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Dominion

October 3, 2003

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

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**Dominion Nuclear Connecticut, Inc. (DNC)**
**Millstone Power Station, Unit No. 2**
**Order EA-03-009 Relaxation Request Number RR-89-48 for Nozzle Inspection Ultrasonic Test Coverage Requirements**

On February 11, 2003,[1] the U.S. Nuclear Regulatory Commission (NRC) issued Order EA-03-009 for interim inspection requirements for reactor pressure vessel (RPV) heads at pressurized water reactor facilities. The Order requires specific inspection of the RPV head and associated penetration nozzles. Compliance with Section IV.C(1)(b) of the Order does not allow the combination of inspection techniques that are needed for inspection of the Control Element Drive Mechanism (CEDM) penetration nozzles at Millstone Unit No. 2. The ultrasonic test (UT) technique is unable to examine the bottom inside diameter (ID) of these nozzles due to their internal threading to accept a guide funnel. Pursuant to Section IV.F of the Order, Dominion Nuclear Connecticut, Inc. (DNC) requests relaxation from Section IV.C.(1)(b) of the Order to allow use of a combination of UT and dye penetrant testing (PT) on the CEDM penetration nozzle base material, and reduced examination coverage below the weld in the non-pressure boundary portion of the nozzle. Attachment 1 contains the request and describes how the nozzle configuration makes inspection in accordance with the Order difficult and involves a hardship without a compensating increase in the level of quality or safety.

The NRC has recently approved similar relaxation requests, most recently for Saint Lucie Nuclear Plant, Unit 2, in May 2003.[2] In its safety evaluation approving the request, the NRC staff stated that the alternative provides reasonable assurance of the structural integrity of the RPV head. Saint Lucie Nuclear Plant is a similar Combustion Engineering plant, and the hardship and structural integrity evaluation associated with the Millstone Unit No. 2 proposal are similar to those presented in the Saint Lucie application. The Millstone Unit No. 2 request uses comparable methodology for a crack

(1) NRC Order EA-03-009, "Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated February 11, 2003, (Accession No. ML030380470).

(2) NRC letter and Safety Evaluation, "Saint Lucie Nuclear Plant, Unit 2 – Order EA-03-009 Relaxation Request Nos. 1 and 2 Regarding Examination Coverage of Reactor Pressure Vessel Head Penetration Nozzles (TAC Nos. MB8165 and MB8166)," May 29, 2003. (Accession No. ML031500489)

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growth analysis that establishes how many and which nozzles will be subject to PT surface exams. Both proprietary and non-proprietary versions of the structural integrity evaluation for Millstone Unit No. 2 will be submitted by a separate letter to support NRC review of this proposal. Additionally, when the actual extent of UT examination coverage is established during the upcoming refueling outage, DNC will provide information on the scope of PT surface examinations that are performed, and the flaw tolerance on each CEDM penetration.

DNC requests approval of the proposed relaxation request by October 20, 2003, to support inspection activities scheduled during the upcoming fall 2003 refueling outage.

There are no regulatory commitments contained within this letter.

If you should have any questions regarding this submittal, please contact Mr. Paul R. Willoughby at (804) 273-3572.

Very truly yours,

DOMINION NUCLEAR CONNECTICUT, INC.

William R. Matthews
Senior Vice President – Nuclear Operations

cc: H. J. Miller, Region I Administrator
R. B. Ennis, NRC Senior Project Manager, Millstone Unit No. 2
Millstone Senior Resident Inspector

The Director, Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Serial No. 03-513/B18985
MPS 2 Relief Request RR-89-48

COMMONWEALTH OF VIRGINIA )
)
COUNTY OF HENRICO )

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by William R. Matthews who is Senior Vice President – Nuclear Operations of Dominion Nuclear Connecticut, Inc. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 3rd day of October, 2003.

My Commission Expires: 3-31-04.

