STP Nuclear Operating Company
South Texas Project Electric Generating Station P.O. Box 289 Wadsworth, Texas 77483

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10 CFR 50.55a

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

South Texas Project
Units 1 and 2
Docket No. STN 50-498, STN 50-499
Request for Relaxation of Requirements from Revision 1 of Order EA-03-009
Establishing Interim Inspection Requirements for Reactor Pressure Vessel
Head Penetrations (Relief Request RR-ENG-2-46)

References:

1. Letter from David W. Rencurrel to NRC Document Control Desk, "Results of Reactor Head Penetration Inspection Pursuant to Revision 1 of Order EA-03-009," dated December 12, 2006 (NOC-AE-06002094) (Unit 1)
2. Letter from David W. Rencurrel to NRC Document Control Desk, "Results of Reactor Head Penetration Inspection Pursuant to Revision 1 of Order EA-03-009," dated June 27, 2007 (NOC-AE-07002180) (Unit 2)
3. Letter from Brandon L. Jenewein to NRC Document Control Desk, "WCAP-16636-P, Revision 0, Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: South Texas Units 1 & 2, September 2006 (Proprietary)," dated November 6, 2007 (NOC-AE-07002233)

Pursuant to Revision 1 of NRC Order EA-03-009, STP Nuclear Operating Company (STPNOC) performed volumetric examinations of the South Texas Project (STP) Unit 1 and Unit 2 reactor pressure vessel head penetrations. The results of the inspections were provided in the referenced correspondence. As required by paragraph F, Section IV, of the Order, areas where compliance with the Order could not be achieved were noted in the reported results. Full compliance with the Order for specific nozzles poses a hardship or unusual difficulty without a compensating increase in the level of quality and safety. Because 100% compliance is not possible, STPNOC proposes relaxation of the nondestructive examination requirements described in the Order.

The NRC staff previously approved similar requests for:

- Diablo Canyon Unit 1, approved October 26, 2005 (TAC No. MC7071)
- Diablo Canyon Unit 2, approved November 23, 2004 (TAC No. MC4932)
- St. Lucie Unit 2, approved December 27, 2004 (TAC No. MC3107)
- Palo Verde Unit 1, approved May 5, 2004 (TAC No. MC2388)

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Once approved, this alternative will be applicable for the duration of the second inspection interval for the South Texas Project. The second inspection interval ends September 24, 2010 for Unit 1, and October 8, 2010 for Unit 2. However, relaxation of requirements is needed only until replacement of the RPV heads is complete. Unit 1 is scheduled for head replacement during the refueling outage beginning October 2009. The Unit 2 head is expected to be replaced during the March 2010 refueling outage.

There are no commitments included in this letter.

If there are any questions, please contact either Mr. P. L. Walker at (361) 972-8392 or me at (361) 972-7431.

Brandon L. Jenewein
Manager
Testing/Programs

PLW

Attachment: Request for Relaxation of Requirements from Revision 1 of Order EA-03-009 Establishing Interim Inspection Requirements for Reactor Pressure Vessel Head Penetrations (Relief Request RR-ENG-2-46) cc:

(paper copy)

Regional Administrator, Region IV
U. S. Nuclear Regulatory Commission
611 Ryan Plaza Drive, Suite 400
Arlington, Texas 76011-8064

Mohan C. Thadani
Senior Project Manager
U.S. Nuclear Regulatory Commission
One White Flint North (MS 7 D1)
11555 Rockville Pike
Rockville, MD 20852

Richard A. Ratliff
Bureau of Radiation Control
Texas Department of State Health Services
1100 West 49th Street
Austin, TX 78756-3189

C. M. Canady
City of Austin
Electric Utility Department
721 Barton Springs Road
Austin, TX 78704

Senior Resident Inspector
U. S. Nuclear Regulatory Commission
P. O. Box 289, Mail Code: MN116
Wadsworth, TX 77483

(electronic copy)

