Entergy

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10 CFR 50.55a

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Palisades Nuclear Plant
Docket 50-255
License No. DPR-20

Request for Relief from ASME Section XI Code Requirements for Repair of Reactor Pressure Vessel Vent Line Penetration

Dear Sir or Madam:

Pursuant to 10 CFR 50.55a, Entergy Nuclear Operations, Inc. (ENO) is requesting relief from certain sections of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code, Section XI, 2001 Edition with Addenda through 2003, as described in the attached enclosure for Palisades Nuclear Plant (PNP).

ENO requests relief from the ASME Code, Section XI, IWA-3300, "Flaw Characterization," IWB-3142.4, "Acceptance by Analytical Evaluation," IWB-3420, "Characterization," IWB-4220, "Code Applicability," and IWB-3613, "Acceptance Criteria for Flanges and Shell Regions Near Structural Discontinuities." ENO proposes an alternative to the specified code requirements in accordance with 10 CFR 50.55a(g)(5)(iii), on the basis that the code requirements are impractical and the proposed alternative provides reasonable assurance of structural integrity.

ENO is performing ultrasonic examinations and visual examinations of the reactor vessel closure head (RVCH) vent line in accordance with Order EA-03-009, "Issuance of First Revised NRC Order (EA-03-009) Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors," dated February 20, 2004. ENO requires the enclosed relief request in the event a RVCH vent line nozzle penetration is in need of a repair at PNP. ENO will implement an AREVA-Advanced Nuclear Products (ANP) design repair, for the PNP, if a RVCH vent line nozzle penetration repair is necessary during the 2007 refueling outage.

AREVA-ANP provided detailed analyses that justify this repair technique at PNP per the code of record. ENO has reviewed and approved these analyses. A summary of the analyses that support the relief request, AREVA Document 51-5049676-002, "Palisades Vent Line Nozzle Repair Analysis Summary," dated April 2007, is included in Enclosure 1, Attachment 2. This is a non-proprietary report.

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ENO requests approval of the proposed alternative for the fourth ten-year interval of the Inservice Inspection Program for PNP, which will conclude on or before December 13, 2015.

ENO requests approval of the proposed relief request by September 1, 2007, in order to support the refueling outage schedule.

Christopher J. Schwarz
Site Vice President
Palisades Nuclear Plant

Enclosure (1)

CC Regional Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
NRC Resident Inspector, Palisades USNRC

ENCLOSURE 1
RELIEF REQUEST: EMBEDDED FLAW
REACTOR PRESSURE VESSEL VENT LINE PENETRATION

ASME Code Component Affected

The affected component is the Palisades Nuclear Plant (PNP) reactor vessel closure head (RVCH) vent line nozzle penetration. PNP has one vent line penetration that is an American Society of Mechanical Engineers (ASME) Class 1 penetration.

Applicable Code Edition and Addenda

The applicable code edition and Addenda for the RVCH vent line nozzle penetration repair is the ASME Boiler and Pressure Vessel (B&PV) Code, Section XI, 2001 Edition with Addenda through 2003. PNP is currently in the fourth 10-year inservice inspection interval.

Applicable Code Requirement

The applicable code requirement for the RVCH vent line nozzle penetration repair is ASME Section XI. IWB-2500, examination category B-P, "Pressure Retaining Components," Item B15.10, is applicable to the inservice examination of the vent line nozzle to RVCH weld. IWA-3300, IWA-4220, IWB-3142.4, IWB-3420 and IWB-3613 are applicable to any flaws discovered during inservice inspection. Specifically:

1. IWA-3300(b) contains a requirement for flaw characterization.

2. IWA-4220 establishes the requirements for code usage for repair/replacements. The Construction Code applicable to this weld repair activity is ASME Section III, 1989 Edition, no Addenda. NB-4453.1 requires defects to be removed and the resulting surface be liquid penetrant or magnetic particle examined in accordance with NB-5110 and meet the acceptance criteria of NB-5350 or NB-5340.

3. IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subsequently examined in accordance with IWB-2420(b) and (c).

4. IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300.

5. IWB-3613 provides acceptance criteria for flaws in flanges and shell regions near structural discontinuities.

The original construction code for the PNP RVCH is ASME Section III, 1965 Edition, including Addenda through Winter 1965.

