NMC
Committed to Nuclear Excellence

Palisades Nuclear Plant
Operated by Nuclear Management Company, LLC

December 12, 2001

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

DOCKET 50-255 - LICENSE DPR-20 - PALISADES NUCLEAR PLANT
WITHDRAWAL OF RELIEF REQUEST TO PERFORM WELD OVERLAY REPAIRS ON CONTROL ROD DRIVE MECHANISM (CRDM) UPPER HOUSINGS; AND RESTATEMENT OF RESPONSES CONCERNING WELD NO. 1 (TAC NO. MB3001)

By letter dated September 17, 2001, Nuclear Management Company, LLC (NMC) submitted the subject relief request specifically pertaining to the use of Code Case N-504-1 to perform weld overlay repairs on Weld No. 3 of the CRDM upper housings at Palisades. By letter dated October 16, 2001, the NRC Staff issued a request for additional information (RAI) pertaining to this submittal. The NRC also requested information concerning Weld No. 1 (reactor vessel head nozzle pipe to flange weld below the upper housings) in this RAI. NMC letter dated November 6, 2001, provided the responses to the RAI. Subsequently, NMC provided further clarifying information concerning Weld No. 1 to the NRC Staff on November 17, 2001.

NMC and the asset owner, Consumers Energy Company, decided to replace all 45 CRDM upper housings, on August 29, 2001. The subject relief request was still considered necessary in the event that problems with the production and installation of the new upper housings required the repair and reuse of some of the existing upper housings. On November 16, 2001, NMC decided to withdraw the subject relief request, based on satisfactory production and installation performance of the new upper housings. NMC notified the Palisades NRC Project Manager of the decision at that time.

The purpose of this letter is to address two issues. The first issue is to document the withdrawal of the subject relief request and the commitment associated with this request. The second issue is to restate, and make complete, all responses associated with Weld No. 1.

The attachments to this letter contain the responses associated with Weld No. 1, as provided on November 6 and November 17, 2001.

A001

Rec'd 01/18/02

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SUMMARY OF COMMITMENTS

This letter contains no new commitments and the withdrawal of one previous commitment.

The commitment to be withdrawn, as stated in NMC letter dated November 6, 2001, is as follows:

> All of the repaired CRDM housings not replaced after one operating cycle will be inspected during the first refueling outage that follows repair. The inspection shall consist of radiographic and ultrasonic testing, as a minimum, to ensure the integrity of the overlay and detect any unexpected crack propagation. A report describing the inspection results and providing an engineering evaluation of those results shall be submitted to the NRC Staff within 60 days after the inspections have been performed. At least 6 months before the start of the next scheduled refueling outage, NMC shall submit, for the NRC's review and approval, a performance-based inspection plan for repaired CRDM housings not replaced.

Laurie Lahti

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Attachments

ATTACHMENT 1

NUCLEAR MANAGEMENT COMPANY
PALISADES NUCLEAR PLANT
DOCKET 50-255

December 12, 2001

Response to Request for Additional Information Regarding Weld No. 1 (Reactor Vessel Head Nozzle Pipe to Flange Weld) as provided November 6, 2001

6 Pages

<u>REQUEST FOR ADDITIONAL INFORMATION</u>

<u>BY THE OFFICE OF NUCLEAR REACTOR REGULATION REGARDING</u>

<u>WELD OVERLAY REPAIR OF CONTROL ROD DRIVE MECHANISM UPPER HOUSINGS FOR THE PALISADES PLANT</u>

<u>Requested Item 1.</u>

The NRC staff is concerned for the quality and scope of non-destructive examinations (NDE) completed to date on CRDM housing Weld No. 1 (the first weld above the reactor head). Specifically, the NRC staff is concerned that the ultrasonic testing (UT) examinations completed to date do not provide reasonable assurance that significant cracks, if they exist in this weld, would have been detected. For Weld No. 1 (flange to pipe dissimilar metal weld – 316 stainless steel flange and Inconel pipe), you have conducted UT inspections of [24] accessible housings near the periphery of the vessel head. Because of the curved surface on the flange side of the weld, you were only able to scan from the pipe side during UT examinations. The NRC staff concluded, in Inspection Report 50-255/01-11, that this examination would not likely detect circumferentially oriented cracks in the weld material or flange side base material. This inspection report also documented that UT examinations of Weld No. 3 were not successful in identifying axial or circumferential indications that did not have substantial through-wall extent. Finally, you have not produced a technical basis to exclude Weld No. 1 from being susceptible to the cracking seen at Weld No. 3. Therefore, an adequate basis for the quality and scope of NDE examinations for Weld No. 1 has not been established.