A. H. Gutterman, Esquire
Morgan, Lewis & Bockius LLP

Mohan C. Thadani
U. S. Nuclear Regulatory Commission

Thad Hill
Steve Winn
Harry Holloway
Eddy Daniels
Marty Ryan
NRG South Texas LP

J. J. Nesrsta
R. K. Temple
Ed Alarcon
Kevin Pollo
City Public Service

C. Kirksey
City of Austin

Jon C. Wood
Cox Smith Matthews

**SOUTH TEXAS PROJECT
UNITS 1 AND 2**

# REQUEST FOR RELAXATION OF REQUIREMENTS FROM REVISION 1 OF ORDER EA-03-009 ESTABLISHING INTERIM INSPECTION REQUIREMENTS FOR REACTOR PRESSURE VESSEL HEAD PENETRATIONS (RELIEF REQUEST RR-ENG-2-46)

## 1.0 COMPONENTS AFFECTED

Description: Reactor Pressure Vessel Head Penetrations

Class: ASME Code Class 1

Function: Reactor coolant pressure boundary

**Configuration**

The RPV head has a total of 76 penetrations with J-groove welds:

- 57 CRDM penetrations (with thermal sleeves and guides)
- 4 CRDM penetrations (spares) with cap latch housing
- 2 Reactor Vessel Water Level penetrations (modified dummy can)
- 4 Core Exit Thermocouple penetrations (with guides attached)
- 7 adapter plug penetrations (CRDM spares) (no thermal sleeves or guides)
- 1 head vent
- 1 de-gas vent

The RPV head penetration configuration is depicted in Figures 1 and 2.

The dimensions of most of the penetrations are identical, with a 4.00-inch outside diameter (OD) and a wall thickness of 0.625 inch. The head vent OD is 1.315 inches and the wall thickness is 0.250 inch. For the de-gas vent, the OD is 3.490 inches and the wall thickness is 0.433 inch. The penetrations to be inspected and their respective angle groupings are listed in Table 1.

## 2.0 APPLICABLE EXAMINATION REQUIREMENTS

The NRC issued Revision 1 of Order EA-03-009 (the Order) on February 20, 2004, establishing interim inspection requirements for reactor pressure vessel (RPV) heads. The Order requires non-visual nondestructive examination (NDE) of each penetration by February 11, 2008, in accordance with Section IV.C, paragraphs (5)(b)(i), (ii), or (iii), which requires:

(i) Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from two inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to two inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than two inches [see Figure IV-1]); OR from two inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all

RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater. In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least two inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to two inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than two inches [see Figure IV-3]); OR from two inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-4).

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.
2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

Option (i) is the criterion applicable to the South Texas Project.

## 3.0 REASON FOR REQUEST

Compliance with the Order results in a hardship or unusual difficulty without a compensating increase in the level of quality and safety. STPNOC is not able to completely comply with the requirements of Section IV.C(5)(b)(i) of the Order for ultrasonic test (UT) inspection of the RPV head penetration nozzles below the J-groove weld due to the physical configuration of the nozzles and the limitations of the test equipment.

CRDM penetrations at the periphery (Figure 3) have the shortest extensions below the head and J-groove weld. Due to drawing tolerances and additional weld deposition, the available length of CRDM below the J-groove weld can be shorter on some of the peripheral penetrations than on others. In addition, the chamfer on the ID and OD of the tube reduces the available coverage from the end by approximately 0.2 inch. The "hash-mark" areas in Figure 3 indicate the volume of the penetration that cannot be inspected.

While the Order allows for eddy current testing or dye penetrant examination (Section IV.C(5)(b)(ii)) to be used as an alternative to UT, neither is a suitable substitute for this application on tubes with coverage less than one inch below the J-groove weld:

- The bottom of each nozzle terminates in a chamfered surface below the downhill side of the J-groove weld. Eddy current probes do not maintain adequate contact with the nozzle at its lower end due to this nozzle geometry and so cannot perform a complete examination.
- Dye penetrant testing requires extensive work under and around the RPV head where radiation levels are anticipated to be between 4000 and 9000 mR/hour. Performing dye penetrant testing on the bottom nozzle area would result in significant radiation exposure to personnel without a compensating increase in the level of quality or safety.