Notary Public Maggie McClure

SEAL

Attachment 1

Millstone Power Station, Unit No. 2

Order EA-03-009 Relaxation Request Number RR-89-48 for
Nozzle Inspection Ultrasonic Test Coverage Requirements

Millstone Power Station, Unit No. 2
Order EA-03-009 Relaxation Request RR-89-48 for the
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*Proposed Alternative*
*in Accordance with Section IV.F of the Order*

*- Hardship or Unusual Difficulty without Compensating Increase in Level of Quality or Safety -*

## 1.0 ASME CODE COMPONENT(S) AFFECTED

### 1.1 Reactor Pressure Vessel Head

The Millstone Unit No. 2 Reactor Pressure Vessel (RPV) head was fabricated by Combustion Engineering and has 69 penetrations for Control Element Drive Mechanisms (CEDMs), 8 for incore instrumentation (ICI) nozzles and 1 head vent connection. The penetrations are all made of ASME SB 167, Alloy 600 material produced by Huntington Alloys. The vent line is a three-quarter inch NPS Schedule 80S pipe. The Millstone Unit No. 2 reactor vessel was built to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section III, Nuclear Vessels, Class A, 1968 edition with addenda through summer 1969.

### 1.2 CEDM Penetration Nozzles

This relaxation is applicable to the 69 CEDM RPV head penetration nozzles with attached threaded guide funnels.

## 2.0 APPLICABLE EXAMINATION REQUIREMENTS

The U.S. Nuclear Regulatory Commission (NRC) issued an Order on February 11, 2003,[(3)] establishing interim inspection requirements for reactor pressure vessel heads of pressurized water reactors. The Order establishes a minimum set of RPV head inspection requirements as a supplement to existing inspection requirements contained within the ASME Code and NRC regulations.

Based upon criteria in Section IV.B of the Order, the Millstone Unit No. 2 RPV head has a high primary water stress corrosion cracking (PWSCC) susceptibility. The category of high susceptibility is based in part upon having effective degradation years (EDY) of greater than 12. The Millstone Unit No. 2 RPV is expected to accrue 12.74 EDY by the end of cycle 15. The susceptibility category

[(3)] NRC Order EA-03-009, "Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated February 11, 2003.

is also based upon the identification and repair of indications found in three CEDM penetration nozzles as a result of UT inspections on each of the penetrations conducted during the previous refueling outage. None of those indications were through wall and leak paths were not detected.

According to Section IV.C.(1)(b) of the Order, RPV head penetration nozzles in the "High" PWSCC susceptibility category shall be inspected using _either_ of the following non-destructive examination (NDE) techniques each refueling outage:

"(i) *Ultrasonic testing (UT) of each RPV head penetration nozzle (i.e., nozzle base material) from two (2) inches above the J-groove weld to the bottom of the nozzle and an assessment to determine if leakage has occurred into the interference fit zone, OR*

(ii) *Eddy current testing (ECT) or dye penetrant testing (PT) of the wetted surface of each J-groove weld and RPV head penetration nozzle base material to at least two (2) inches above the J-groove weld."*

DNC understands that the Order requires the same technique specified in Section IV.C(1)(b) be used to inspect the entire population of RPV head penetration nozzles; and that combining techniques, or using one technique on one nozzle and the other technique on another nozzle, is not permitted.

## 3.0 REASON FOR THE REQUEST

DNC intends to perform UT examination in accordance with Section IV.C(1)(b)(i) of the Order which requires UT examination from 2 inches above the J-groove weld to the bottom of the RPV head penetration nozzle. Compliance with this requirement of the Order is difficult because the UT equipment cannot interrogate the bottom inside diameter (ID) of a CEDM penetration nozzle, where the nozzle is internally threaded at the bottom to accept a guide funnel. Each threaded funnel is permanently attached in place with a weld. Due to this CEDM nozzle configuration, the UT examination coverage will be less than the coverage required by the Order on the nozzle base material below the weld in the non-pressure boundary portion of the nozzle. Refer to Figure 1 for the general arrangement.

There are also difficulties related to implementing Section IV.C(1)(b)(ii) of the Order, and in combining the examination techniques of UT with ECT or PT to obtain the required examination coverage that include the following:

- There are 69 CEDM penetration nozzles.

- Access to the OD of the nozzles is limited by the adjacent nozzles and attached funnels. The nozzles follow the curvature of the RPV head as do the attached funnels. Spacing between the funnels in the horizontal plane is tight. Consequently, it will make performance of surface examinations on the OD surfaces of the bottom of the nozzles difficult and dose intensive.

