Public Service
Electric and Gas
Company

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Vice President and Chief Nuclear Officer

October 13, 1988
NLR-N88172

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

Gentlemen:

REQUEST FOR RELIEF 10 CFR 50.55a
SALEM GENERATING STATION UNIT NO. 2
FACILITY LICENSE NO. DPR-75
DOCKET NO. 50-311

On October 5, 1988, Public Service Electric and Gas Company (PSE&G) met with the NRC staff in Rockville, MD to discuss the details of the Mechanical Seal Clamp Assembly (MSCA) which is designed to replace the canopy seal weld which provides a leakage barrier on the spare head adapter caps. At this meeting, PSE&G was informed that the NRC disagreed with PSE&G's determination that the application of the MSCA is not a code repair. Therefore, in accordance with the requirements of 10 CFR 50.55a (g)(5)(iii), PSE&G hereby requests relief from ASME Section III Code requirements for the Mechanical Seal Clamp Assembly modification. The MSCA is designed in accordance with NB-3671.7 requirements except for the material selection which was purchased to ASTM requirements. The justification for relief is provided in the enclosed report. The MSCA modification is considered temporary and is not intended to be used in excess of three cycles. Appropriate verification of proper pre-load during refueling outages, and visual verification of zero leakage during the shutdown and outage Reactor Head area inspections will be performed to verify MSCA integrity.

PSE&G requests a prompt review of this relief request as the Unit is scheduled to enter Mode 4 on October 22, 1988.

A001 1/1 w/check $150 #2407

A check for $150.00 is enclosed for the application fee as required by 10 CFR 170.21. If you have any questions on this matter please do not hesitate to call.

Sincerely,

Enclosure

C Mr. J. C. Stone
Licensing Project Manager

Mr. R. W. Borchardt
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1.0 COMPONENT

Seal Weld Canopy for Reactor Vessel Spare Head Adapter Caps (Figures 1a and b) and its Mechanical Seal Clamp Assembly (Figure 2).

2.0 DESCRIPTION

2.1 Component Description and Operating History

Every penetration attached to the reactor vessel closure head consists of two (2) piece construction, an Inconel tube section welded to a stainless steel flange. The Inconel tube section is inserted in the opening in the reactor vessel closure head and held in place by a partial penetration weld. The reactor vessel closure head is fabricated from carbon steel material therefore, for thermal expansion reasons, the tube is fabricated from inconel. The stainless steel flange has male ACME threads and is fabricated with a canopy lip. Every flange on a particular plant is designed the same. Therefore, there is no distinction during vessel fabrication to determine what the attachment is. Each attachment is threaded on to the flange and seal welded to the flange. ASME Section III Code requirements state that threaded joints in which threads provide the only seal shall not be used. Therefore, a seal weld between the flange and attachment is utilized. The types and number of attachments mated to the Salem Unit 2 reactor vessel closure head penetrations are: 53 full length Control Rod Drive Mechanisms (CRDMs), 8 part length CRDMs, 8 inactive latch housings (the same component used for the pressure boundary portion of the full length CRDM), 5 female flanges (utilized at core exit thermocouple locations for the penetration of the thermocouple columns through the pressure boundary), and 4 head adapter caps (utilized at spare locations). Figure 1a and b depict a head adapter plug attached to a reactor vessel closure head penetration and also show the location of the seal weld.

In the past two years canopy seal leakage has been reported at several plants. The amount of leakage past the threads and out through the canopy seal has been determined by Westinghouse not to be a safety issue. The concern is with regard to the corrosion of carbon steel (reactor vessel closure head and reactor vessel studs) in a boric acid environment. Laboratory tests have indicated that corrosion rates as high as 0.400 in. per month can be expected.

Salem Unit 2 experienced its first canopy seal weld leak, on a T/C column, in August, 1987. This event was reported to the NRC and was subsequently included in IN 86-108, Supplement 2, Degradation of Reactor Coolant Pressure Boundary (RCPB) Resulting from Boric Acid Corrosion. Minor damage was experienced on the RV head. During startup in January 1988 from a refueling outage, Salem Unit 1 experienced leaks on 3 of its 13 spare head adapter cap locations. On closer inspection another 3 spare head adapter cap locations were found to have locations on the canopy seal weld where failures had just occurred but boric acid had not progressed below the seal weld area. No damage resulted to the Unit 1 Reactor Vessel (RV)head. This event was discussed with the NRC on 2/4/88. A follow up special report was sent 10/4/88, NLR-N88156.

Most recently September 14, 1988, during Unit 2's shutdown for its Fourth Refueling Outage, the CRDM cooling shroud and head insulation were totally removed at the start of the outage and the head penetrations were inspected for leakage. One spare head adapter cap location was found to have leakage from two locations on the seal weld area. The leakage extended down the column but not onto the head. Also a thermocouple column was found to have experienced seal weld failure, but the boric acid leakage was extremely small.

2.2 Corrective Actions Salem Unit 2

As a result of the earlier failure in Unit 2 and the failures in Unit 1, PSE&G prepared an action plan to address canopy seal weld reliability during the Unit 2 Fourth Refueling Outage. The action plan involved four design changes, which are described below, to significantly reduce the probability of canopy seal leakage and to enhance leakage detection in case leakage occurred.

2.2.1 Thermocouple (T/C) Column

As a result of an earlier decision to go to all bottom mounted instrumentation, the core exit T/C's were changed from top entry to bottom entry. PSE&G cut the 5 peripheral T/C columns (Figures 3 and 4), below the flanged area and welded on full penetration butt welded caps. The new, 5/8" thick weld provides both the structural strength and the leakage barrier. All analyses, materials, welding, and NDE fully complied with the applicable ASME Sections III and XI requirements. As an added precaution the root weld was also RT'd. The resulting configuration is shown on Figure 5.

2.2.2 Spare Head Adapter Cap

Early in 1988 PSE&G evaluated the options available for Salem Unit 2 to address the industry concern on the poor reliability of the canopy seal welds on the spare head adapter caps even though failures had not yet occurred on a Unit 2 spare head adapter. Among the criteria used to evaluate the options were remote installation and high reliability. PSE&G selected the Mechanical Seal Clamp Assembly (MSCA) proposed by Combustion Engineering (CE). The MSCA is shown in Figure 2. Key in the decision to use them was the fact that they could be installed as a precautionary measure over the existing canopy without any adverse effect on the canopy. Should a leak develop in the canopy area, PSE&G considered the Grafoil to be an excellent leakage barrier based on CE experience with Grafoil seals and PSE&G's experience with Grafoil packing. After finding the leak on one of the four spare head adapters caps, PSE&G reevaluated its original decision and again concluded that the MSCA was the best available fix at the time for the central spare head adapter caps. PSE&G performed a remote cleaning of the canopy area on the spare head adapter caps and installed the MSCA's. The installation by the vendor was monitored by

PSE&G. No difficulties or deviations were noted from the original mock-up training.

As part of the design of the MSCA, CE evaluated any interaction between the MSCA and the existing joint, both threads and canopy, and the RV head due to the added weight. In addition, CE performed a full qualification program including prototypical testing, qualification testing, and mock-up installation training to ensure proper installation and performance of the MSCA. Material selection was performed to ensure the MSCA, both the metallic portions and the Grafoil, would be resistant to boric acid and would not adversely affect the spare head adapter caps. The Grafoil material was specified with the lowest available leachable chloride. Analyses were performed to verify that the metallic components of the MSCA were not overstressed, and analyses and testing was performed to ensure the Grafoil was kept at a suitable compression. The metallic portions of the MSCA were, however, not initially analyzed against any specific portion of the ASME Code nor were the materials procured as ASME Code materials. Materials were procured as ASTM with a Certificate of Compliance (C of C) from the material vendor, with traceability to the heat numbers.

PSE&G, along with Combustion Engineering, performed a code applicability review. The resulting non-code interpretation for the MSCA assembly was based on the fact that the MSCA neither provided any strength to the joint (the strength of the joint is maintained solely by the ACME threads), nor was it attached by welding to the existing joint. The MSCA was treated in the same manner as packing retaining material and pump seals which are excluded from code rules. The metallic portions of the MSCA hold the Grafoil in compression against the canopy area. Leakage across a canopy seal weld would be stopped by the Grafoil. The metallic portions of the MSCA will not be pressurized, even if the leakage were not stopped by the Grafoil. Thus, the Grafoil was considered the leakage barrier and the rest of the MSCA was treated as a structural item. Recognized was the fact that the ASME code does not allow threaded joints without added leakage barrier and the fact that specialty seal welds are covered by the code. Refer to Attachment 2 for further discussion on CE's discussion on CE's code interpretation.