Therefore, pursuant to Revision 1 of the Order, Section IV.F(2), STPNOC requests relaxation of the requirements specified in the Order for examination of Unit 1 and Unit 2 RPV head penetrations under Section IV.C(5)(b)(i)..

## 4.0 PROPOSED ALTERNATIVE

Relaxation will change the required UT examination range to two inches above the J-groove weld down to the lowest elevation that can be practically inspected on each nozzle with the UT probe.

## 5.0 BASIS FOR USE

### 5.1 Inspection Results

**Unit 1**

During 1RE13, STPNOC performed a non-visual nondestructive volumetric examination of the reactor head penetration tubes in compliance with Section IV.C.(5)(b)(i) of Revision 1 of the Order. No reportable indications were found.

Of the 79 penetrations:

- 75 were examined from the underside of the reactor vessel head using ultrasonic test equipment maneuvered into place using a remote positioning manipulator;
- One penetration (head vent) was examined using both automated ultrasonic testing and manual eddy current testing; and
- Three penetrations were not included because they are not attached to the head with "J-groove" welds.

In accordance with Paragraph IV.C(5)(b)(i), the affected penetrations were scanned starting from the taper-to-cylinder transition at the bottom of each nozzle up to at least two inches above the highest point of the J-groove weld. WCAP-16636, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: South Texas Units 1 & 2," documents an analysis which supports limiting the examination zone to 1-inch below the lowest point of each J-groove weld. UT coverage of most of the penetrations with J-groove welds addressed at least the specified one inch.

There are two exceptions:

- One Control Rod Drive Mechanism penetration (#69) had examination coverage less than one inch because the penetration length only allowed examination to 0.73-inch below the weld toe.

- The de-gas penetration has an unchamfered end-piece extending 0.67-inch below the lowest point of the J-groove weld. Because it was unchamfered, scanning coverage extended to the end of the degas penetration nozzle.

Consequently, relaxation for Unit 1 is only required for reactor head penetration #69.

**Unit 2**

During 2RE12, STPNOC performed a bare metal visual of the RPV head surface in compliance with Section IV.C.(5)(a) and non-visual nondestructive volumetric inspection of the reactor head penetration tubes in compliance with Section IV.C.(5)(b)(i) of Revision 1 of the Order. No reportable indications were found.

Of the 79 penetrations:

- 74 penetrations were examined from the underside of the reactor vessel head using ultrasonic test equipment maneuvered into place using a remote positioning manipulator;
- Two penetrations (head vent and de-gas) were examined using both automated ultrasonic testing and manual eddy current testing; and
- Three penetrations were not included because they are not attached to the head with "J-groove" welds.

In accordance with Paragraph IV.C(5)(b)(i), the affected penetrations were scanned starting from the taper-to-cylinder transition at the bottom of each nozzle up to at least two inches above the highest point of the J-groove weld. WCAP-16636 documents an analysis which supports limiting the inspection zone to 1-inch below the lowest point of each J-groove weld. UT coverage addressed at least the specified one inch of most of the penetrations with J-groove welds. The exceptions are eight Control Rod Drive Mechanism penetrations with inspection coverage less than one inch because the inside diameter chamfer on the end of each nozzle precludes coverage to the very end of the nozzle below the J-groove weld. The following penetrations had limited examination coverage below the weld toe due to their insufficient penetration length:

| PENETRATION | FUNCTION | AXIAL COVERAGE BELOW LOWEST POINT OF J-GROOVE WELD (inches) |
|---|---|---|
| 65 | CRDM Spare | 0.74 |
| 66 | CRDM | 0.63 |
| 68 | CRDM | 0.71 |
| 69 | CRDM | 0.89 |
| 70 | CRDM | 0.81 |
| 71 | CRDM | 0.78 |
| 72 | CRDM | 0.76 |
| 73 | CRDM | 0.63 |

The head vent and de-gas lines were examined with both ultrasonic testing (UT) and eddy current testing (ET) to satisfy the requirements of the Order. These penetrations were scanned starting from the taper-to-cylinder transition at the bottom of the weld to at least two inches above the highest point of the J-groove weld. The vent and de-gas lines are flush with the inside contour of the head and the chamfer on the corner of these penetrations prevents full coverage to the very end of the nozzle. Consequently, the configuration of the weld at the base of these lines is not suitable for inspection by UT. The J-groove weld surface for these penetrations was examined using ET. No recordable indications were found using either method.