Impracticality of Compliance

ASME Section XI, IWA-3300(b), IWA-4220, IWB-3142.4, IWB-3420 and IWB-3613, contains requirements for flaw characterization, allowable flaw acceptance, code usage for repair/replacements, and successive examinations.

If inspection of the RVCH vent line nozzle penetration reveals flaws affecting the J-groove attachment weld, it may be impractical to totally remove the flaw prior to repair. Additionally, it would be impractical to characterize these flaws by nondestructive examination (NDE) and to perform any successive examinations of these flaws. The original vent line nozzle to RVCH weld configuration is impractical to examine ultrasonically (UT) due to the compound curvature and fillet radius. The configuration is not conducive to UT due to the configuration and dissimilar metal interface between the NiCrFe weld and the low alloy steel RVCH. Furthermore, due to limited accessibility from the RVCH outer surface and the proximity of adjacent nozzle penetrations, it is impractical to scan from this surface on the RVCH base material to detect flaws in the vicinity of the original weld. These conditions preclude ultrasonic coupling and control of the sound beam in order to perform flaw sizing with reasonable confidence in the measured flaw dimension. It is impractical, and presently, the technology does not exist to characterize flaw geometries that may exist therein. Therefore, ENO is requesting relief from ASME Section XI, IWA-3300(b), IWA-4220, IWB-3142.4, IWB-3420, and IWB-3613 pursuant to 10 CFR 50.55a(g)(5)(iii), on the basis that the code requirements are impractical.

Burden Caused By Compliance

The burden caused by complying with the Code requirement consists of creating a new technology to characterize a flaw in this location. A sub-critical embedded flaw (SCEF), between the low alloy steel RVCH and new weld can not be characterized. The technology to characterize a flaw in this location does not currently exist.

Proposed Alternative and Basis for Use

Entergy Nuclear Operations, Inc. (ENO) is requesting relief from ASME Section XI, IWA-3300(b), IWA-4220, IWB-3142.4, IWB-3420 and IWB-3613, pursuant to 10 CFR 50.55a(g)(5)(iii). These sections would require flaw characterization, repair, and successive examinations for a RVCH vent line nozzle penetration. ENO is proposing an alternative to perform a RVCH vent line nozzle penetration repair by removing a portion of the degraded Alloy 182 J-groove weld material, and potentially a portion of the original butter (depending upon excavation depth), and filling the cavity with Alloy 52/52M/152 weld metal. This would leave an embedded flaw between the low alloy steel RVCH and the new weld. The repair approach is provided in Attachment 1.

Specifically, ENO is proposing the following alternatives:

1. IWA-3300(b) contains a requirement for flaw characterization. Flaws affecting the J-groove attachment weld of the RVCH vent line nozzle penetration cannot be sized by current available nondestructive examination techniques. In lieu of this requirement, a flaw analysis was performed on the postulated remaining flaw in the butter. It is assumed that the "as-left" condition of the partial penetration weld includes degraded or cracked material throughout that portion of the original Alloy 182 butter that is not removed by excavation. The remaining flaw is termed a SCEF since the weld is excavated to a depth that reduces the size of the embedded flaw, after welding, to an acceptable size per Section XI of the ASME Code, considering fatigue growth over the life of the repair. A fracture mechanics analysis was performed to demonstrate that the postulated remaining embedded flaw after a vent line nozzle weld repair satisfies the acceptance standards of Section XI of the ASME Code, 2001 Edition with Addenda through 2003, with the alternative values described below. A summary of this analysis is provided in Attachment 2.

2. Per IWA-4220, weld repairs, if required, would be performed in accordance with ASME Section III, 1989 Edition, no Addenda. NB-4453.1 does not permit welding on surfaces, i.e., over flaws that do not meet the acceptance criteria of NB-5350. However, this practice is permitted in ASME Section XI, Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2 and 3 Austenitic Stainless Steel Piping, Section XI, Division 1," applicable to stainless steel piping weld overlays. The initial weld layer covering the flaw would be penetrant examined (PT) in accordance with NB-5110, and meet the acceptance criteria of NB-5350, to assure a sound weld overlay exists. Progressive PT examination, in accordance with NB-5245, would be performed during the balance of welding.

