head Penetration Embedded Flaw Repair" for a schematic of the proposed repair configuration.

3. Cook Nuclear Plant Proposed Embedded Flaw Repair

The Cook Nuclear Plant 1 and 2 reactor vessel head penetrations are typical of those in Westinghouse designed plants. These penetrations are nominally 4.0 inches OD with a 2.75 inches ID. The embedded flaw repair technique is considered to be practical for axial flaws with a depth up to through wall. If application of this technique is considered for axial through-wall or circumferential flaws of any extent, a separate submittal to the NRC will be required. The flaw extent will determine the extent of the repair, and the flaw depth will determine the thickness of the weld repair. The penetration tube is sufficiently stiff, and constrained by the vessel head, so the integrity of the tube will be maintained by the weld overlay regardless of the extent of the flaw. When the repair process is complete, the ID surface of the penetration has been restored and is readily inspectable

There is a known flaw in an unsleeved penetration for which this repair process could be used. However, as a contingency, the possibility of performing this repair on a sleeved penetration also needs to be considered. This repair process is equally useful for sleeved and unsleeved penetrations, but it has additional advantages for sleeved geometries. To eliminate the necessity for thermal sleeve removal, an excavation and weld overlay repair of the penetration is performed through a "window" which will be cut in the thermal sleeve. A local weld overlay (as opposed to 360° coverage) over the cracked area will be used to minimize penetration deformation and residual stresses.

The "embedded flaw" repair methodology has been developed using technology which has been demonstrated in WCAP 13998, entitled "RV Closure Head Penetration Tube ID Weld Overlay Repair". Although this report contains a number of approaches for penetration tube repair, only some of these are used in the embedded flaw repair technique. Section C, below, will highlight the key portions of the report that are used as the technical basis for the proposed repair.

C. Summary of Key Relevant Topics of WCAP 13998

The technical basis for the embedded flaw repair technique is developed as shown in report WCAP 13998. The following paragraphs provide a summary of the key relevant topics of the report.

The report contains all of the elements of a repair design package, and an outline of the package is contained in Chapter 2. The potential repairs were performed on a full scale mockup of a head penetration along with several mock penetration tubes. The preparation of these mockups is described in Chapter 4.

The welding process uses Alloy 52 filler metal, to maximize the corrosion resistance of the weld. The development of the welding process and its qualification are shown in Chapter 5, which also contains pictorial examples of overlay welds performed over flaws machined into the penetrations using electrical discharge machining. Test results showed no cracks in the weld or cracking of the surrounding area. The welding specification is contained in Appendix A.

A range of weld overlay thicknesses was investigated. It was found that the thickest overlays produced measurable deformation of the tubes, as shown in Chapter 6. Smaller deformations occur with a smaller amount of weld metal thickness. One of the benefits of the embedded flaw overlay is that with a smaller amount of weld deposit, the deformation is minimized.

To verify the adequacy of the weld repair process, a series of residual stress measurements was also performed on excavated and repaired tubes, and these results are discussed in Chapter 7. As expected, the residual stresses are increased as more weld metal is deposited. The residual stresses produced by local weld overlays were comparable to the unrepaired configuration for excavation and weld deposit up to 0.25 inch in depth. The measured residual stresses also compare favorably to those of a three-dimensional finite element analysis for residual stress. These comparisons are shown in Chapter 7, Figures 7.4-1 through 7.4-4.

To complete the weld repair design package, a generic safety evaluation according to 10CFR50.59 was performed, and was provided to AEPSC as a separate document from the WCAP.

D. Comparison of the Embedded Flaw Approach and WCAP 13988

To produce an embedded flaw configuration, a weld overlay thickness of 0.090 to 0.125 inch is needed. With the embedded flaw repair, the weld is applied in a circumferential direction for an unsleeved penetration. Should this repair process be used for a sleeved penetration, however, the weld is applied in an axial direction. The welding process which was utilized in the WCAP applies the weld in a circumferential direction relative to the longitudinal axis of the penetration.

It is judged that welding axially in this range of thicknesses will maintain the penetration ID surface residual stresses comparable to the unrepaired tube. This

judgement is based on the results listed in the WCAP that showed this comparable condition for weld thickness up to 0.25 inch.

Further, the residual stress measurement results and their favorable comparison to previous analyses (refer to Chapter 7 Figures 7.4-1 through 7.4-4 of WCAP 13998) is sufficient to provide confidence that the penetration stresses after weld repair have been fully described such that additional testing for corrosion behavior is not necessary.

As part of the Westinghouse program to evaluate small amounts of zinc additives to the RCS coolant, measurements were taken of the electromechanical potentials of the various primary side materials. No difference was found among them, including 600 and 690 materials. This is in agreement with the investigations by others in the high temperature electrochemistry area. At high temperatures the potentials of all of these alloys tend towards the potential of the hydrogen electrode; i.e., there are no differences to promote any galvanic coupling effects.