2.2.3 Enhanced Leakage Detection

As a result of the Salem 1 canopy seal leaks, a new experimental Reactor Head Main Coolant System Leakage Air Particulate Monitor (MCSLAPM) was installed in Unit 1 and, subsequently in Unit 2.

MCSLAPM is an air particulate monitor developed to identify RCS leakage from the reactor head area. MCSLAPM takes an air sample from all four CRDM vent fans and detects the Rb88 activity as it decays from Kr88, a noble gas, which is extremely abundant in the RCS. Kr88 decays with a 2.8 hour half life to a highly charged particulate daughter Rb88 which has a 17.8 minute half life. The air samples from these four locations are transported via stainless steel tubing into a receiver vessel. This vessel is used as a hold up/decay tank to optimize the system response to Kr88. The Rb88 particulate is collected on a movable filter paper and dominates the detector response due to its very high beta energy. The detector, a beta scintillator, has been fine tuned to optimize its sensitivity to Rb88. The detector assembly is located on 100' elevation in the containment. An analog output from the rate meter is transmitted to a recorder in the control equipment room.

The detector was calibrated using RCS chemistry samples from the primary sample room and a high purity germanium detector (HPGD) traceable to the National Bureau of Standards. With the reactor at 100% power and no RCS leakage, the detector registers 35-50 cpm. The reactor head MCSLAPM is estimated to be capable of detecting RCS leakage of approximately 0.05 gpm. Based on a mathematical model, this should correspond to 90 cpm. Comparatively an RCS leak of 1 gpm should correspond to 1800 cpm.

The reactor head MCSLAPM in conjunction with the general area containment monitors (R11A) provide excellent head leakage detection. The reactor head MCSLAPM will respond to a leak in the reactor vessel head area. The general containment monitors detect the overall Kr88 air activity and is sensitive to leakage as low as 0.01 gpm. By analyzing the responses of the two systems, a determination can be made as to whether an unknown leak is from the reactor head area or some other location. Specifically, if the leak is from the head area, it is anticipated that the MCSLAPM will see the leakage first and the ratio between the MCSLAPM reading and the R11A reading will increase. On the contrary, if the leakage developes outside the head area, the MCSLAPM reading will probably lag the R11A reading, but the eventual ratio, once steady state is reestablished, will remain relative constant.

The reactor head MCSLAPM is not safety related. Once more experience has been obtained, more specific criteria will be developed and provided to operations department personnel to enhance their ability to quickly act in the event of a RCS reactor head area leakage.

In addition, three inspection ports were added to the lower CRDM cooling shroud. This allows direct visual observation of the upper portions of the head penetrations, including the canopy seal weld areas, any time the reactor is not critical.

3.0 REQUESTED RELIEF

On October 5, 1988, PSE&G presented to the NRC the overall corrective action plan and summarized the design of the MSCA. The NRC disagreed with PSE&G's interpretation that the MSCA was not pressure boundary (and therefore exempt from the code). The NRC position was based on the premise that the original canopy seal weld was covered by the code and since threaded joints by themselves are not allowed by the code, all portions of the leakage barrier become part of the joint and must be in full compliance with the code. As a result of this meeting, PSE&G and CE initiated a review of the MSCA against the ASME code.

Since the ASME code of record for Salem Unit 2, ASME 1966 with Winter of 1966 Addenda, does not provide any specific guidance for a MSCA, Section NB-3671.7 "Sleeve Coupled and Other Mechanical Joints" was selected from the 1986 edition of the ASME Section III code for guidance. The design review against NB-3671.7 was focused on the leakage barrier portion of the joint. The structural strength of the joint provided by the ACME threads is not being adversely affected by the MSCA. The design review, Attachment 1, shows that the MSCA is in compliance with the requirements of NB-3671.7 except for material qualification.

Prior to making the decision to install the MSCA, PSE&G evaluated the other options available and determined the MSCA to be the best presently available fix. Replacement of the MSCA with a fix that is recognized by all parties involved as code acceptable was considered impractical as it would require substantial work and high radiation exposure (remote tooling for code acceptable repairs are not presently available). PSE&G is requesting code exemption from the NRC to use the MSCA based on the justification provided in Section 4.0. PSE&G considers the MSCA to be a high reliability leakage barrier. PSE&G will implement a program to address field verification that the Grafoil is not being relaxed (by verifying that the preload on the MSCA is being maintained) and will continue to pursue with vendors alternate fixes.

4.0 BASIS FOR RELIEF

4.1 Leakage Concern Only

The MSCA, which is installed over the existing canopy provides only for joint leakage integrity. The strength of the joint depends solely on the ACME threads.

The ACME threads are machined from 304 stainless steel material. This material was selected because of its compatibility with Boric Acid and its excellent corrosion resistance. All five male and female thread assemblies from the T/C columns removed from Salem Unit 2 have been fluorescent liquid penetrant tested. No indications of any degradation were noted. In addition, Westinghouse has been contacted concerning the joints they have received for examination from other utilities.

Westinghouse stated that the threads were not subject to any specific examination but none of the threaded areas have had any damage noted.

No thread damage was anticipated. The problem with the canopy seal welds is in the welded areas or the heat affected zone of the canopy. No welding is done on the threaded area.

Without any leakage barrier whatsoever the maximum leakage across the ACME threads has been calculated at 3 to 4 gpm. Failures of canopy seal welds have been limited to pinhole failures of much lesser leakage rates. Leakage across a failed canopy seal weld and/or a failed MSCA clearly is not an immediate safety challenge since it is well within the normal RCS make-up capacity. Leakage is a concern due to wastage on the carbon steel RV closure head.

4.2 MSCA Failure

The MSCA is in full compliance with more conservative interpretation of the ASME code with the exception of the use of ASTM as opposed to ASME material.

The metallic portions of the MSCA are required to hold the Grafoil in compression against the canopy area. In order for the metallic portions of the MSCA to fail to perform their intended function, they would have to structually deform. Defects in the ASTM material, other than those which would cause structural degradation of the MSCA, would not degrade the leakage integrity of the MSCA. None of the metallic portions of the MSCA are intended to, nor can they, become pressurized. During installation of the MSCA, it is preloaded to ensure compression of the Grafoil. Neither anticipated, abnormal, nor emergency plant transients would increase the structural loading on the MSCA. In addition, neither failure of the underlaying canopy seal nor leakage across the Grafoil barrier would subject the MSCA to added structural loading. Faulted conditions are addressed in Attachment 1, paragraph 5.3.1 (c). MSCA integrity is also assured during faulted conditions.

The successful testing and installation of the MSCA provides high assurances that the MSCA will not structurally fail in service.

4.3 Overall Head Leakage Reduction Initiatives

To date, the concern on leaking canopy seal welds has been almost exclusively on spare head adapter caps and T/C columns.

PSE&G has in their action plan (described in 2.2) systematically addressed the canopies on both these type of head penetrations. All five T/C columns have been severed below the joint containing the ACME thread and canopy seal. This joint on the T/C columns has been replaced with a full penetration butt welded cap.

The three spare head adapter caps without a leaking seal have also had the MSCA installed. In this application, the MSCA provides a redundant leakage barrier which does not adversely affect the canopy underneath.

The MSCA on the spare head adapter cap, with the leaking canopy seal weld, is expected to have excellent leakage integrity. This MSCA will be specifically examined during the RCS hydro which will be performed at plant start-up. The criteria will be "no leakage". The MSCA can be seen through the shroud inspection doors.

4.4 Leakage Detection

Head leakage detection protection provides a back-up means to ensure no head degradation occurs.

Salem Unit 2 Reactor Vessel Closure Head has enhanced leakage detection capabilities, both visual and remote, in excess of the original design to provide early detection of any leakage in the area of concern.