3. NB-4453.1 addresses defect removal and PT examinations of the repair excavation with acceptance criteria per NB-5350. In the proposed weld repair, defects would not be completely removed. Instead, the repair would be performed by partially excavating the flaw in the J-groove weld and potentially a portion of the butter (depending upon excavation depth), followed by welding over the remaining flaw. The remaining flaw is termed a SCEF since the weld is excavated to a depth that reduces the size of the embedded flaw, after welding, to an acceptable size per Section XI of the ASME Code, considering fatigue growth over the life of the repair.

4. IWB-3142.4 allows for analytical evaluation to demonstrate that a component is acceptable for continued service. It also requires that components found acceptable for continued service by analytical evaluation be subject to successive examination. Analytical evaluation of the worst-case flaw referred to above has been performed to demonstrate the acceptability of continued operation. However, because of the impracticality of performing any subsequent examination that would be able to characterize any remaining flaw, successive examination would not be performed.

5. IWB-3420 requires the characterization of flaws in accordance with the rules of IWA-3300. As previously stated, a flaw analysis was performed on the remaining flaw in the butter, which cannot be sized by current available NDE techniques.

6. IWB-3613(a), ASME Section XI, 2001 Edition with Addenda through 2003, requires the use of K_{Ia} for fracture toughness and RT_{NDT} + 60°F for the limiting temperature. The vent line analysis that was performed in accordance with ASME Section XI was based on alternate evaluation standards where K_{Ic} was used for the fracture toughness and RT_{NDT} was used for the limiting temperature. The technical justification for the use of these alternatives is described below.

Three analyses were performed to show the suitability of the repair design. Attachment 2 provides a summary of the three analyses described below.

<u>Palisades Reactor Vessel Head Vent Nozzle Stress Analysis</u>

A stress analysis was performed to verify whether the repair design meets the applicable requirements of the ASME Code, Section III, Subsection NB, 1989 Edition, no Addenda.

Stress analysis of the vent line nozzle repair led to creation of a 2-D finite element model and stress analysis of the nozzle configuration. The model was subjected to the temperature and pressure conditions of the various PNP RVCH loads. The vent line pipe was modeled to be perpendicular to the RVCH surface since it is very close to the apex. The model only includes a section of the vent line piping that is enough to account for the stress concentration at the nozzle. The analysis demonstrates that the repair design meets the stress and fatigue requirements of the ASME Code, Section III, Subsection NB, 1989 Edition, no Addenda. Based on the conservative fatigue analysis, the maximum usage factor for 27 years of operation of the repair design is 0.2079 for the nozzle, 0.1588 for the weld and 0.0497 for the RVCH, compared to the ASME allowed maximum of 1.0. Because the maximum usage factor values are well below the ASME maximum usage factor, the proposed alternative provides a reasonable assurance of structural integrity.

<u>Palisades Vent Line Nozzle J-Groove Weld SCEF Evaluation</u>

A flaw growth analysis was performed on the remaining flaw in the butter, which cannot be sized by current available nondestructive examination techniques. Therefore, it was assumed that the "as-left" condition of the partial penetration weld includes degraded or cracked material throughout that portion of the original Alloy 182 butter material that is not removed by excavation. It was postulated that a radial crack in the Alloy 182 weld metal would propagate due to PWSCC, through the weld and buttering, to the interface with the RVCH low alloy steel base material. It is fully expected that such a crack would then blunt and arrest at the butter-to-head interface. The remaining flaw is termed a SCEF since the weld is excavated to a depth that reduces the size of the embedded flaw, after welding, to an acceptable size per Section XI of the ASME Code, considering fatigue growth over the life of the repair. A fracture mechanics analysis was performed to demonstrate that the remaining embedded flaw after a vent line nozzle weld repair satisfies the acceptance standards of Section XI of the ASME Code, 2001 Edition with Addenda through 2003, with the alternative values described below.