In addition, Westinghouse has many years of experience in laboratory tests and field exposures with alloys 600 and 690 intimately connected either mechanically or by welding in steam generator applications. Exposures of approximately 15 years on hybrid expansion joints have not produced any evidence of galvanic coupling. Sleeving and plugging exposures have not revealed any evidence of galvanic interaction over years (5 at least) of operation.

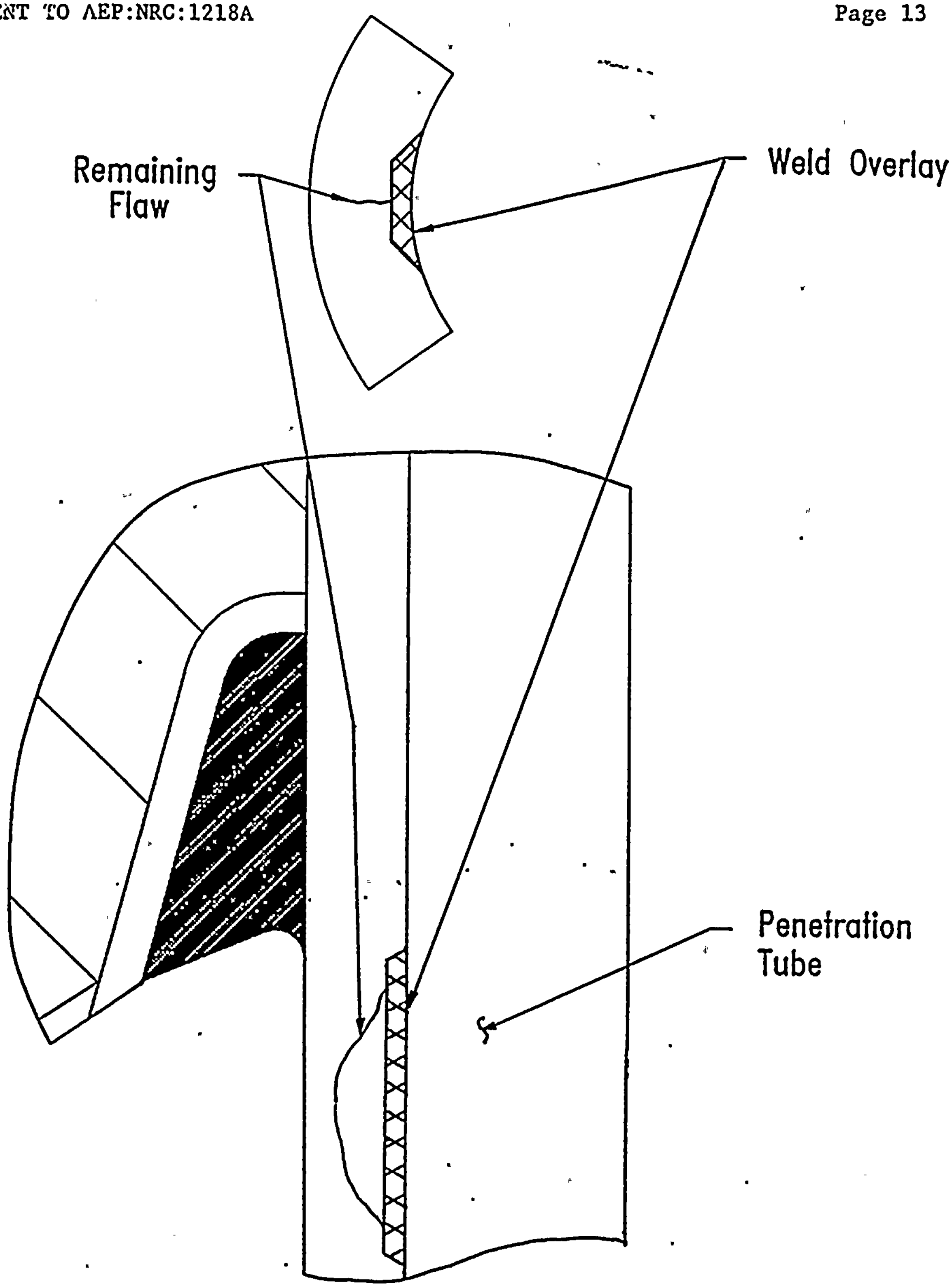
E. Flaw Acceptability

Although the flaw characterization rules of Section XI, paragraph IWA 1300 are being used to establish sufficient weld overlay thickness to classify the repaired flaw configuration as subsurface, determinations about flaw acceptability will be based on NEI/NUMARC guidelines. These guidelines were accepted in a safety evaluation report issued to Wisconsin Electric Power Co. on March 9, 1994 (Docket No. 50-226), and in a previous safety evaluation report issued November 19,1993, to W. Rasin of NEI/NUMARC.