4.5 Summary

The design of the MSCA, with the exception of the use of ASTM material qualification, has been demonstrated to be in compliance with the ASME code. The MSCA has been subject to development and testing to provide a high reliability leakage barrier. The ASTM material is the same as the equivalent ASME material but it is not subject to as intensive controls. Nevertheless, since the metallic portions of the MSCA are only required to maintain the Grafoil in compression, will not be pressurized, nor will they see a loading in excess of their original installation load, the ASTM material selected, as well as the installation checks and in-service leak check, should provide a sufficiently high degree of reliability that the MSCA will perform as intended.

In the unlikely event of a structural failure of the MSCA, which will release the Grafoil from compression, and result in a leak (assuming the canopy seal weld has also failed), there would be no immediate safety concern since the leakage is expected to be less than 1 gpm. The enhanced RV head leakage detection system, as well as normal containment monitors, would alert station personnel of the leak prior to any RV head boric acid wastage. In addition, failure of the MSCA would result in leakage significantly less than failures in seals and 1", and under, instrument lines for which the code allows the use of non-code materials (NB-2121 (b) and (d), respectively).

PSE&G, in order to reduce the overall concern on leaking canopy seal welds, has taken the same corrective measures on non-failed canopies where industry trends have demonstrated an unacceptable failure rate.

PSE&G considers that the overall actions already taken should considerably reduce the risks associated with leaking canopy seal welds. Removing the MSCAs and performing an alternate fix is impractical at this time since it would result in significant radiation exposure to personnel and start up delays with little perceived benefit.

SUMMARY REPORT

CONFORMANCE OF MECHANICAL SEAL CLAMP ASSEMBLIES TO THE ASME BOILER AND PRESSURE VESSEL CODE

1.0 INTRODUCTION

This report summarizes the conformance of the Mechanical Seal Clamp Assemblies (MSCA) to the requirements of ASME Boiler and Pressure Vessel Code, Section III, subsection NB, paragraph 3671.7. The MSCA are installed on spare head adapter caps at the Public Service Electric and Gas Company Salem Unit #2.

2.0 SCOPE

This report applies to the MSCA installed on Salem Unit #2. The effects of normal operation, upset conditions, and faulted conditions are addressed. Compliance with the Design Specification for the MSCA (Reference 6.1) is documented.

The ACME threads provide the structural strength of the original and modified joint. The new leakage barrier, i.e. the MSCA, does not adversely impact the ACME threads. Since the ACME threads are covered in the original design report, they are not further addressed in this report.

3.0 METHODS OF COMPLIANCE

3.1 Demonstration of provision to prevent separation of the MSCA under all service loadings is provided by testing backed up by analyses.

3.2 Demonstration that MSCA components are accessible for maintenance, removal and replacement after service is provided by installation tests and actual installation at Salem Unit 2.

3.3 Demonstration of the safety of the MSCA under service conditions is performed by performance testing of the simulated seal joint under simulated service conditions. This testing is backed up by analyses.

4.0 BASIC DATA AND ASSUMPTIONS

The dimensions and other characteristics of the spare head adapter caps were taken from References 6.2. The MSCA dimensions and characteristics are taken from Reference 6.3. The installation procedure and resulting installed condition of the MSCA are taken from Reference 6.4. The spare head adapter cap locations are shown on Figure 4. For purpose of discussion the various components of the spare head adapter caps and the MSCA are as identified on Figure 2.

Performance testing of the MSCA is reported in Reference 6.5.

5.0 SIGNIFICANT RESULTS

5.1 Prevention of Separation of the MSCA.

5.1.1 Summary of Results

The MSCA is preloaded onto the spare head adapter cap using a tensioning device. This places the Grafoil into 4,800 psi of compression and places each bolt into 7,500 lbs of preload. Since Grafoil compression is required to maintain leakage integrity, the performance testing performed in Reference 6.5 verify that the MSCA is not being separated. As discussed in 5.3.1 (C), this preloading is by far the major load on the MSCA. Other loads, e.g. seismic, will at worst have a temporary and negligible impact on this preload.

5.1.2 Conclusion - Prevention of Separation of Joint

It is concluded that the MSCA will remain intact for postulated service conditions provided that the installation/assembly procedure is in accordance with Reference 6.4.

5.2 Accessibility for Maintenance, Removal and Replacement

5.2.1 Summary of Results

The MSCA is installed in accordance with Reference 6.4. Special tools are defined in Reference 6.4. The same special tools may be used to maintain, remove or replace the MSCA. The Seal Clamp loading tool is only required if a replacement MSCA is to be installed.

No maintenance on the MSCA is required. The torque load on the socket head cap screws may be checked (e.g. at refueling outages) to verify that the Grafoil seal remains fully loaded. The socket head cap screw torque should be restored to 75 feet lbs after checking.

If the MSCA is removed a new Grafoil seal (item 8 on Figure 2) should be used when reinstalling the MSCA.

The installation of the MSCA's at Salem Unit 2 provided field verification of Reference 6.4. The MSCA are installed from the Reactor Vessel Head Lift Rig work platform. Periodical checking of torque loading can also be done from this platform.

5.2.2 Conclusions - Accessibility for Maintenance, Removal and Replacement

It is concluded that the MSCA can be maintained, removed and/or replaced.

5.3 Demonstration of Safety of the Joint Under Service Conditions

5.3.1 Summary of Results

A MSCA was tested to demonstrate acceptable performance under simulated plant service conditions (Reference 6.5). The MSCA was installed on a mockup of the spare head adapter cap. The mockup included a 1/8 inch diameter hole to simulate a worst case leak in the seal weld area. The test included the following conditions:

a) Hydrostatic pressure test to 3100 + 50 psig for 30 minutes.

b) Thermal cycle of the spare head adapter cap from less than 130°F to 625°F or higher at a pressure of 2500 + 50 psig. The maximum temperature condition was held for a minimum time period of one hour for each of two thermal cycles. The clamp body temperature reached 350°F. These temperature transients provided a conservative simulation of thermal expansion under service condition because the MSCA had to be insulated to achieve a clamp body temperature of 350°F. During service conditions the Seal Clamp Assembly will not be insulated and the temperature transient will be somewhat less. The seal clamp assembly is located in the cooling plenum for the CRDM motor assemblies which have a maximum operating temperature of 350°F (150°F nominal).

c) Vibration, fatique, cyclic conditions. The preload on the seal clamp assembly is much higher than possible loads due to seismic, vibration, fatigue or other loading conditions. For example, the maximum load on the bolts due to postulated seismic/LOCA conditions is less than 6% of the preload on the socket head cap screws. Thus the conservatism in the performance test of Reference 6.5 more than compensates for not explicitly including these other loading conditions in the performance test.

During the qualification tests, (Reference 6.5) no leakage was observed past the Grafoil seal before during or after the test.

5.3.2 Analytical Verification

Although the MSCA design was qualified by testing, all the components were analyzed to verify adequate margins. The results of the anlyses are tabulated in Table 1. All components are within allowable stresses.

5.3.3 Conclusion, Safety of Joint Under Service Conditions

It is concluded that that the requirements of the Design Specification (Reference 6.6) for no joint leakage under service conditions are met.

5.4 Compliance with ASME B&PV Code Section III, Subsection NB, Paragraph NB-3671.7

It is concluded that the MSCA meets the intent of Paragraph NB-3671.7 of section III, ASME B and PV Code. The following specific points of clarification apply:

1) The Seal Clamp Assembly material is procured as ASTM material in lieu of SA. The equivalent SA material allowable loads are assumed to apply. The Grafoil seals are procured as Quality Class 2 requirements which is typical for primary pressure boundary gasket material.

2) The components are fabricated in accordance with Quality Class 2 requirements by a manufacturing facility which has been approved by CE for Class 2 work. A Certificate of Conformance is issued by the manufacturing facility and a Certificate of Equipment is issued by CE to document conformance to the purchase order and design requirements. The Seal Clamp Assembly is not, however, an ASME code component.

3) The Grafoil seal is gasket material and thus code requirements are not applicable. None of the other CRDM Seal Clamp Assembly components are exposed to primary coolant pressure nor do they act as a restraint for forces that result from primary system pressure.