## 5.2 WCAP-16636

Relaxation of the examination requirements is consistent with the analysis submitted in industry topical report MRP-55, "Materials Reliability Program (MRP) Crack Growth Rates for Evaluating Primary Water Stress Corrosion Cracking (PWSCC) of Thick-Wall Alloy 600 Materials," Revision 1, and the site-specific analysis in WCAP-16636-P, Revision 0.

Five rows of penetration nozzles were analyzed for WCAP-16636. The magnitude of the hoop stress at a distance of one inch or more below the toe of the downhill side of the J-groove weld is less than 20 ksi for the analyzed penetrations. The required inspection coverage for those penetration nozzles not being analyzed can be determined using the bounding results from those analyzed penetrations with bounding nozzle angles. The inspection requirements of the Order are satisfied provided that minimum inspection coverage of one inch is achieved.

The major inherent conservatisms in WCAP-16636-P, Revision 0, are summarized below:

- **Conservatism in Assumed Crack Geometry:**

  High stresses, on the order of the material yield strength, are necessary to initiate PWSCC. There are no known cases of PWSCC of Alloy 600 occurring below the yield stress. The yield strength for wrought Alloy 600 head penetration nozzles is in the range of 37 ksi to 65 ksi. Weld metal yield strengths are generally higher. The yield strengths of the head penetration nozzles for South Texas Project Unit 1 and Unit 2 vary from 35.5 ksi to 55 ksi. At a stress level less than 20 ksi, PWSCC initiation is extremely unlikely. The assumption of a through-wall flaw in these unlikely PWSCC initiation regions of the head penetration is an important additional conservatism because the penetration tubes will be inspected with maximum achievable coverage on the tube ID.

  The axial blade probe is used in the thermally sleeved penetrations between the penetration ID and the thermal sleeve OD. The axial blade probe propagates ultrasound circumferentially rather than axially and as such does not require additional axial length to support the ultrasonic wave propagation. Thus, data can be collected very close to the penetration end. See Figure 4.

- **Conservatism in Recommended PWSCC Crack Growth Rate:**

  The reactor vessel head penetration nozzles for South Texas Units 1 and 2 are constructed from material supplied by Huntington Alloys USA. From Table 5-3 of MRP-55, Revision 1, the log mean power law constant (at 325°C) for typical Huntington Alloy 600 heats is summarized below:

| Heat | Log Mean Power Law Constant (SI units) |
|---|---|
| NX8101 | 1.37 x E-12 |
| NX8664 | 1.29 x E-12 |
| NX6420G | 7.21 x E-13 |
| NX9240 | 4.97 x E-13 |
| NX8168G | 1.93 x E-13 |

The recommended crack growth constant from the NRC flaw evaluation guidelines is 2.67E-12 in SI units. The recommended PWSCC crack growth rate is approximately a factor of 1.9 greater than that obtained from the test data for any of the Huntington Alloy 600 heats.

- **Conservatism in Flaw Propagation Calculations:**

  STPNOC has calculated the susceptibility of the Unit 1 and Unit 2 RPV heads to PWSCC, as represented by effective degradation years (EDY) at the end of each operating cycle. Unit 1 EDY is projected to be 7.37 by Spring 2008 (refueling outage 1RE14) and 7.87 in Fall 2009 (1RE15). Unit 2 EDY is projected to be 8.16 in Fall 2008 (2RE13) and 8.66 in Spring 2010 (2RE14). Examination criteria consistent with the "Moderate" category are applicable to Unit 2 when EDY is 8 or higher until the head is replaced.