- PT methods for performing nozzle OD examinations are manually applied and dose intensive. A remote ECT process for RPV head penetration nozzle examination remains unavailable at the station, as it has not been qualified by DNC and its vendor for use in the upcoming refueling outage 15 at Millstone Unit No. 2.

- The radiation exposure to workers from PT of the wetted surfaces in the manner required by Section IV.C(1)(b)(ii) of the Order is estimated to be 2.5 Rem per nozzle, or 173 Rem for all 69 CEDM nozzles. Considering the effectiveness of UT examinations, DNC considers that extensive use of PT examinations represents an unnecessary level of exposure.

- The radiation exposure to workers from performance of a supplemental PT of a portion of the nozzle that will augment UT examination coverage is approximated to be 11 Rem for all 69 CEDM nozzles. DNC considers that exposures can be further reduced by using a more discriminating application of the supplemental PT without any adverse impact to the level of quality and safety prescribed by the requirements in the Order.

## 4.0 PROPOSED ALTERNATIVE

DNC proposes to perform UT examinations from 2 inches above the weld to below the weld to the extent possible. Nozzles that cannot be UT examined to at least 0.38 inches below the weld will receive a supplemental outside diameter (OD) PT examination that overlaps with the end of the UT coverage by at least 0.125 inches and extends below the 0.38 inch level below the J-groove weld by at least 0.125 inches. DNC will provide in the 60-day report for Millstone Unit No. 2 the specified inspection information required by the Order; i.e., extent of inspections and results of those inspections.

## 5.0 BASIS FOR USE

The phenomena that are of concern are leakage through the J-groove weld and circumferential cracking in the nozzle above the J-groove weld that can become a precursor to conditions having a greater potential for nozzle ejection. In the pressure boundary region and in the region from the bottom of the J-groove weld to two inches above the J-groove weld, 100 percent coverage will be obtained and thus the UT examination coverage will be fully compliant with required examination coverage of the Order. This request changes requirements for examination coverage only in the region below the J-groove weld where the UT examination coverage is not significant to the phenomena of concern.

DNC considers that this change in the examination coverage that is required by the Order retains an acceptable level of quality and safety because the only portion of the nozzle not fully interrogated is a region near the bottom of each nozzle below the toe of the J-groove weld. Below the J-groove weld, the nozzle is essentially an open-ended tube and the nozzle wall below the J-groove weld is not part of the reactor coolant system pressure boundary. Any cracks in this region would have to grow through the examined portion of the nozzle to reach the weld and pressure boundary. At the end of the operating cycle following the upcoming refueling outage 15, a new RPV head will be installed. This request is only applicable to upcoming inspections during refueling outage 15 and the single operating cycle that follows. Due to the low stresses in the bottom portion of the nozzles and the corresponding low crack growth rates, DNC believes there is adequate assurance of the structural integrity of the RPV head nozzles despite the limitations on expected examination coverage below the pressure boundary weld.

The relevant bases for this request are taken from industry operating experience, recent UT examination of each of the nozzles during the previous outage, the proposed extent of UT coverage and a flaw tolerance analysis that is based upon an industry accepted methodology. These are discussed in some detail in the balance of this section.

5.1 Industry Operating Experience

Experience with inspection of reactor vessel head penetrations has shown that cracks have initiated only in regions where the stresses have been at or near the material yield strength. The source of these stresses, in this case, is the J-groove attachment weld. Weld shrinkage in the J-groove attachment weld causes the high residual tensile stress in the penetration tube necessary to initiate PWSCC.

Because there is no operational loading the residual stresses decrease rapidly with distance below the weld. Consistent with the drop off in stress levels, industry experience has been that flaws are not expected in the unexamined low stress area unless they are the extension of a flaw already present in the region near the weld examined by UT. The only cases where cracks have been found near the bottom of the reactor vessel head penetrations have been in B&W designed plants where multiple cracks have been found. In the B&W plants inspected with UT, however, there were no cases where indications were recorded in the base material below the weld region that were not associated with other cracking extending from the high stress weld region. Thus, even the exceptional case of cracking near the bottom of a penetration is accompanied by related cracking in the region examined by UT. This experience base provides a high confidence that the extent of UT coverage achievable with the current technique is adequate to detect the flaws.