Based on an evaluation of fatigue crack growth of the SCEF flaw in the original J-groove butter material into the low alloy steel RVCH and the new Alloy 52/152 weld filler and weld overlay, it has been demonstrated that the remaining flaw would satisfy Section XI flaw acceptance criteria for a 27-year design life with the following restrictions:

1. Plant cooldown must be terminated before the coolant temperature reaches 72 °F.

2. A design safety factor of $\sqrt{2}$ on the K_{Ic} fracture toughness must be utilized as a flaw acceptance criterion near the end of cooldown when the system pressure is less than 20 percent of the design pressure and the coolant temperature is not less than the RT_{NDT} of the RVCH (72 °F at the location of the vent nozzle).

3. An alternative evaluation standard was used in the vent line analysis. This allows for the use of the K_{Ic} fracture toughness, which is higher than the K_{Ia} fracture toughness specified in ASME Code Section XI, 2001 Edition with Addenda through 2003. This also allows for the use of RT_{NDT} as the limiting temperature, instead of RT_{NDT} + 60 °F, which is specified in ASME Code Section XI, 2001 Edition with Addenda through 2003. The justification for the use of this alternative evaluation standard is described below.

   ASME Section XI, IWB-3613(a), provides acceptance criteria for shell regions near structural discontinuities, which include the intersections of nozzles and pressure vessel shells per Code Interpretation, XI-1-04-03, File #IN 03-013, (applicable to the 1989 Code Edition through the 2001 Edition with Addenda through 2003). Per IWB-3613(a), at pressures below 20% of the design pressure and temperatures not less than RT_{NDT} + 60 °F, K_I is limited to $K_{Ia}/\sqrt{2}$. At low pressure and temperature conditions near the end of cooldown, the present flaw evaluations for the PNP vent line nozzle were based on alternate evaluation standards. The following alternate criteria were used:

   1. The fracture toughness requirement was changed from $K_{Ia}/\sqrt{2}$ to $K_{Ic}/\sqrt{2}$.

      The crack arrest toughness, K_{Ia} (or K_{IR}), was originally used in the 1974 Code edition to provide additional margin thought to be necessary to cover uncertainties, as well as a number of postulated (but un-quantified) effects. The use of the crack arrest toughness for determining the condition for fracture initiation was a conservative assumption to address the possibility of local areas of low fracture toughness in weldments. The philosophy of using K_{Ia} conservatively assumes that the fracture event is one of arresting a dynamic running crack from an area of local embrittlement. Significantly more information is now known about these uncertainties and effects such that the fracture toughness requirements can be changed.

For nuclear plants, transient conditions are generally slow, so that stress conditions are quasi-static for a stationary flaw. For these transient conditions, the rate of change of pressure and temperature are several orders of magnitude lower than those associated with dynamic conditions associated with crack arrest testing. The only time when dynamic loading can occur and where the dynamic/arrest fracture toughness, K_{Ia}, should be used is when a crack is propagating. Whereas this situation may be postulated during accident conditions for assessing the potential for crack arrest, it is not a credible scenario for crack initiation. Therefore, use of the static lower bound fracture toughness, K_{Ic}, is more technically correct for evaluating the potential for crack initiation.

Since the original formulation of the K_{Ia} and K_{Ic} fracture toughness curves in 1972, the fracture toughness database has increased by more than an order of magnitude, and both K_{Ia} and K_{Ic} remain lower bound curves. In addition, the temperature range over which the data have been obtained has been extended to include both higher and lower temperatures than the original database. Only a few data points fall below the K_{Ic} curve, and just barely, providing a high degree of confidence for using K_{Ic} to predict crack initiation.

The concern that there could be a small, local zone in a weld or heat-affected zone of the base material that could pop-in and produce a dynamically moving cleavage crack is not warranted based on test data. After over 30 years of research on reactor pressure vessel steels fabricated under tight controls, micro-cleavage pop-in has not been found to be significant. Researchers have not been able to produce a catastrophic failure of a vessel, component, or even a fracture toughness test specimen in the transition temperature region. Thus it is overly conservative to use the lower bound K_{Ia} curve to address the effect of this postulated condition on crack initiation.

The change from K_{Ia} to K_{Ic} has already been implemented in the 2001 Edition of Section XI, Appendix G for determining pressure-temperature limits. The use of K_{Ic} in the flaw acceptance criteria of IWB-3613(a) is therefore consistent with the latest fracture toughness requirement in Appendix G.