  Crack growth evaluation for partial through-wall flaws is based on the worst-case stress distribution through the penetration wall in the immediate vicinity of the penetration welds. A series of crack growth calculations presume a flaw where the lower extremity of this initial through-wall flaw is conservatively postulated to be located on the penetration nozzle where either the inside or outside surface hoop stress decreases below 0 KSI.

  The methodology and the technical basis of the crack growth calculation, which is based on the hoop stress distribution and the PWSCC crack growth rate recommended in MRP-55 Revision 1, are provided in WCAP-16636-P.

  The calculation demonstrates that a flaw in an unexamined area of the penetration nozzle would require more than one operating cycle to elapse before propagating into the pressure boundary formed by the J-groove weld. The operating cycles for Unit 1 and Unit 2 are approximately 18 months, or 1.5 EFPY. The minimum time for a flaw to propagate from 0.63 inches (minimum length examined) below the weld to the bottom of the J-groove weld is greater than 6 EFPY (approximately four operating cycles); this exceeds the projected operating time until the reactor pressure vessel heads are replaced. The extent of the available inspection coverage provides reasonable assurance of the structural integrity of the RPV head penetrations.

STPNOC understands that, should the NRC staff find that the crack-growth formula in industry report MRP-55 is unacceptable, the analysis justifying relaxation of the Order will be revised within 30 days after STPNOC is notified of an NRC-approved crack-growth formula.

- If the results from the revised analysis exceed the crack-growth acceptance criteria prior to the end of the current operating cycle, this relaxation request will be rescinded and STPNOC will, within 72 hours, submit to the NRC written justification for continued operation.
- If the revised analysis shows that the crack-growth acceptance criteria are exceeded during the subsequent operating cycle, STPNOC will, within 30 days, submit the revised analysis for NRC review.
- If the revised analysis shows that the crack-growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, STPNOC will submit a letter to the NRC within 30 days confirming that the analysis has been revised.

## 5.3 Acceptability of Alternative

The proposed inspection coverage is adequate because the cited inspection limitation for the nozzles does not preclude full UT examination coverage of the portions of the nozzles that are of primary interest. This is because:

- UT of the most highly stressed portion of the nozzle (the weld heat-affected zone) is unaffected by this limitation.
- UT of the interference fit zone above the weld (for leakage assessment) is unaffected by this limitation, and cracks initiating in the unexamined bottom portion (non-pressure boundary) of the nozzle would be of minimal safety significance with respect to pressure boundary leakage or nozzle ejection, since this portion of the nozzle is below the pressure boundary. Any cracks would have to grow through a significant examined portion of the tube to reach the pressure boundary.

The zones of inspection selected are such that the stresses in the uninspected zones are at levels for which primary stress corrosion cracking is considered highly unlikely. Operating experience also indicates that locations with low stress levels are much less susceptible to PWSCC. If examination of the high stress locations of these nozzles (i.e., nozzle locations adjacent to the J-groove weld and associated heat affected zone areas) finds no cracks, then cracking at the low stress locations is unlikely.

STPNOC intends to replace the RPV heads of both Unit 1 and Unit 2. The Unit 1 head is to be replaced during the refueling outage scheduled for October 2009 (1RE15). Replacement of the Unit 1 head will occur at an EDY of 7.87 years, while still having low susceptibility. The Unit 2 head is to be replaced during the refueling outage beginning in March 2010 (2RE14). Unit 2 EDY at that time is expected to be 8.66, with the head then classified as having moderate susceptibility.

## 6.0 <u>Duration of Proposed Alternative</u>

Once approved, this alternative will be available for use for the duration of the second inspection interval. However, the change in requirements is needed only until he reactor pressure vessel heads are replaced. As previously stated, Unit 1 is scheduled for head replacement during the refueling outage beginning October 2009. The Unit 2 head replacement will be completed in the March 2010 refueling outage.