DNC also notes that the most recent industry inspections in response to this Order continue to support the observations that are described above. The flaws found this past spring at the Saint Lucie Nuclear Plant, Unit 2, another

Combustion Engineering designed plant, were all within the proposed UT inspection zone. Cracking was not detected at the bottom of nozzles and all indications were associated with cracking that extended from the high stress weld region and, therefore, detectable with UT examinations.

5.2 Results of Previous UT Examinations at Millstone Unit No. 2

During the last refueling outage in spring 2002, Millstone Unit No. 2 performed UT of all 78 RPV head penetration nozzles and identified three CEDM nozzles with indications (Nozzles 21, 34 and 50), which were subsequently repaired. A summary characterizing those indications is provided in Table 1. As can be noted, there were no through wall flaws in any of the penetration nozzles. All indications were associated with cracking that extended from the high stress region at the toe of the J-groove weld, and no indication was more distant than 0.21 inches below the toe of the J-groove weld. The indications were UT detectable flaws that extended well into the weld elevations. It is also notable that the listed flaws below the weld did not occur in isolation but were accompanied by other detectable flaws. Plant-specific experience thus reinforces the conclusion that axial crack initiation starts from the higher stress regions of the nozzle near or at weld elevations. This conclusion is empirically supported by the data shown in Table 1. The UT examination and nozzle repairs only one cycle prior to the upcoming inspection greatly reduces uncertainty in the assessment of the extent of Primary Water Stress Corrosion Cracking (PWSCC) at Millstone Unit No. 2.

5.3 Extent of UT Examination Coverage in CEDM Nozzles

The actual extent of UT examination coverage that can be achieved below the J-groove weld will not be established until performance of UT examinations during the upcoming refueling outage. The inspection data will show the minimum distance below the toe of the J-groove weld that can be interrogated by a UT examination. The accessible distance below the weld varies due to the weld configuration and nozzle location; however, the most limiting UT examination coverage can be expected for the downhill side of the nozzles near the outside perimeter of the vessel head. DNC expects several nozzles will have limited UT examination coverage below the J-groove. Consequently, several manual applications of a supplemental PT could be required that would result in significant exposures. As noted in the Alternative the combined coverage, when required, includes overlapping exams in the area of 0.38 inches below the weld. This assures that no recordable flaw initiating on the edges of cracking-susceptible areas would escape detection. The combined exams will thereby achieve an overlapping coverage that exceeds the coverage required to support the assumption of the flaw tolerance evaluation (described below).

## 5.4 Flaw Tolerance Evaluation

A flaw evaluation analysis is used to ensure that stresses for the unexamined portion of the nozzle are so low that initiation of an axial flaw is unlikely. The analysis also ensures that, even if a flaw does initiate, the time required for it to grow to the point of contact with the weld would exceed one plant operating cycle until the next examination or repair/replacement. The crack propagation time estimates conservatively neglect the time required for a crack to grow through the weld region to the pressure boundary region above the weld. This evaluation is based on a methodology consistent with the one recently recommended by the NRC and outlined in the letter dated April 11, 2003,[4] from the Office of Nuclear Reactor Regulation to Alex Marion, Nuclear Energy Institute (NEI). The recommended crack growth rate and the minimum evaluation time (one plant cycle) are also followed. The plant-specific flaw tolerance evaluation for Millstone Unit No. 2 is documented in the structural integrity evaluation report, WCAP-15813-P, Revision 01.[5] A proprietary and non-proprietary version of this structural integrity evaluation report will be submitted separately. The analyses and figures from the report were used to establish the adequacy of the 0.38-inch UT coverage criterion stated in the Alternative.