Therefore, applied stress intensity factors were limited to $K_{Ic}/\sqrt{2}$ for low temperature conditions when pressure is less than 500 pounds per square inch atmospheric (psia) and the temperature is at least 72 °F (which is the RT_{NDT} of the RVCH base metal).

2. The temperature requirement was changed from RT_{NDT} + 60 °F to RT_{NDT}.

   This is consistent with current pressure-temperature limit criteria in the 2001 Edition with Addenda through 2003 of Section XI, Appendix G, Article G-2222(c) for shell regions near geometric discontinuities, and in 10 CFR 50, Appendix G, Table 1, Item 2.a for the closure flange region prior to core criticality.

The fracture mechanics analysis demonstrates that the remaining embedded flaw after a vent line nozzle weld repair would satisfy the acceptance standards of the applicable ASME code. Therefore, the proposed alternative provides a reasonable assurance of structural integrity.

Palisades Vent Nozzle Axial Flaw Evaluation

A flaw growth analysis was performed considering a leak path that existed between the outside diameter (OD) of the nozzle and the original J-groove weld. After the weld repair, an axial flaw that could follow this leak path was postulated to be present on the OD surface of the modified vent nozzle. It was postulated that a radial crack in the Alloy 182 weld metal would propagate due to PWSCC, through the weld and butter, to the interface with the RVCH low alloy steel base material. It is fully expected that such a crack would then blunt and arrest at the butter-to-head interface. The length of the axial flaw corresponds to the height of the weld remnant. The analysis was performed using the guidance provided in the letter from R. Barrett (NRC) to A. Marion (Nuclear Energy Institute), "Flaw Evaluation Guidelines," dated April 11, 2003 (ADAMS Accession # ML030980322), and Attachment 2, "Appendix A: Evaluation of Flaws in [Pressurized Water Reactors] PWR Reactor Vessel upper head Penetration Nozzles," of that letter (ADAMS Accession # ML030980333).

Based on the results of the OD axial flaw evaluation, it is concluded that a maximum allowable initial axial flaw size that is 50% of the nozzle wall thickness is acceptable for a 27-year design life with the repaired PNP vent line nozzle configuration.

ENO is proposing an alternative to perform a RVCH vent line nozzle penetration repair by removing a portion of the degraded Alloy 182 J-groove weld material, and potentially a portion of the original butter (depending upon excavation depth), and filling the cavity with Alloy 52/52M/152 weld metal. This would leave an embedded flaw between the low alloy steel RVCH and the new weld. The alternative repair method discussed above provides an acceptable level of quality and safety without performing flaw characterization, repair, and successive examinations as required in ASME Section XI 2001 Edition with Addenda through 2003, IWA-3300, IWA-4220, IWB-3142.4, IWB-3420 and IWB-3613.

Based on the information presented, and pursuant to 10 CFR 50.55a(g)(5)(iii), ENO requests approval for the proposed alternative on the basis that the code requirements are impractical and the proposed alternative provides reasonable assurance of structural integrity.

Duration of Proposed Alternative

ENO requests approval of the proposed alternative for the remainder of the fourth ten-year interval of the Inservice Inspection Program for PNP, which will conclude on or before December 13, 2015.

Precedent

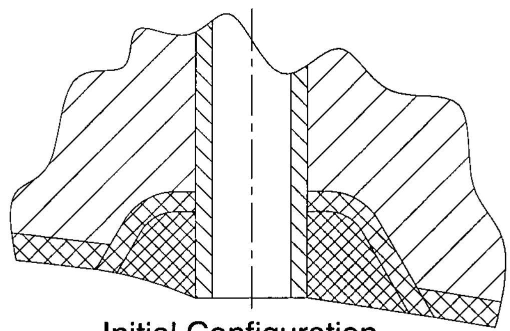
By letter dated October 11, 2005 (ADAMS Accession # ML052870321), Nuclear Management Company, LLC (NMC), the former licensee for PNP, submitted a similar relief request. NMC requested relief from certain sections of the ASME B&PV Code, Section XI, 1989 Edition. The request proposed relief from characterizing flaws through NDE that remain in the control rod drive (CRD) and incore instrumentation (ICI) nozzle J-groove weld after repair due to impracticality. Additionally, the request proposed relief from the successive inspection requirements of these flaws because of impracticality to characterize the flaws through NDE. By letter dated April 3, 2006 (ADAMS Accession # ML060790061), the NRC approved the relief request for PNP. Similar to this submittal, ENO is requesting relief from certain sections of the ASME B&PV Code, Section XI, 2001 Edition with Addenda through 2003. ENO is requesting relief from characterizing flaws through NDE that remain in the RVCH vent line nozzle penetration after repair due to impracticality. Additionally, ENO is requesting relief from the successive inspection requirements of these potential flaws because of impracticality to characterize the flaws through NDE. NMC's request was for flaws in the CRD and ICI nozzle J-groove. ENO's request is for flaws in the vent line.