In view of the above NRC staff concern, please indicate and justify your position regarding the quality and scope of NDE completed on Weld No. 1 to date. This discussion should include your basis for not performing an internal visual examination on a sample of CRDM housings at the Weld No. 1 location prior to restart of the plant. Also, provide your basis for the conclusion that you have satisfied the additional examination requirements of ASME Code, Section XI, paragraph IWB-2430(b).

<u>Response</u>

The quality and scope of non-destructive examinations, to ensure a thorough extent of condition is determined and adequate corrective actions are taken, are assured through our corrective action program in accordance with 10CFR50 Appendix B. Although the examinations of Weld No. 1 have no direct relevance to our relief request to use code case N-504-1 to perform a weld overlay repair process for flaw indications on Weld No. 3, we understand the concern expressed by the NRC Staff regarding Weld No. 1 and have provided the additional information below.

QUALITY AND SCOPE OF NDE COMPLETED ON WELD NO. 1 TO DATE

In total, 5 of the Weld No. 1 locations were examined by dye penetrant from the OD surface and 24 were examined by manual UT from the OD, resulting in no flaw indications.

The welds were examined with both surface and volumetric examination techniques. The volumetric exam was a manual ultrasonic (UT) examination-using IGSCC qualified personnel. It was recognized that the UT exams would be limited and that not all of the Code required volume could be obtained due to the geometries involved with each weld. To supplement this examination a surface examination (dye penetrant) of five of the welds was also performed. The surface examination served two purposes, it allowed all of the required weld volume to be examined to satisfy the examination volume requirement and it provided a means to detect any flaws that might be generated from the outside diameter surface.

BASIS FOR NOT PERFORMING AN INTERNAL VISUAL EXAMINATION ON A SAMPLE OF CRDM HOUSINGS AT THE WELD NO. 1 LOCATION PRIOR TO RESTART OF THE PLANT

The basis for not performing an internal visual exam at the Weld No. 1 location prior to startup is based on its low susceptibility to Transgranular Stress Corrosion Cracking – the mechanism determined to be present in the Weld No. 3 cracks. Considering this low susceptibility, the additional radiation exposure and costs that would be incurred are not justified at this time. The low susceptibility is based on the following:

<u>Requirements for Transgranular Stress Corrosion Cracking (TGSCC)</u>

Stress corrosion cracking is a phenomenon that occurs when three concurrent requirements are met: there is a susceptible material such as austenitic stainless steels, there is sufficient tensile stress, and they exist in a suitable environment. There are two typical modes of SCC, transgranular and intergranular. As the names suggest, TGSCC is a cracking mode that goes across the grain, and IGSCC is a cracking mode that tends to favor progression via the grain boundaries. It is important to note that the two modes are not mutually exclusive within a specific failure. TGSCC tends to be caused by impurities such as chlorides in the presence of oxygenated water. As discussed below, the requirements for TGSCC that concurrently existed at Weld No. 3, are not present to nearly the same extent in the Weld No. 1 locations, and therefore, provide the requested basis for not performing additional examinations on CRDM nozzle Weld No. 1 prior to restart of the plant.

Determination of Individual Weld Susceptibility

Material Susceptibility

The CRDM Upper Housing Assemblies are constructed of type 347 stainless steel, and the Weld No. 1 is a bi-metallic weld consisting of the nozzle (alloy 600) welded to a stainless steel (type 316) flange. The weld material is I-82 and I-182. Stainless steel type 316 is slightly more resistant to TGSCC than 347 SS. However, 316 SS is more susceptible to IGSCC than 347 SS. Alloy 600 is more resistant to both TGSCC and IGSCC than either of the stainless steels. With these concessions, 316 SS is considered to be neither better nor worse than 347 SS with respect to susceptibility to SCC.