The establishment of the 0.38-inch minimum coverage is consistent with the approach that is described in Footnote 1 of the NRC Order EA-03-009 for the criteria to set the necessary height of the surface examination. Therefore, the coverage addressed by this request provides reasonable assurance of structural integrity of the component. The structural integrity evaluation provides specific stress analyses of four head/penetration intersection angles that represent the range of such angles for all CEDM nozzles on the RPV head. Table 2 in this Attachment shows the flaw tolerance, in terms of stress levels and acceptable length of service, calculated for each of these intersection angles.

### 5.4.1 Conclusions From Analysis

Table 2 shows that if an axial flaw were to exist 0.38 inches below the toe of the weld, the predicted time for the flaw to grow to a point of contacting the weld is $\geq$ 1.9 years of operation as compared to the 1.5 years required for the next plant cycle. Penetration nozzles at other angles would have a greater acceptable service life. As noted in reference 3, prediction of crack growth is required for only one cycle of operation. The margin of service duration is reasonable considering

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(4) Letter from Office of Nuclear Reactor Regulation to Alex Marion (NEI), "Flaw Evaluation Guidelines," dated April 11, 2003. (Accession No. ML030980327)

(5) Westinghouse Electric Company LLC, "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation: Millstone Unit 2," WCAP-15813-P, Revision 01 (Draft).

the above-described conservatisms of the analysis and the assurance that Millstone Unit No. 2 is not an outlier provided by the actual UT data from the previous refueling outage.

The flaw tolerance evaluations supporting the above acceptable service life are consistent with the referenced guidelines and, therefore, maintain safety margins in accordance with Section XI of the ASME Code.

Table 2 also summarizes stress levels, and shows that the hoop stress at operating conditions for a nozzle at the intersection angles, with one exception, are below 34 ksi and less than 72 percent of the yield stress of the materials used for the unit's vessel head nozzles. For the one exception, the stress is less than 75 percent of yield. Stresses at or near yield are needed to initiate cracking. The surface examination can be limited to the nozzle OD on the downhill side to achieve the proposed coverage since the hoop stresses are highest on the nozzle OD directly adjacent to the weld. Operating experience has shown that cracking occurs predominantly on the downhill side. Stress level figures in the referenced structural integrity evaluation show further that stress levels decrease rapidly beyond 0.38 inches below the J-groove weld. Thus, stress levels 0.38 inches below the weld are considerably less than the material yield level and are decreasing with greater distance from the weld. Regions of the nozzles not inspected by either UT or PT therefore have operational hoop stress levels that are relatively low and are not expected to initiate or propagate cracking. Hence, examination of the penetration nozzles below the proposed Alternative examination region by any examination method does not enhance or demonstrate structural integrity of the nozzle.

5.4.2 Stress Model Basis Compared with Field Conditions

A finite element model of the Millstone Unit No. 2 head penetration nozzle region, including J-groove weld, was developed from the nominal dimensions and weld sizes specified on the fabrication drawings. The analysis results of the model were used by the structural integrity evaluation to develop stress levels and expected crack growth over time. The only feature of the penetration design that could vary significantly in the as-built condition is the size of the fillet weld "cap" for the J-groove weld. The purpose of this fillet weld cap (toe of the weld) is to reduce the notch effects, or stress risers. It is not required for structural integrity. Because the fillet weld cap is not explicitly included in the model, its as-built dimensions are not important to the validity of the finite element analysis. It is conservative to not explicitly model the fillet weld because the fillet weld provides a geometric transition that helps to reduce peak stress levels as compared to analysis in which the fillet weld is neglected. The residual stresses resulting from the weld fabrication process are due primarily to the shrinkage of the partial penetration J-groove weld, and not the fillet weld leg. Unlike the J-groove weld, the fillet weld cap is not constrained by the reactor vessel head. Therefore, the fillet weld does not affect the overall structural behavior of the penetration region and the flaw evaluation tables contained in the structural integrity evaluation are not affected by fillet weld size.