6.0 REFERENCES *

6.1 CE Design Specification No. 71186-MPS-5DS-003, Rev. 0 "CRDM Seal Clamp Assembly for PSE&G Salem Unit #2

6.2 PSE&G Drawing 601953-A-1352

6.3 CE Drawing E-71186-156-002, Rev. 02 "CRDM Seal Clamp Assembly" 2 sheets

6.4 CE Document 71186-MPS-5EFPR-020 "Engineering Field Procedure Requirements for the Installation of the CRDM Seal Clamp on Salem, Unit 2" Rev. 02

6.5 CE Test Report TR-ESE-759, Rev. 0 "Qualification of the Seal Clamp Assembly for use as a Reactor Primary Pressure Boundary" dated May 27, 1988

6.6 CE Calculation 00000-MPS-5CALC-046 Rev. "CRDM Seal Clamp Assembly Stress Analysis"

6.7 CE Design Report 71186-MPS-6DSR-021, Rev. 0 "Seismic and LOCA Analysis for the Salem Unit 2 Capped Spare CRDM Nozzles"

* CRDM Seal Clamp Assembly and Mechanical Seal Clamp Assembly are one and the same. Likewise, Capped Spare CRDM Nozzles and Spare Head Adapter Caps are one and the same.

ATTACHMENT 1 - TABLE 1

Summary of Analytical Results

Loading Condition	Component*	Calculated Stress KSI	Code Allowable Stress KSI
Normal Operating	Seal Carrier (4) & (5)	20 bending	28 bending
		5.6 vertical shear	11.2 shear
		10.5 horizontal shear	11.2 shear
	Seal Carrier Housing (3)	2.6 vertical shear	11.2 shear
		4.3 horizontal shear	11.2 shear
		4.3 bending	28.0 bending
	Top Plate (2)	1.6 bending	28.0 bending
	Socket Head Cap Screw (6)	33.5 tensile	54.4 tensile
	Seal Weld	-14.9 hoop	18.7 hoop
	(CRDM Nozzle Cap to CRDM Housing)	-4.0 radial	18.7 radial

* Refer to Figure 2

SUMMARY OF CE EXPERIENCE WITH GRAFOIL SEALS - REACTOR APPLICATIONS

The following is a summary of CE experience with the use of Grafoil seals either in reactors or on attachments to the reactor vessel.

There have been three applications that have been used on multiple plants. There are: heated junction thermocouple (HJTC) probe assemblies, fixed in-core instruments (ICI's) and core exit thermocouple nozzle assemblies (CETNA). The configuration of these applications is shown in Figures 6, 7, and 8 respectively. Table 1 provides a listing of reactor units where this equipment has been installed. Figure 9 shows a fourth application which has been installed on a CRDM nozzle at the Nuclenor Reactor Unit (BWR) in Spain. Note that for this application the grafoil seal assembly is installed inside the reactor vessel. It is continuously exposed to the primary coolant environment.

The HJTC application has been in service for a number of years for most of the plants listed in Table 1. The longest period of operation is about six (6) years for this application. The ICI application has been in service for up to fifteen years on the plants listed in Table 1 that have fixed ICIs. The CETNA application has been in operation for up to three (3) years.

The following information is provided on compliance of these Grafoil seal applications with the ASME Boiler and Pressure Vessel Code:

HJTC

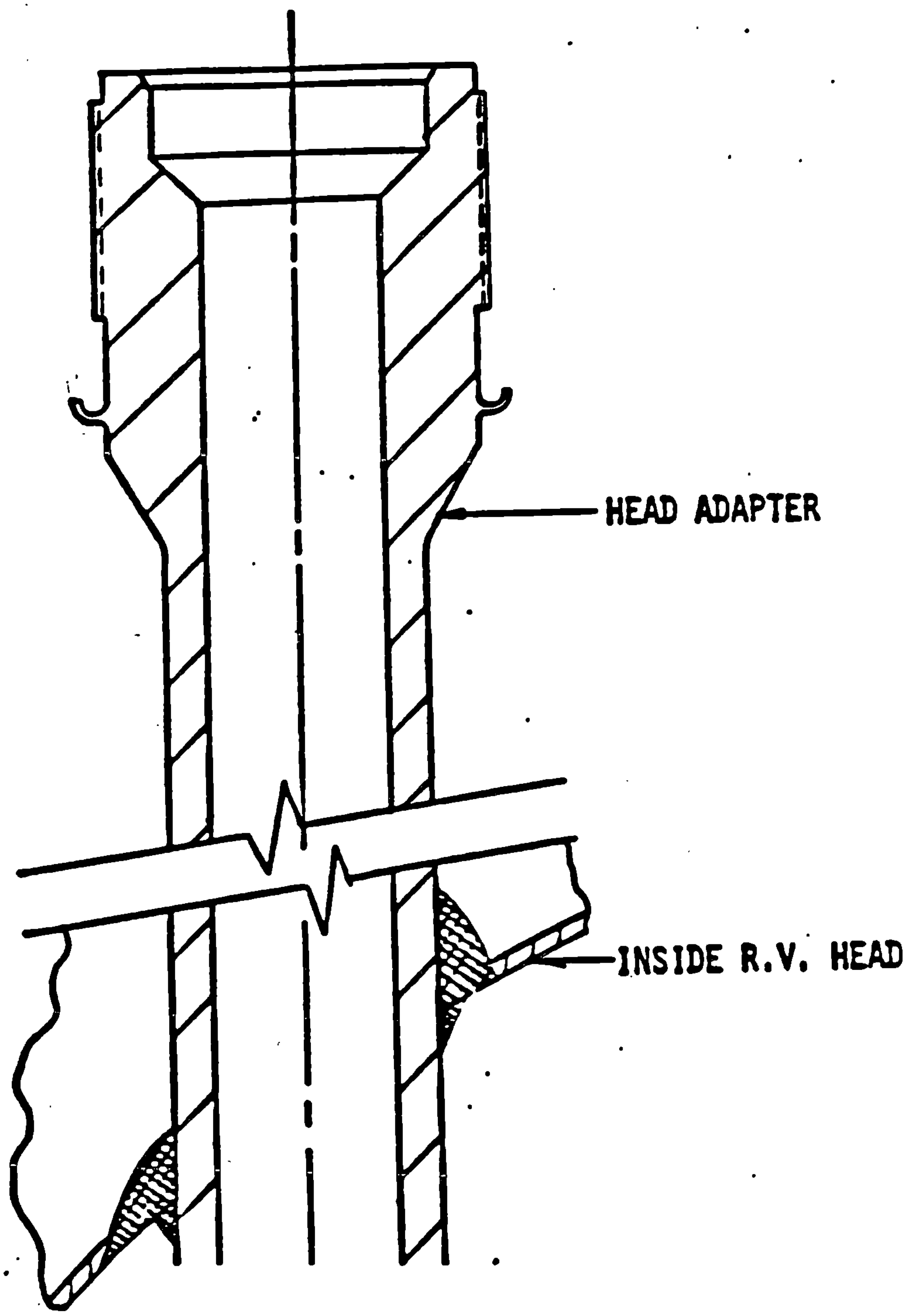
The HJTC probe assembly (instrument) is not a code component. The Grafoil seal and fitting are not code components. The HJTC probe assembly and fittings are not considered code components. Section III, subsection NCA-1130 (c) states that "the rules (of section III) do not apply to instruments...". In addition, subsection NB2121(d) states that for instrument line fittings one (1) inch nominal pipe size and less material specifications other than those listed in the code may be used. These articles are considered applicable to the HJTC probe Grafoil seal. The Grayloc flange which makes up the HJTC probe joint includes primary pressure retaining components (Grayloc subs) and components that have pressure retaining loads transmitted to them (clamps). These components are designed and fabricated to Section III of the code.

ICIs

The in-core instruments (fixed in-core nuclear flux detectors), the Grafoil seal and fittings are not considered code components. The bases is the same as for the HJTC, i.e., the ICI is an instrument and instrument line fittings are less than one inch in diameter.

CETNA

The CETNA includes a clamp or upper nozzle housing that is a pressure retaining component. The primary pressure load is transmitted through the drive sleeve. These two components are procured to code requirements. Other components of the CETNA (with the exception of the Grafoil) are not exposed to primary pressure. They are not procured as code components. The Grafoil seal is considered a gasket material and code requirements are not applicable.