Tensile Stresses

The stresses in the stainless steel side of Weld No. 1 at the inner surface are, at worst, only slightly tensile, whereas, the other weld stresses are significantly more tensile. There are two major reasons for the substantially lower stresses at Weld No. 1. First the residual stresses are much lower due to the original fabrication process, and second, differential thermal expansion between the stainless steel and Alloy 600 causes compressive forces on the stainless steel. Both axial and hoop stresses were calculated for all of the welds. The determination of operating stresses was a definite calculation, whereas the determination of residual stresses was based on industry data for butt welds, adjusted for the specific manufacturing process used. The inside and outside portions of the CRD nozzle/flange assembly were machined to remove about 50% (~18% of material removed from the ID) of the walls after welding which removed much of the residual tensile stress from the welding process that reside near the surfaces. The residual stresses in both the axial and hoop orientations were both determined to be on the order of 6 ksi tensile. The operating stresses for the axial and hoop orientations were calculated to be approximately 4 ksi compressive and 7 ksi compressive, respectively. The sum of the operating and the residual stresses in the vicinity of Weld No. 1 were 2 ksi tensile for the axial stress and 1 ksi compressive for the hoop stress. The resultant stresses at Weld No. 1 are more than 30 ksi lower than those calculated for Weld No. 3.

Surface condition from the manufacturing process also plays an important role. Although the specified surface finish for all machined surfaces within the upper housing was 125 RMS, this surface finish requirement was specifically waived for locally ground/blended weld areas (such as Welds No. 3). Since Weld No. 3 is located between an eccentric reducer and a long pipe section, this weld would have been the most difficult to post-weld blend due to the design geometry. Visual examinations found the ID of Weld No. 3 heavily ground in a non-uniform manner. This grinding was most likely conducted from the narrow opening of the eccentric reducer (~4 inch diameter), which is about six linear inches from the grinding location. This would have resulted in significantly limited access and visibility for grinding. In contrast, Weld No. 1 was simply machined on both the ID and the OD, with no waiver to allow grinding as was done on Weld No. 3. The final machining on the ID surface would result in only a thin cold worked layer in the material at Weld No. 1. This contrasts with the abusive grinding process used at Weld No. 3, which resulted in considerably higher surface stresses from the cold work, which extend to a greater depth in the material. The smoother surface finish at Weld No. 1 also indicates an absence of the local stress risers and surface crevices that served as crack initiation sites at Weld No. 3.

Enabling Environment

The most significant variables for an enabling environment for TGSCC are the oxygen and chloride concentrations, with higher levels resulting in greater likelihood of TGSCC occurrence. The environmental conditions are assumed to be similar with respect to O_2 and Cl^- concentrations for all welds with the exception of Weld No. 1. The environmental conditions at Weld No. 1 are expected to be more representative of PCS bulk water chemistry than the other welds in the CRD upper housings.

Although one might consider the annulus between the thermal sleeve and the CRD nozzle to be a geometric crevice, conditions exist which should reduce the amount of residual dissolved oxygen that might be present. With the presence of sufficient flow, geometrical crevices are effectively precluded from becoming galvanic crevices and therefore do not exacerbate the SCC process.

Three ¼ inch diameter flow holes exist within each CRDM nozzle tube assembly. They are located about 13 inches from the inside of the reactor head. Due to the presence of the upper guide structure between the fuel and the nozzle tube ends, a portion of the reactor coolant flow proceeds upward into the nozzle tube assemblies and out of the three ¼ inch diameter flow holes. In addition to this, a temperature gradient exists between the inside of the thick vessel head and Weld No. 1. This temperature gradient should promote some convective flow within the annulus surrounding the thermal sleeve as would occur in any environment where a temperature gradient exists.

Although the flow between the two scenarios is limited, it is reasonable to conclude that fluid exchange occurs at some rate within the annulus, causing residual oxygen (from vessel fill) to be lessened within the annulus. This conclusion is supported by the occurrence of Primary Water Stress Corrosion Cracking (PWSCC) observed in other pressurized water reactors in this same general area ("J" weld area) as discussed in Generic Letter 97-01. This operating experience supports the notion that the environment in this area may be devoid of oxygen content because PWSCC occurs in oxygen-depleted environments.

The reason for considering the environment at Weld No. 1 different than the environments at the other welds is because there is no viable mechanism to exchange the water contained within the upper housing with PCS bulk water. The above mechanism facilitates some flushing of the annulus with water that has the chemistry characteristics of the bulk PCS water.