5.5 Conclusion of Bases Discussion

Based on the results from the crack growth and flaw tolerance evaluation there is reasonable assurance of structural integrity for the penetration nozzles, assuming the possibility of an undetected flaw more than 0.38 inches below the J-groove weld. The low stress levels and the lack of adverse industry operating experience assure that cracking in such low stressed areas is unlikely. This conclusion is further reinforced by Millstone plant-specific inspection data. The inspection data supports a conclusion that crack initiation has the greatest potential where UT examination coverage can be achieved in the high material stress regions immediately above and below the pressure boundary weld. Considering this inspection data and the industry operating experience, DNC has a high confidence that examination coverage to the bottom of the nozzle, or beyond the proposed 0.38 inches below the toe of the J-groove weld in the low stress surface areas of the nozzle, do not contribute to the safety or quality of the inspection required by the Order. A surface examination such as PT is suitable for detecting surface breaking flaws in regions not accessible to UT, although it has an unacceptable dose impact when applied broadly. Therefore, the proposed Alternative provides an equivalent level of quality and safety, and additional PT beyond the proposed Alternative will be a hardship without a compensating increase in the level of quality and safety.

## 6.0 DURATION OF PROPOSED ALTERNATIVE

This relaxation is applicable to the upcoming fall 2003 refueling outage 15 for Millstone Unit No. 2.

## 7.0 PRECEDENTS

Precedents have been established that this type of nozzle configuration makes inspection in accordance with the Order difficult and that it involves a hardship. Given that a site's specific flaw tolerance analyses for the unexamined areas provides a suitable basis for continuing operation, the NRC has also made the determination that there is not a compensating increase in the level of quality and safety such that these nozzles should be inspected despite this hardship.

On May 29, 2003,[6] Saint Lucie Nuclear Plant, Unit 2, was authorized to use a similar flaw tolerance approach with a proposal for supplemental PT to address a postulated through wall flaw in uninspected non-pressure boundary portions of the CEDM nozzles. The Saint Lucie Nuclear Plant is a similar CE plant, and the hardship and structural integrity evaluations that support that Unit's flaw analysis are similar. Calvert Cliffs was authorized relaxation to implement an inspection with a reduced examination coverage based upon a similar flaw tolerance approach on April 18, 2003.[7] Also, on March 20, 2003,[8] Turkey Point Unit 3 was authorized a relaxation for examination coverage requirements based upon a flaw tolerance approach.

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(6) NRC letter and Safety Evaluation, "Saint Lucie Nuclear Plant, Unit 2 – Order EA-03-009 Relaxation Request Nos. 1 and 2 Regarding Examination Coverage of Reactor Pressure Vessel Head Penetration Nozzles (TAC Nos. MB8165 and MB8166)," May 29, 2003. (Accession No. ML031500489)

(7) Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2 – Relaxation of the Requirements of Order (EA-03-009), Regarding Reactor Pressure Vessel Head Inspections (TAC Nos. MB7752 and MB7753), April 18, 2003 (Accession No. ML031070434)

(8) NRC letter and Safety Evaluation, "Turkey Point Unit 3 – Relaxation of the Requirements of Order (EA-03-009) Regarding Reactor Pressure Vessel Head Inspections (TAC No. MB7990)," March 20, 2003. (Accession No. ML030790501)