Figure
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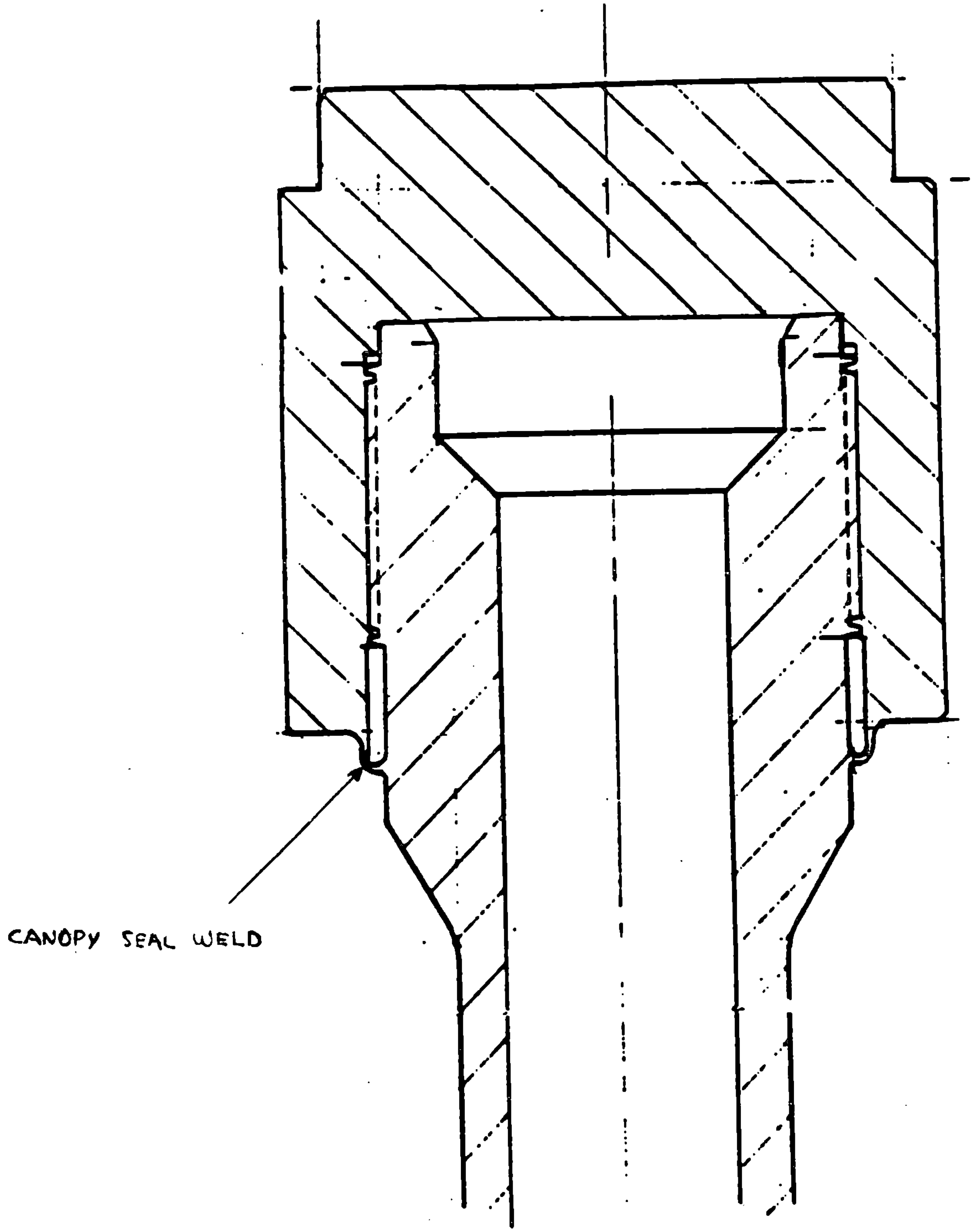

HEAD ADAPTER -
HEAD ADAPTER PLUG

Figure
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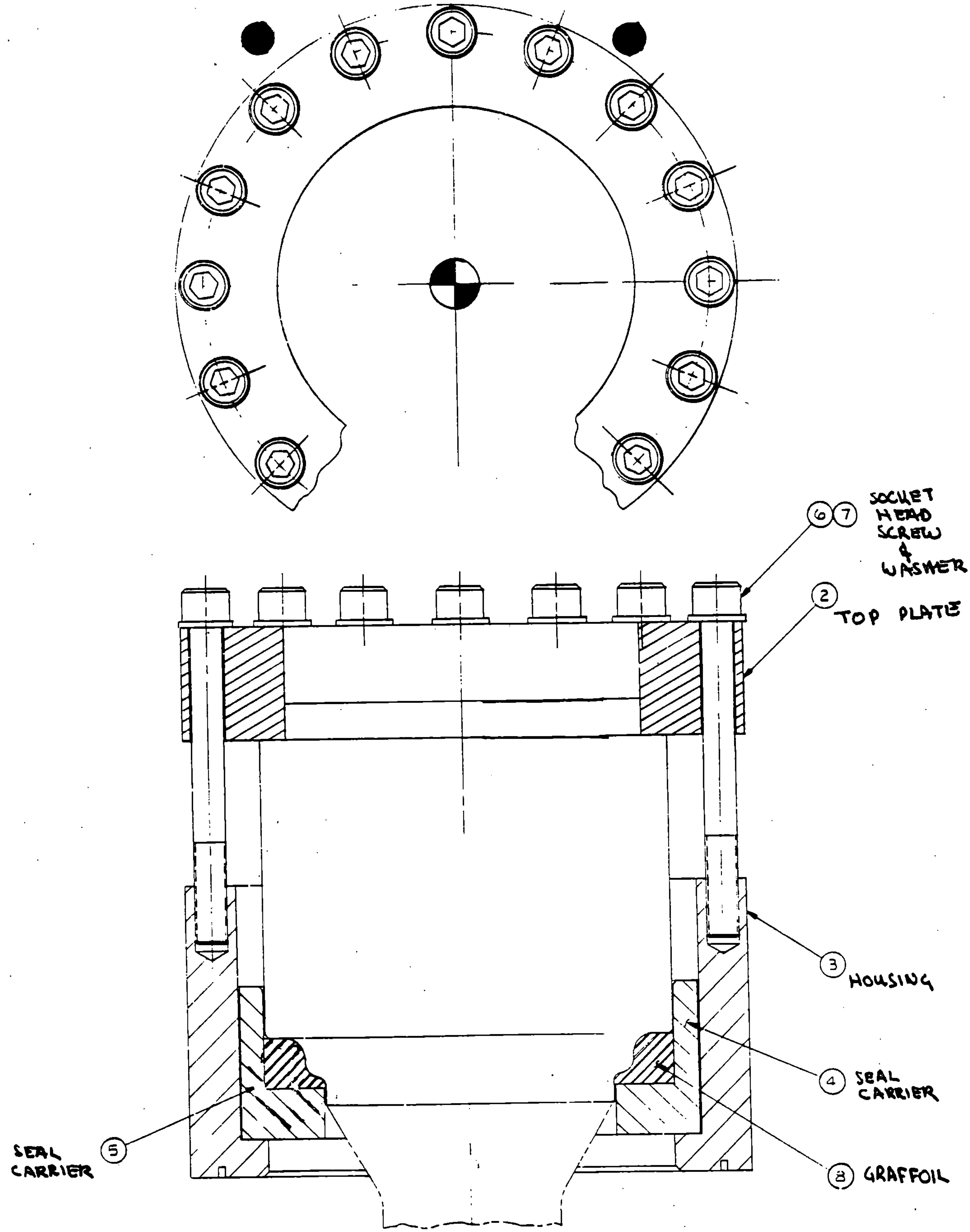