Weld No. 1 is considered the least susceptible weld because:

- The combined stresses are at worst, only slightly tensile due to the fact that the higher residual stress material near the surface was removed after welding as part of the manufacturing process and due to the different thermal expansion properties between the stainless and the Inconel.
- The material surface is smooth and was exposed to much less cold work since the part was machined.
- The environment is not as stagnate as the other weld locations, and there exists a mechanism to dilute the oxygen concentration.

BASIS FOR THE CONCLUSION THAT THE ADDITIONAL EXAMINATION REQUIREMENTS OF ASME CODE, SECTION XI, PARAGRAPH IWB-2430(b) HAVE BEEN SATISFIED.

Subparagraph IWB-2430(b) reads, "If the additional examinations required by (a) above reveal indications exceeding the acceptance standards of Table IWB-3410-1, the examination shall be further extended to include additional examinations at this outage. The additional examinations shall include all the welds, areas, or parts of similar design, size, and function."

Based on this requirement, it was determined that the scope of the additional examinations would be limited to Weld No. 3. This is because failures have been limited to Weld No. 3, with its specific vulnerabilities as described previously, and Weld No. 1 is not of a similar design and size, and contains different stress profiles.

ATTACHMENT 2

NUCLEAR MANAGEMENT COMPANY
PALISADES NUCLEAR PLANT
DOCKET 50-255

December 12, 2001

Follow-up Questions Regarding Weld No. 1 (Reactor Vessel Head Nozzle Pipe to Flange Weld) as provided November 17, 2001

6 Pages

Follow-up Questions on CRDM Housing RAI Responses

Regarding Q1, when in the fabrication process is Weld No. 1 made? Specifically, was Weld No. 1 stress relieved along with the reactor vessel head?

Weld No. 1 was made before the CRD nozzles were installed on the reactor vessel head. Weld No.1 was not heat treated along with the vessel head. There were no stress relief activities performed after the nozzles were welded in place.

Regarding the holes in the thermal sleeve, provide a sketch showing their location relative to Weld No. 1. It is not apparent why there would be flow in the thermal sleeve annulus in the vicinity of Weld No. 1.

The attached sketch shows the location of flow holes. The subject flow holes are not in the thermal sleeves themselves. The three ¼ inch diameter flow holes exist within each CRDM nozzle tube assembly. They are located about 13 inches from the inside of the reactor head. Due to the presence of the upper guide structure between the fuel and the nozzle tube ends, a portion of the reactor coolant flow proceeds upward into the nozzle tube assemblies and out of the three ¼ inch diameter flow holes. In addition to this, a temperature gradient exists between the inside of the thick vessel head and Weld No. 1. This temperature gradient will promote some convective flow within the annulus surrounding the thermal sleeve as would occur in any environment where a temperature gradient exists.

Although the flow between the two scenarios is limited, fluid exchange will occur at some rate within the annulus, causing residual oxygen (from vessel fill) to be lessened within the annulus.

Regarding the discussion of the stresses, the staff needs a more detailed breakout of the stresses, how the residual stresses were calculated, and about the types of loads, load combinations, and how they were combined, and how the analysis was performed (methodology) to determine stresses.

More detailed breakout of the stresses at Weld No. 1:

Hoop Stresses in ksi

	Primary	Thermal gradient	Bi-metallic	Total operating	Residual
TP316	8.2	-1.0	-14.0	-6.8	6
Inconel	8.2	-1.0	14.0	21.2	-6

Longitudinal Stresses in ksi

	Primary	Thermal gradient	Bi-metallic	Total operating	Residual
TP316	1.9	-1.0	-5.0	-4.1	6
Inconel	1.9	-1.0	-5.0	4.1	6

How the residual stresses at Weld No. 1 were calculated:

The residual stresses were assessed based on the linear thru wall residual stress profile described in NRC NUREG 1061, Vol.1, titled Investigation and Evaluation of SCC in Piping For BWR Plants. Stress relieving effects due to machining of the weldment was analyzed based on a linearly unloading model. That is, the redistribution of residual forces and moments are also linear.

The machining induced surface residual stresses were considered. They are not combined with the welding stresses because of their superficial nature. The machining induced residual stresses are highly concentrated on the surface, therefore, have insignificant contribution to the crack growth. This contrasts significantly to the surface condition of Weld No.3, which sustained significant abusive grinding. The abusive grinding not only produces high tensile stresses, but it also produces "grinding grooves, overlaps and crevices which constitute significant local stress riser regions where cracks can start when microstructural and environmental factors are met for stress corrosion cracking" (as stated in ERPI Report NP-944, Studies on AISI Type 304 Stainless Steel Weldments for Use in BWR Applications).