## 7.0 Precedents

The NRC staff has approved similar relaxation of reactor head penetration nozzle ultrasonic examination requirements for use at Diablo Canyon Units 1 and 2, St. Lucie, and Palo Verde, Unit 1. Their applications were approved as follows:

- Diablo Canyon Unit 1, approved October 26, 2005 (TAC No. MC7071)
- Diablo Canyon Unit 2, approved November 23, 2004 (TAC No. MC4932)
- St. Lucie Unit 2, approved December 27, 2004 (TAC No. MC3107)
- Palo Verde Unit 1, approved May 5, 2004 (TAC No. MC2388)

**Table 1 – STP HEAD PENETRATION NOZZLES AND ANGLES**

| NOZZLE | ANGLE (DEGREES) |
|---|---|
| 1 | 0.0 |
| 2 - 5 | 11.4 |
| 6 - 9 | 16.2 |
| 14 - 17 | 23.3 |
| 18 - 21 | 24.8 |
| 22 - 29 | 26.2 |
| 30 - 37 | 30.2 |
| 38 - 41 | 33.9 |
| 42 - 49 | 35.1 |
| 50 - 53 | 36.3 |
| 54 - 61 | 38.6 |
| 62 - 65 | 44.3 |
| 66 - 73 | 45.4 |
| 75 - 79 | 48.7 |

Note: The internal support housing penetration nozzles (74, 80, and 81) are not attached to the head with a J-groove weld configuration; therefore, analyses for these three nozzles are not necessary.