ATTACHMENT 1
WELD REPAIR PROCEDURE FOR REACTOR VESSEL CLOSURE HEAD VENT LINE NOZZLE PENETRATION

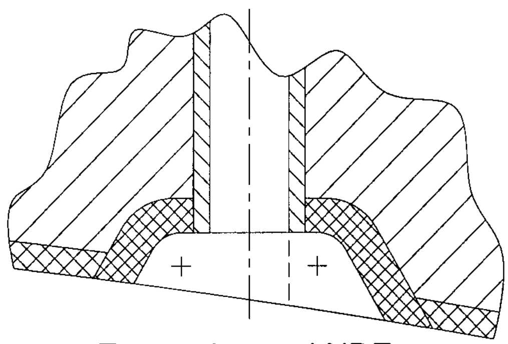
ENO is proposing an alternative to perform a reactor vessel closure head (RVCH), vent line nozzle penetration repair by partially removing the degraded Alloy 182 J-groove weld material and filling the resulting cavity with Alloy 52/52M/152 weld metal. Figure 1 shows the general nozzle configurations during the process. A general process outline is shown below. This outline assumes that a minimum of 3/16 inch of NiCrFe alloy material thickness remains over the reactor vessel head ferritic steel base material.

a. Ultrasonic examine (UT) the weld repair area. Locate and size the detected indications
b. Perform liquid penetrant surface examination of the weld repair area. Chart detected indications.
c. Machine cavity to specified depth.
d. Perform liquid penetrant examination of cavity.
e. Lay out the region for the weld overlay of the original structural weld.
f. Clean repair area suitable for welding.
g. Fit and tack weld dam to the reactor vessel head.
h. Deposit first weld layer.
i. Perform liquid penetrant examination of first layer.
j. Weld one half thickness maximum or one half cavity depth, whichever is less.
k. Prepare weld for liquid penetrant examination.
l. Perform liquid penetrant examination of weld.
m. Weld cavity complete, including overlay of original structural weld.
n. Remove weld dam by machining.
o. Prepare weld for liquid penetrant examination.
p. Perform liquid penetrant examination of weld area.
q. Perform final cleaning in accordance with site requirements.

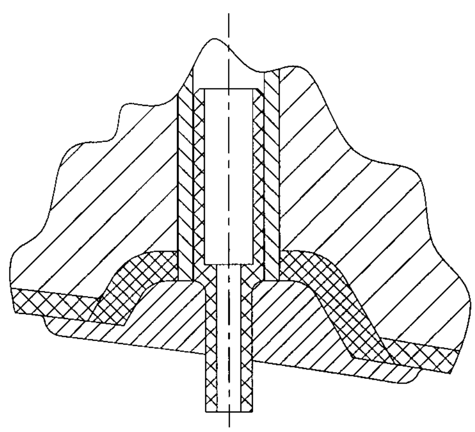
FIGURE 1



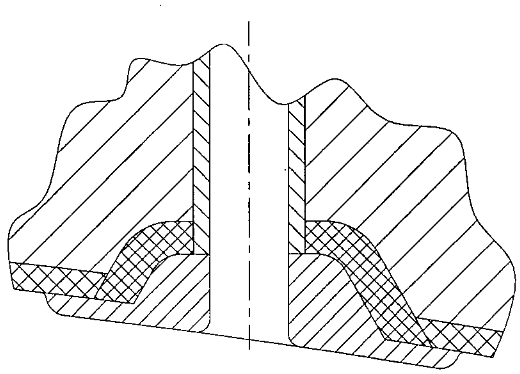
Initial Configuration



Excavation and NDE



Welding



Final Machining