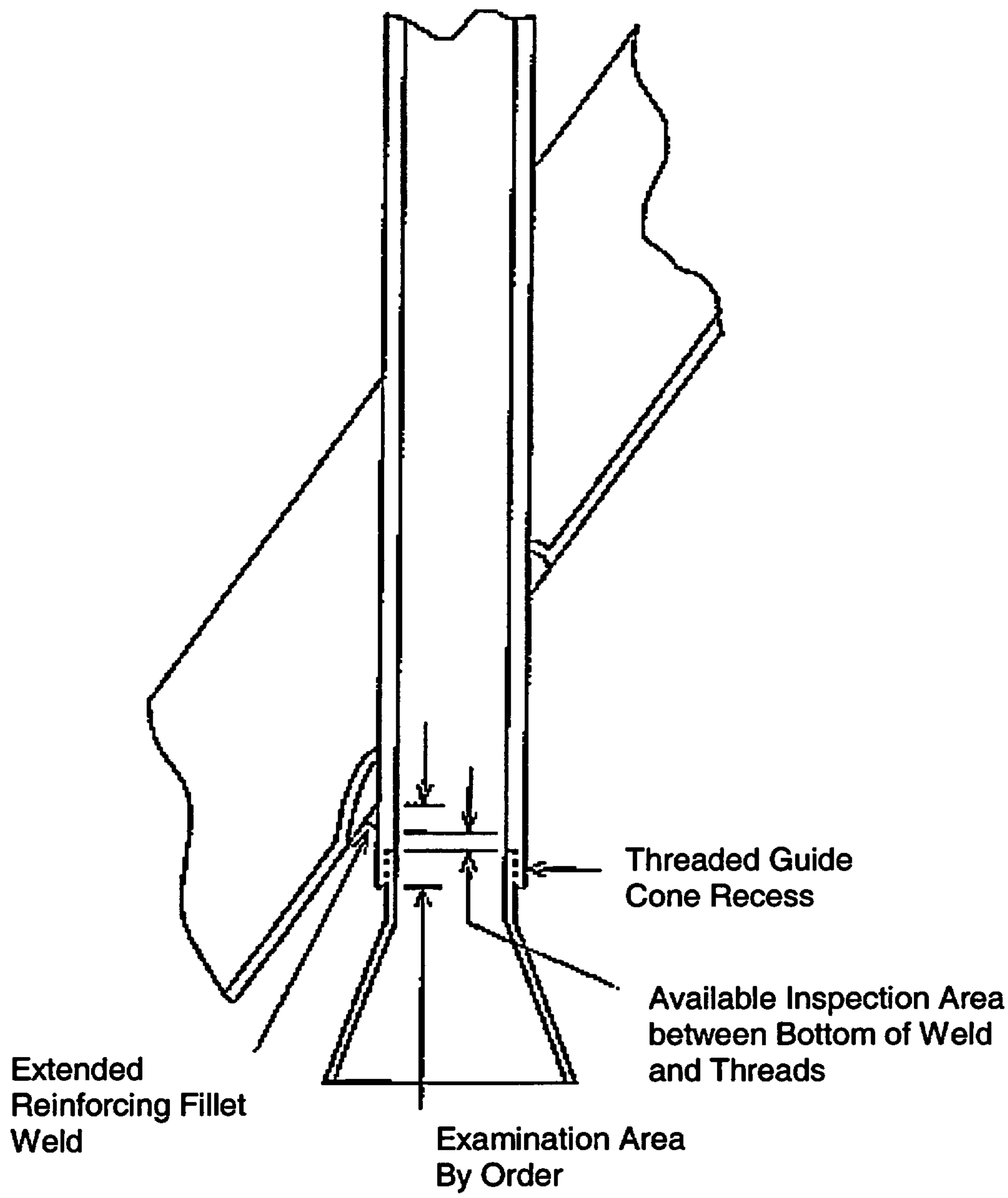


FIGURE 1

TYPICAL CEDM NOZZLE CONFIGURATION

# TABLE 1
# FLAW INDICATIONS FROM ULTRASONIC EXAMINATION DURING THE REFUELING OUTAGE (RFO14) OF VESSEL HEAD NOZZLES AT MILLSTONE UNIT NO. 2

Nozzle No. 21

| Flaw | End Point Elevation | | Weld Elevation at Flaw | | Location | Orientation | TWD[1] (in.) | Length (in.) | Dist. of Flaw Below Min Weld Height (in.) |
|---|---|---|---|---|---|---|---|---|---|
| | Min (in.) | Max (in.) | Min (in.) | Max (in.) | | | | | |
| 1 | 7.60 | 9.63 | 7.94 | 9.68 | Downhill | Axial | 0.20 | 2.04 | at weld elev. |
| 2 | 7.55 | 9.97 | 8.12 | 10.08 | Downhill | Axial | 0.19 | 2.44 | at weld elev. |
| 3 | 7.80 | 8.37 | 8.27 | 10.26 | Downhill | Axial | 0.19 | 0.59 | at weld elev. |
| 4 | 8.12 | 10.39 | 8.67 | 10.65 | Downhill | Axial | 0.09 | 2.28 | at weld elev. |
| 5 | 7.90 | 8.27 | 8.41 | 10.49 | Downhill | Circ | 0.18 | 0.77 | 0.14[2] |
| 6 | 7.81 | 8.17 | 8.10 | 10.17 | Downhill | Axial | 0.15 | 0.37 | at weld elev. |