9 1 CRDM SEAL CLAMP ASSY

Figure 2

INSTRUMENT PORT COLUMN ASSEMBLY

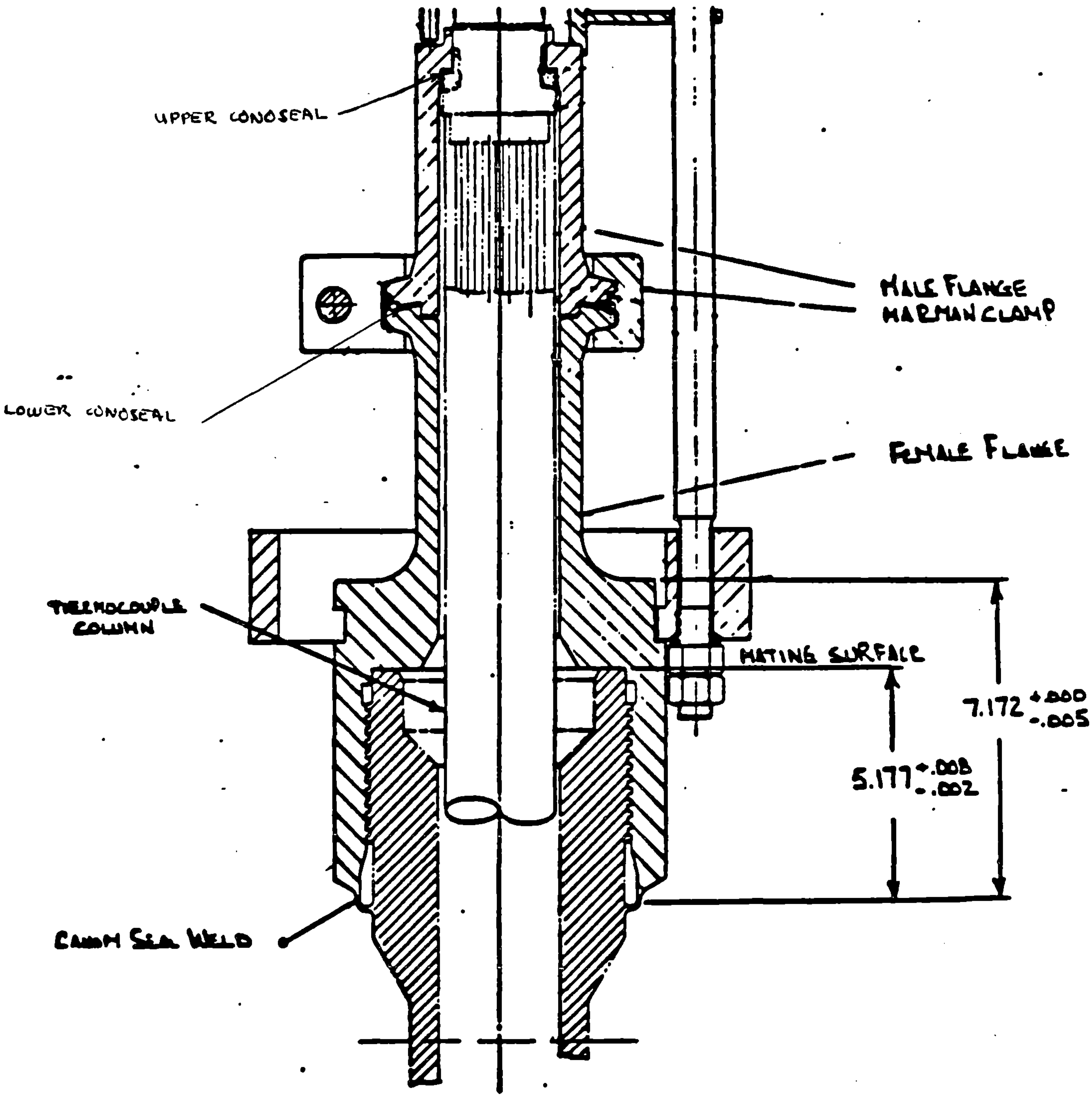


Figure - 3 -

SALEM #2	SYMBOL	DESCRIPTION
53	⬡	STANDARD CRDM - FULL LENGTH
8	Ⓟ	PART LENGTH CRDM
5	⬡ (double)	INSTRUMENTATION COLUMN
4	◒	ADAPTOR PLUG (SPARE)
8	(IA)	SPARE CRDM - FULL LENGTH (INACTIVE)
78		— TOTAL —