**Figure 1: Reactor Pressure Vessel Head Arrangement**

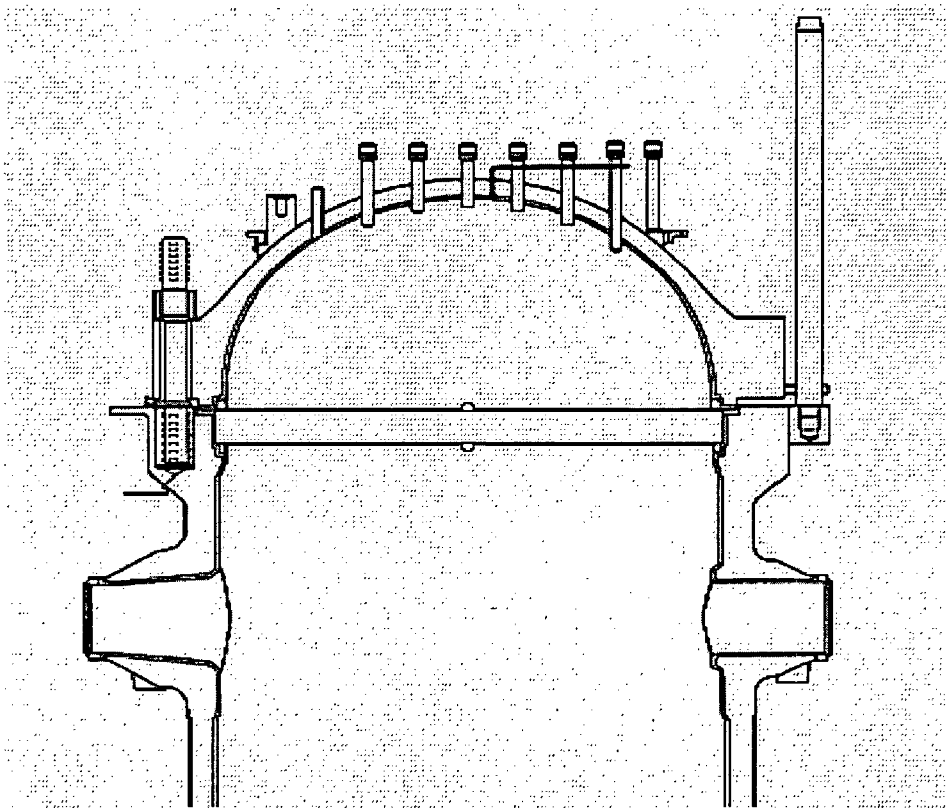


**Figure 2: Penetration Locations**

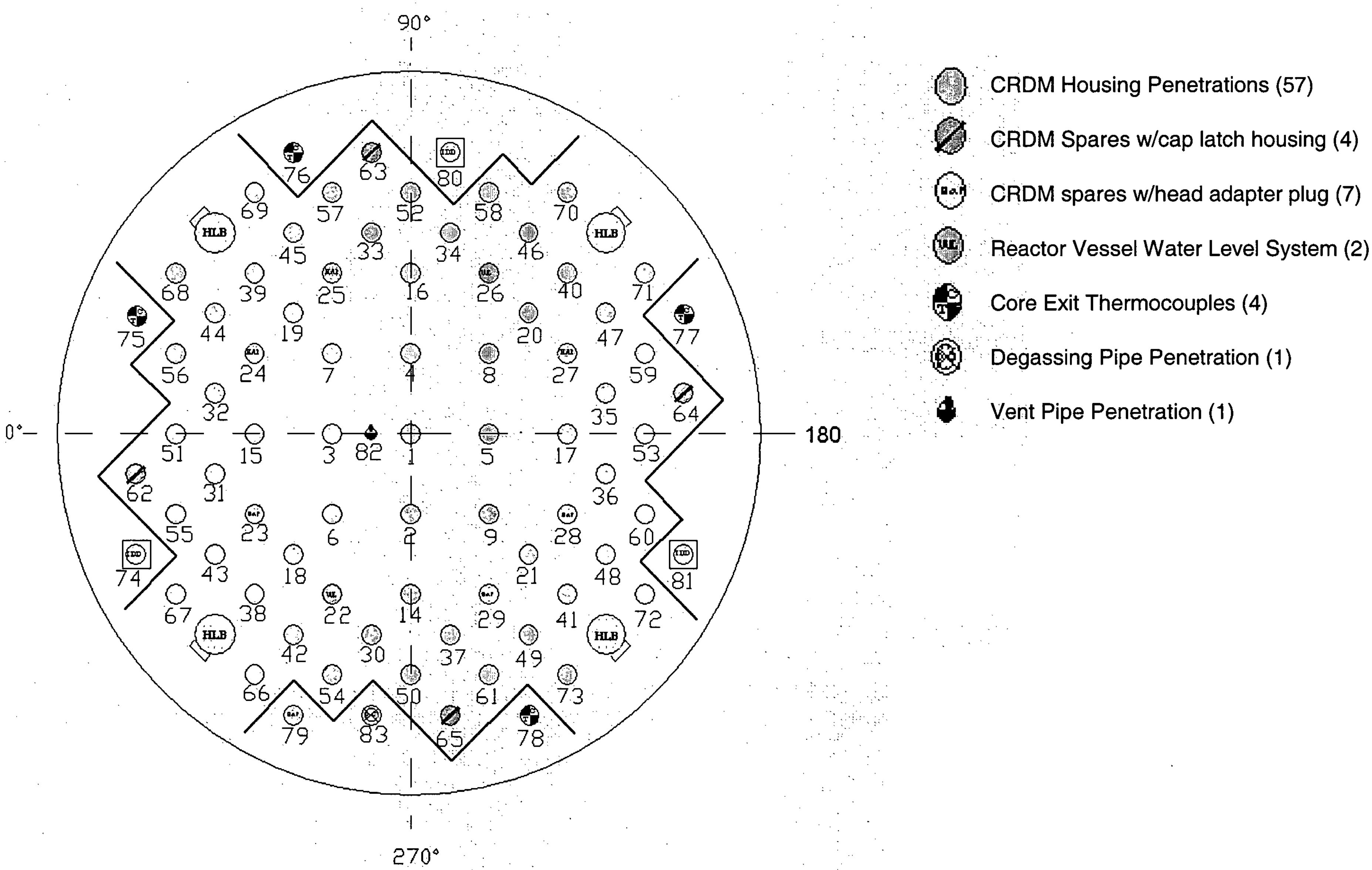
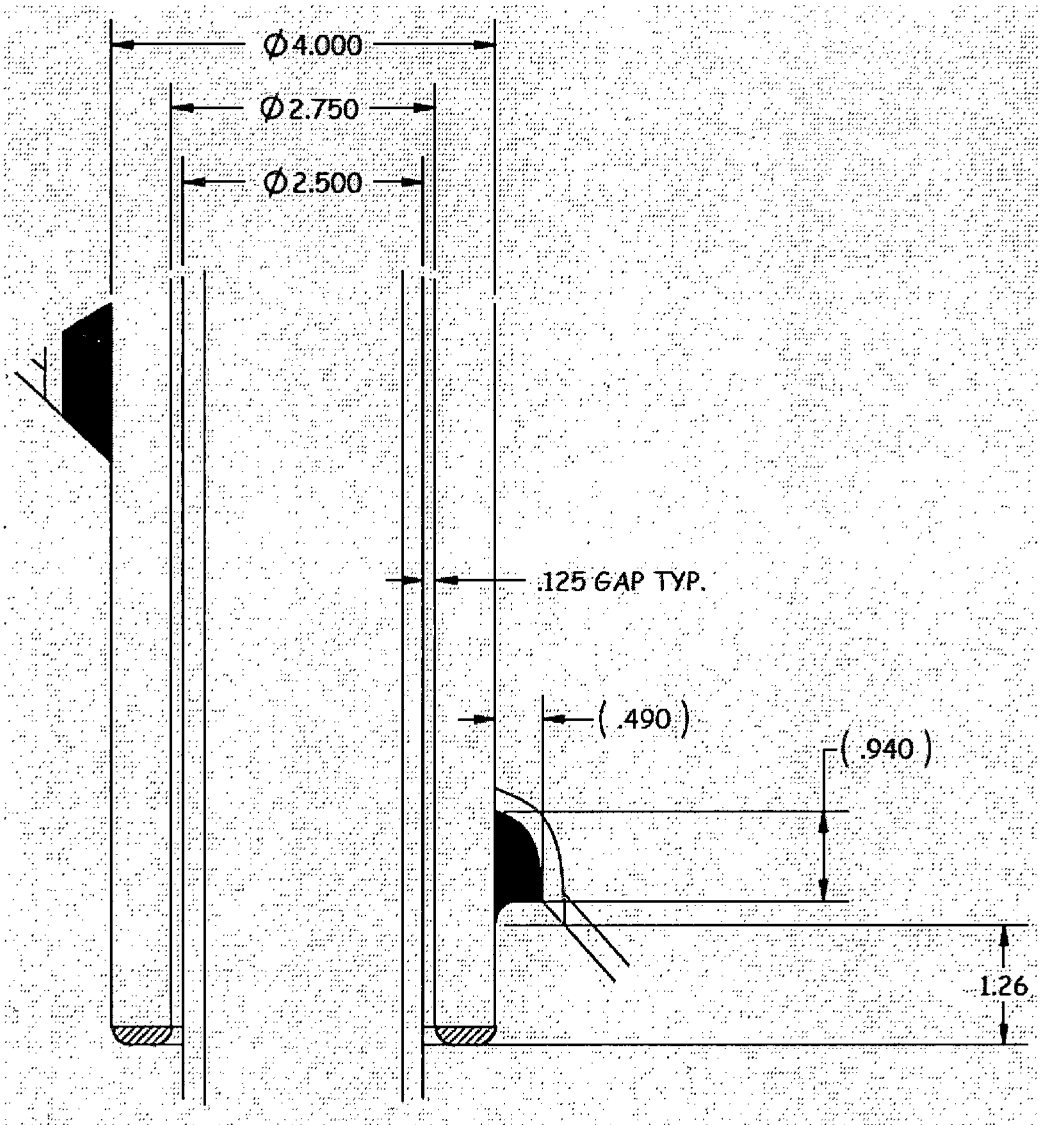


**Figure 3: CRDM Penetration with Installed Thermal Sleeve (Periphery)**




Limited examination region extends 0.2" from end of penetration.

## Figure 4: Comparison of Axial vs. Circ Beam Propagation