Nozzle No. 34

| Flaw | End Point Elevation | | Weld Elevation at Flaw | | Location | Orientation | TWD[1] (in.) | Length (in.) | Dist. of Flaw Below Min Weld Height (in.) |
|---|---|---|---|---|---|---|---|---|---|
| | Min (in.) | Max (in.) | Min (in.) | Max (in.) | | | | | |
| 1 | 7.23 | 8.04 | 7.44 | 9.36 | Downhill | Axial | 0.10 | 0.81 | at weld elev. |
| 2 | 7.16 | 8.04 | 7.50 | 9.40 | Downhill | Axial | 0.10 | 0.88 | at weld elev. |
| 3 | 7.32 | 7.44 | 7.65 | 9.44 | Downhill | Circ | 0.10 | 0.43 | 0.21[2] |
| 4 | 7.26 | 7.32 | 7.50 | 9.40 | Downhill | Circ | 0.10 | 0.86 | 0.18[2] |
| 5 | 7.14 | 8.15 | 7.85 | 9.66 | Downhill | Axial | 0.15 | 1.05 | at weld elev. |
| 6 | 8.66 | 9.20 | 9.01 | 10.89 | Downhill | Axial | 0.14 | 0.61 | at weld elev. |

Nozzle No. 50

| Flaw | End Point Elevation | | Weld Elevation at Flaw | | Location | Orientation | TWD[1] (in.) | Length (in.) | Dist. of Flaw Below Min Weld Height (in.) |
|---|---|---|---|---|---|---|---|---|---|
| | Min (in.) | Max (in.) | Min (in.) | Max (in.) | | | | | |
| 1 | 7.00 | 7.96 | 7.73 | 9.43 | Downhill | Axial | 0.13 | 1.06 | at weld elev. |
| 2 | 7.34 | 8.08 | 7.66 | 9.63 | Downhill | Axial | 0.15 | 0.74 | at weld elev. |

NOTES:

(1) The through-wall depth (TWD) of an indication is provided in this column. The CEDM penetrations are all identical, with a 3.850 inch Outside Diameter (OD) and a wall thickness of 0.566 inch.

(2) Note the orientation of this flaw was circumferential and an extension of other axial flaws that were at weld elevations.

## TABLE 2
## FLAW TOLERANCE SUMMARY FOR ANGLES OF INTERSECTION ANALYZED FOR THROUGH-WALL FLAWS ASSUMED AT 0.38 INCHES BELOW WELD

| Angle(2) of Intersection Analyzed (degrees) | Material Heat No.(1) | Outer Diameter Hoop Stress at Assumed 0.38 inches Below Weld (Ksi) | Inner Diameter Hoop Stress at Assumed 0.38 inches Below Weld (Ksi) | Yield Strength (Ksi) | Time(3) for an Assumed Flaw to Grow to Weld From 0.38 inches Below Weld |
|---|---|---|---|---|---|
| 0 | NX1405 | 34 | 41 | 54 | 2.7 years |
| 29.1 | NX1405 | 30 | 33 | 54 | 3.5 years |
| | NX9967 | 30 | 33 | 46 | |
| | NX1314 | 30 | 33 | 60 | |
| 37.1 | NX1405 | 29 | 28 | 54 | 1.9 years |
| | NX1314 | 29 | 28 | 60 | |
| 42.5 | NX7926 | 27 | 20 | 37.5 | 2.3 years |
| | NX1405 | 27 | 20 | 54 | |

NOTES:
(1) Supplier is Huntington Steels for all Material Heat Numbers.
(2) Head penetration nozzles have a number of intersection angles. However, four CEDM locations have specific flaw tolerance analysis: the outermost CEDM row (42.5 degrees), rows at 37.1 degrees, 29.1 degrees, and the center location.
(3) DNC has derived these values from flaw tolerance summary charts in WCAP-15813-P, Revision 01 (Draft), "Structural Integrity Evaluation of Reactor Vessel Upper Head Penetrations to Support Continued Operation at Millstone Unit 2." The operating cycle is nominally 18 months (1.5 years).