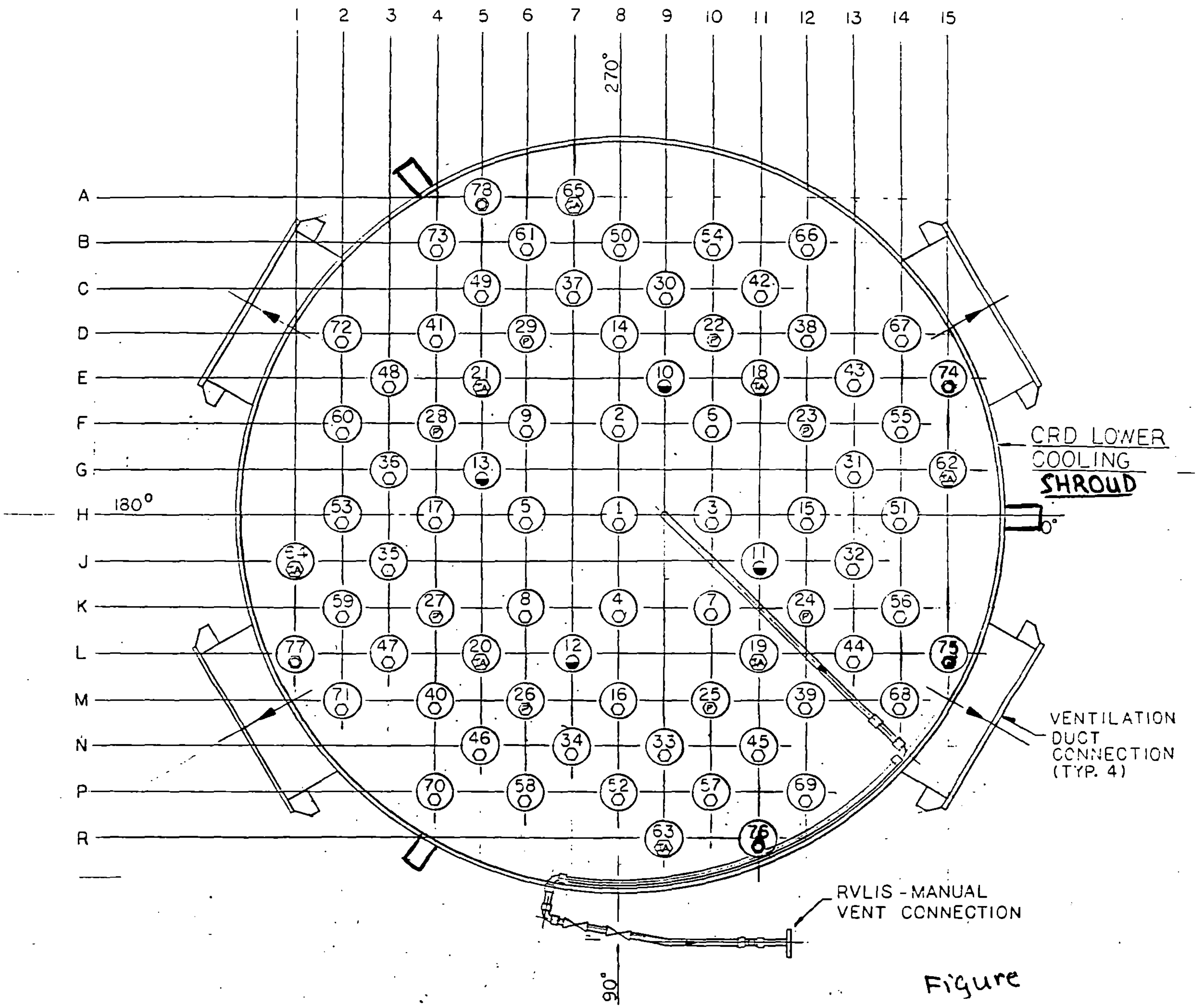


Figure -4-

UNIT NO. 2 - REACTOR HEAD PENETRATIONS

WELDED CAP FROM TOP OF HEAD

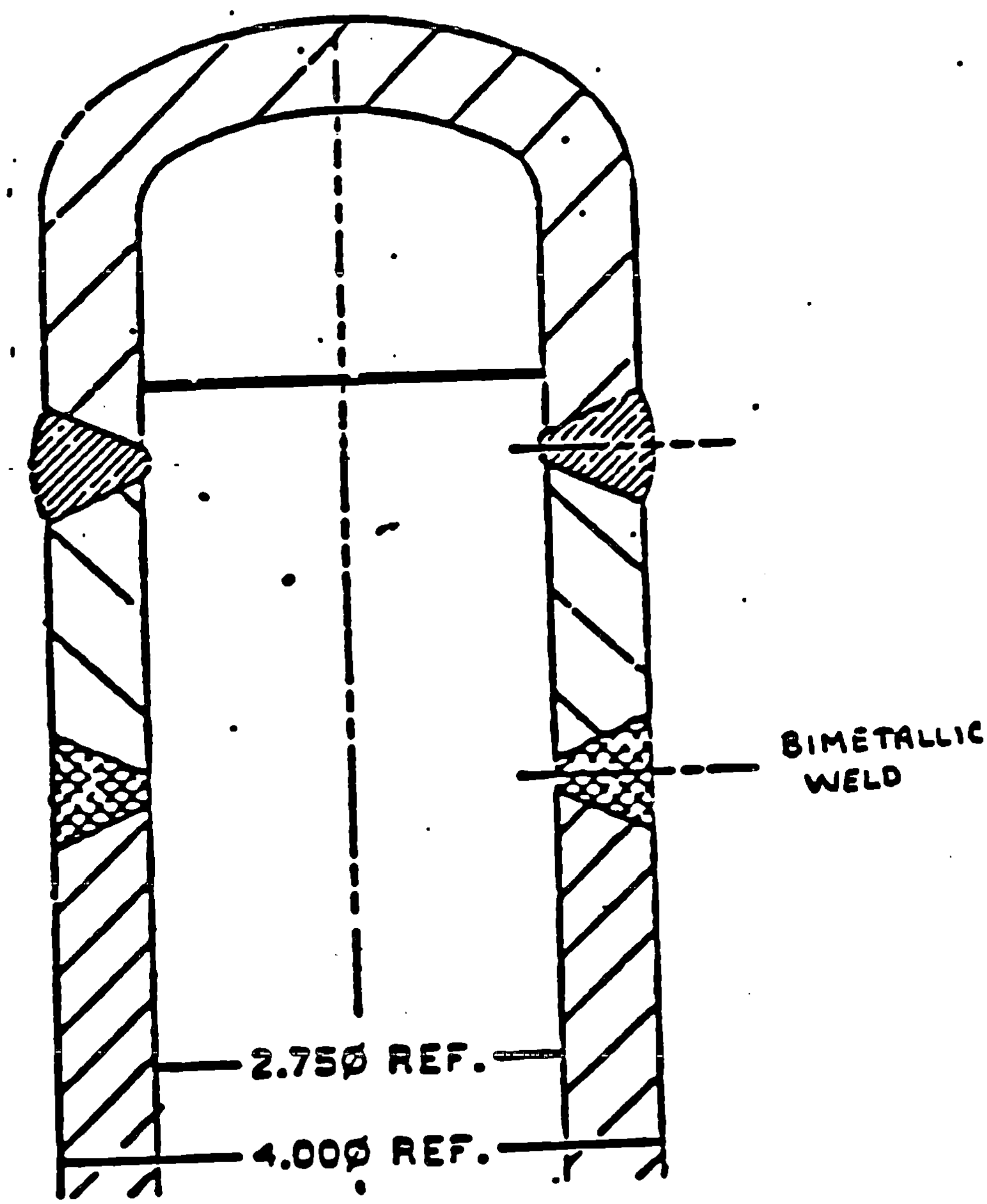
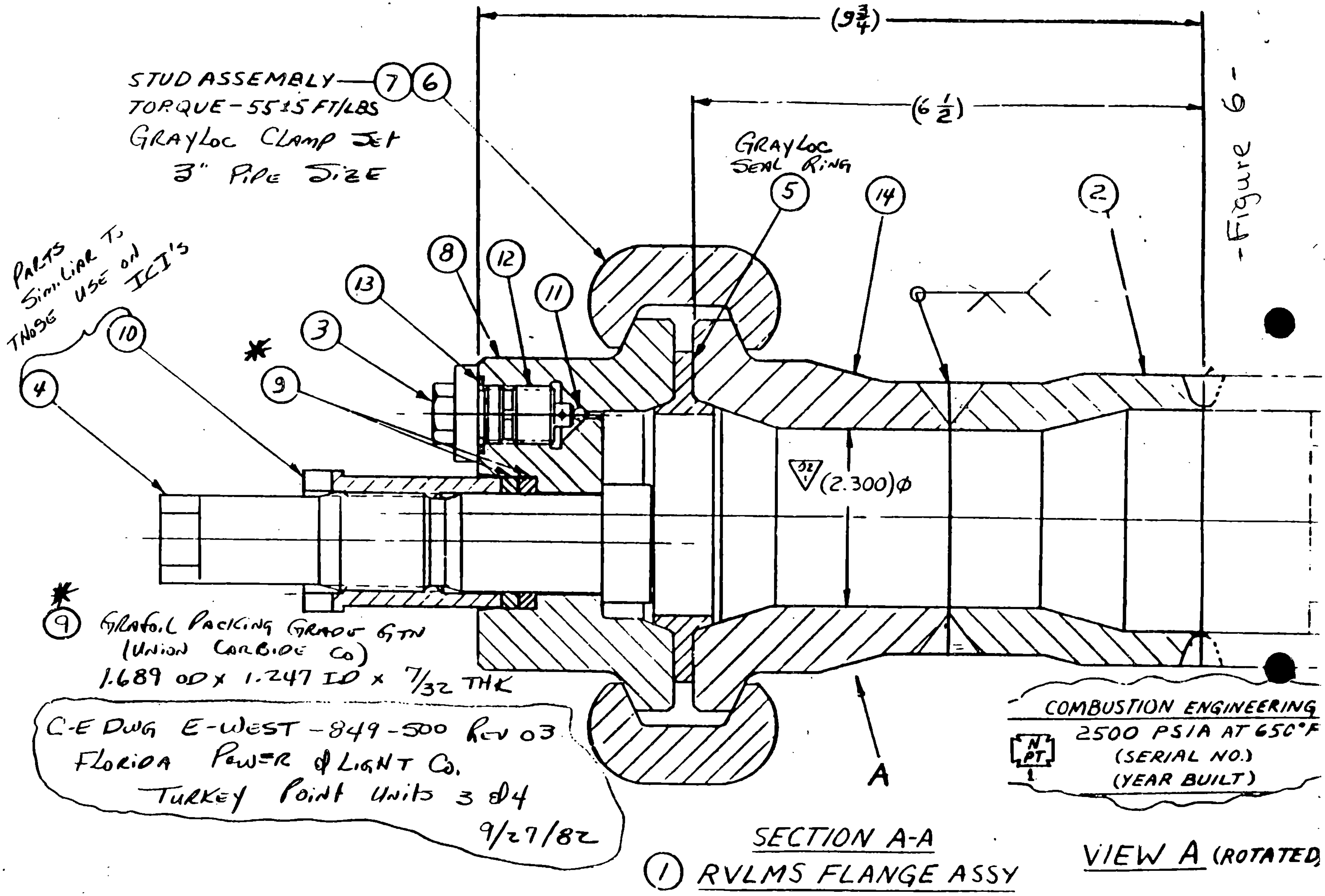
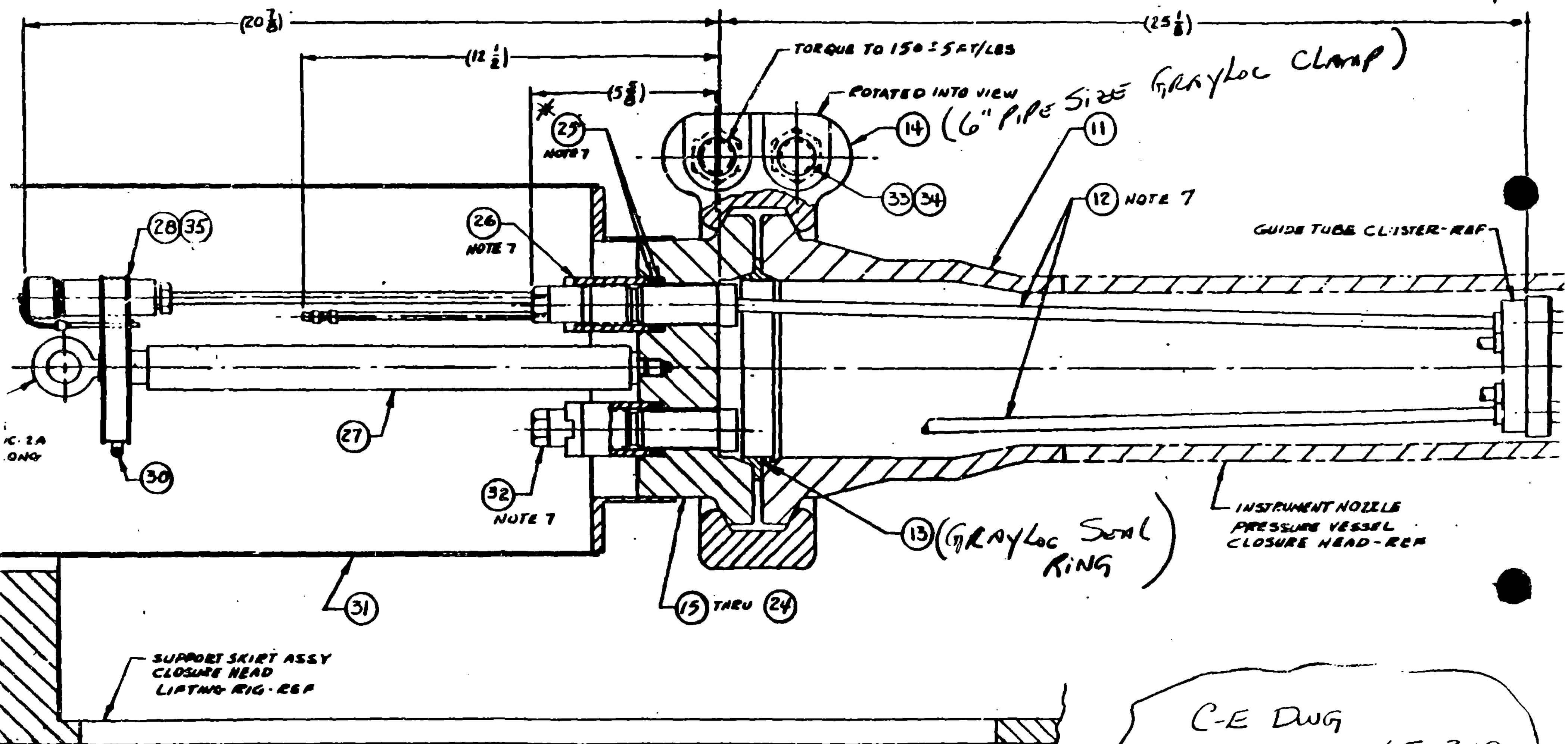