About the types of loads, load combinations, and how they were combined:

The loadings considered include pressure and thermal resulting from both steady state and transient conditions. Flange preload was also included in the stress analysis as a part of primary load.

How the analysis was performed (methodology) to determine stresses:

The design stresses were analyzed in the ASME Analytical Report for the reactor vessel (CENC-1116). The methodology used was the interaction analysis. A new analysis using finite element method was performed based on operating pressure and temperature. The finite element analysis results correlate well with those from the interaction analysis.

Regarding the effectiveness of the UT for weld number 1:

Provide a cross-section of the weld showing the volume that was inspected using qualified procedures and personnel. Show the volume that was inspected using a best effort UT procedure and personnel:

See the attached sketch.

Discuss the types of flaws used in the demonstrations (axial, circumferential, near-side, far-side, etc).

There was no demonstration block used for the Ultrasonic examinations. The ASME Section XI examination category is B-O. This category does not require a performance demonstration in accordance with ASME Section XI, Appendix VIII.

For the best effort UT, describe the flaw depth on the ID that can be detected using a transducer on the OD.

Based on the alternative calibration block, a notch of 0.1" deep located at 1.0 inch thickness was used for the calibration prior to examination.

Discuss how the flaw depth was determined.

It has been demonstrated that depth sizing of circumferential flaws requires access to both sides of a flaw. For weld number 1 access to both sides of the weld for axial scanning was not possible.

Depth sizing of an axial flaw cannot be accomplished. This has been proven through the Performance Demonstration Initiative through the EPRI NDE Center relating to ASME Appendix VIII demonstrations.

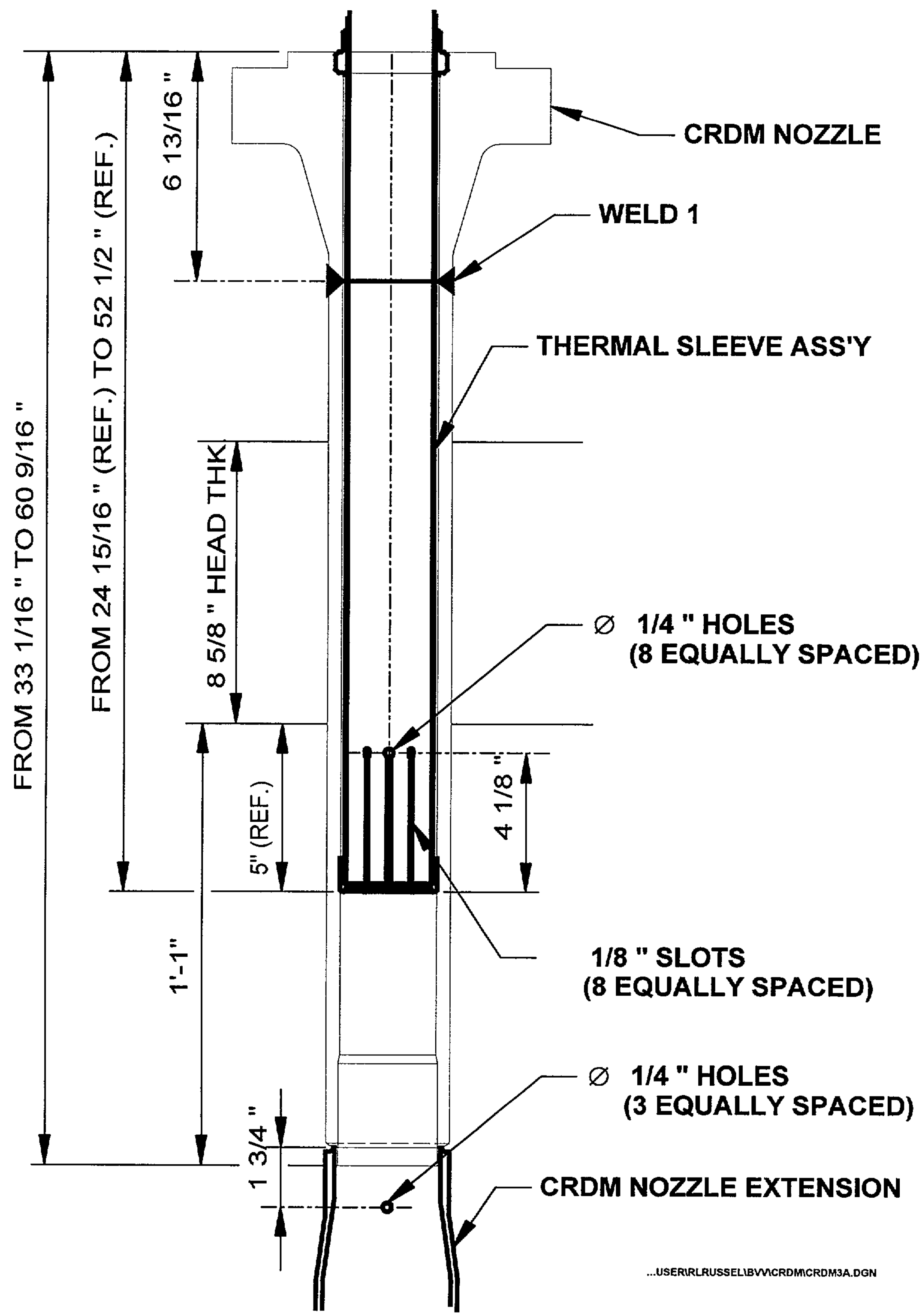
It should be noted that no UT reflectors were observed during the examination of any weld number 1 and the only reflectors identified during the UT examinations were at weld number 3.