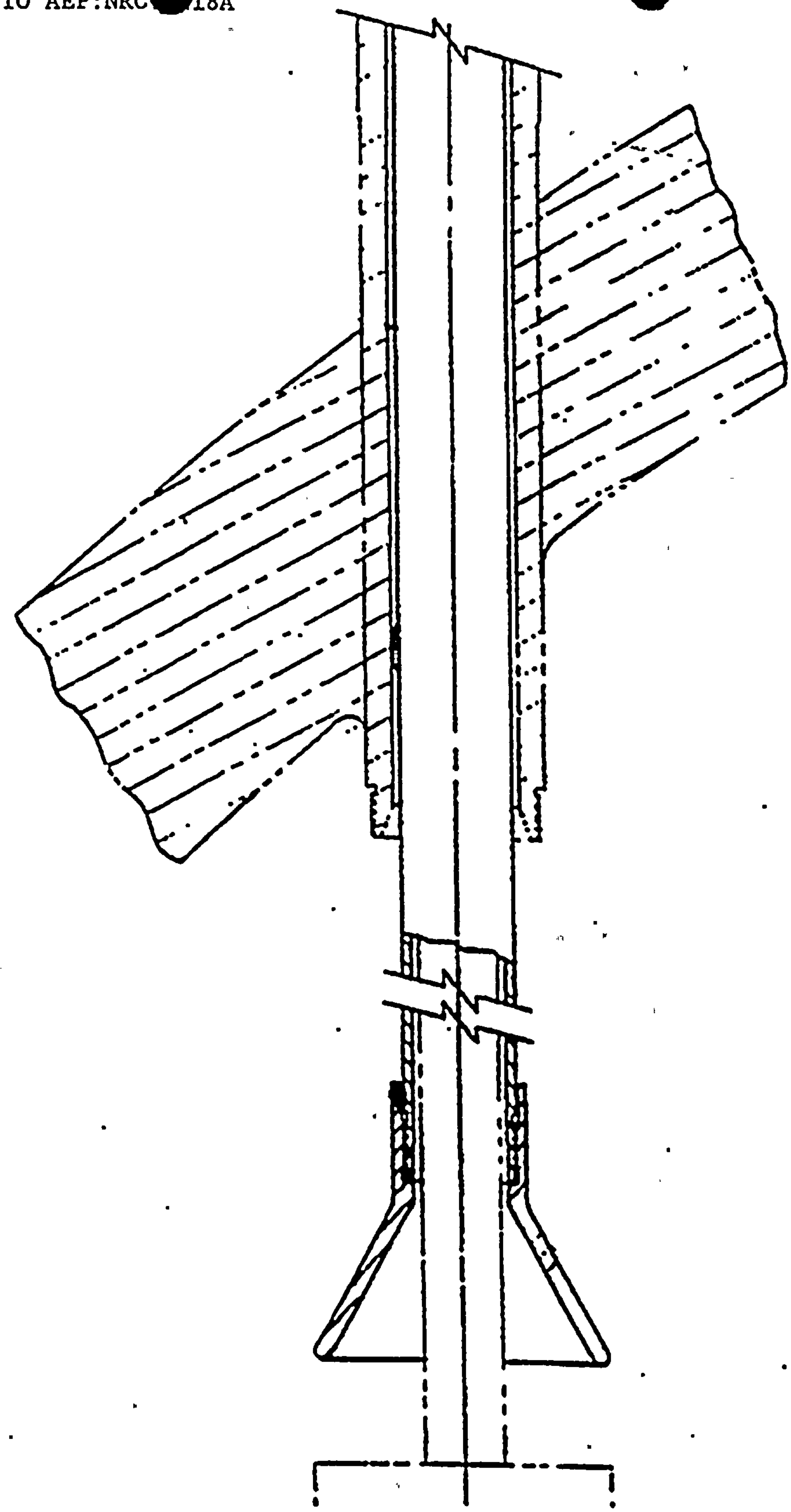
F. Summary and Conclusions

The embedded flaw approach has been developed as a variation on the repair techniques documented in WCAP 13998. The technique is versatile, in that it can be applied to the penetration tubes with or without thermal sleeves, and does not require the removal of the thermal sleeve.

There are a number of advantages to the technique. It results in a permanent repair that seals the flaw from the water environment, and thus stops PWSCC. There is no other mechanism of growth for cracks in these tubes because fatigue fluctuations are very small. The small thickness of the weld minimizes deformation of the tube, as well as residual stresses in the surrounding region.



HEAD PENETRATION EMBEDDED FLAW REPAIR



THERMAL SLEEVE GUIDES