Identify the Transducers used for the examination.

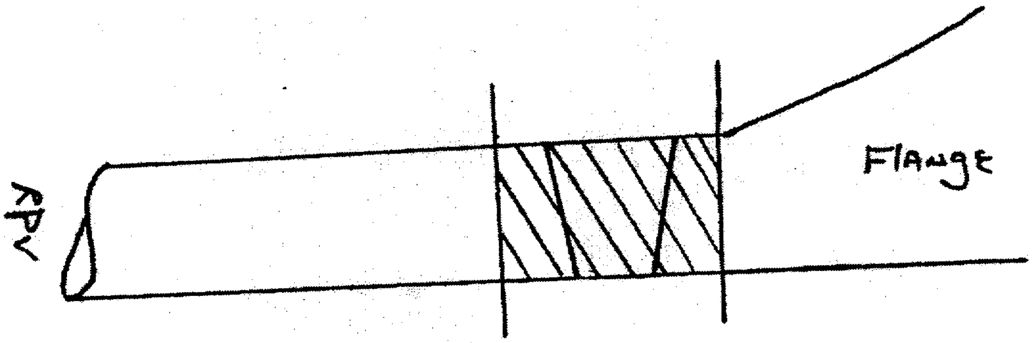
Primary transducer: 0.25" diameter, 2.25MHz, 45deg. Shear-wave with a flat wedge.

Secondary transducer: 0.375" diameter, 1.5 MHz, 60deg. Shear-wave with a flat wedge.

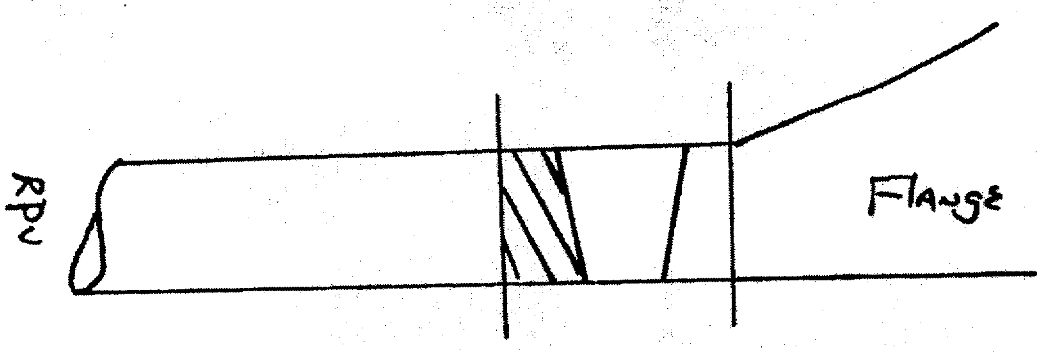
WELD 1/THERMAL SLEEVE:



WELD NUMBER 1



REQUIRED EXAM VOLUME



AREA EXAMINED

\ = AXIAL
— = CIRCUMFERENTIAL