Figure
- 5 -


(9 3/4)
(6 1/2)
STUD ASSEMBLY — 7 6
TORQUE — 55±5 FT/LBS
GRAYLOC CLAMP SET
3" PIPE SIZE
GRAYLOC SEAL RING
5
14
2
-Figure 6-
PARTS SIMILIAR TO THOSE USE ON ICI'S
8
12
13
11
3
10
*
9
4
(2.300)ϕ
32
*
9 GRAFOIL PACKING GRADE GTN (UNION CARBIDE CO)
1.689 OD x 1.247 ID x 7/32 THK
C-E DWG E-WEST-849-500 REV 03
FLORIDA POWER & LIGHT CO.
TURKEY POINT UNITS 3 & 4
9/27/82
A
COMBUSTION ENGINEERING
N PT
2500 PSIA AT 650°F
(SERIAL NO.)
(YEAR BUILT)
SECTION A-A
1 RVLMS FLANGE ASSY
VIEW A (ROTATED)

*(25) GRAFOIL SEALS: 1.689 OD x 1.247 ID x 7/32 THK
(UNION CARBIDE) NUCLEAR GRADE GTN OR GTJ
(SAME AS CE+NA)

-Figure 7-

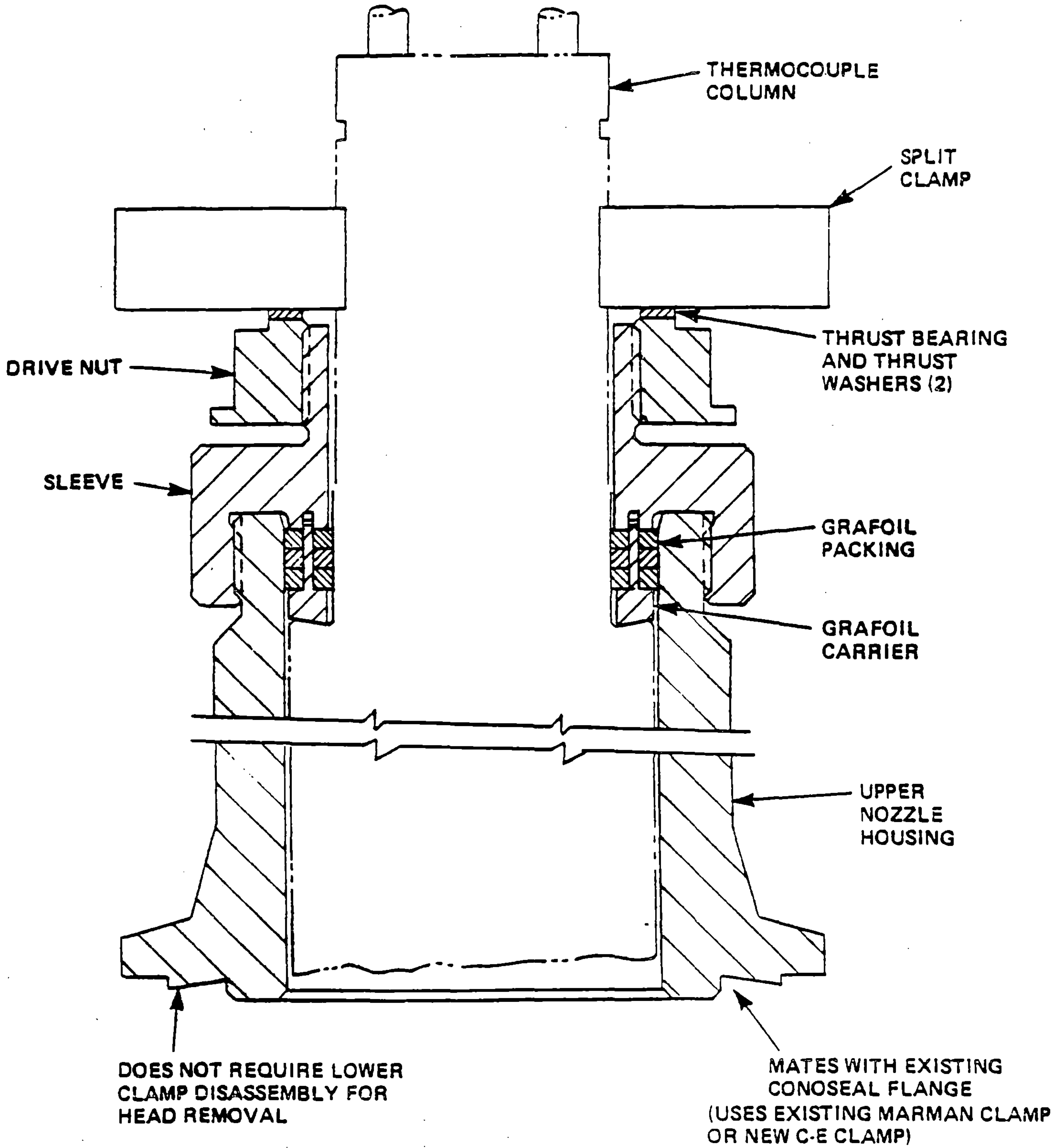


(1) THRU (10) INSTRUMENTATION FLANGE ASSY

C-E DWG
E-1370-165-310
Rev 01
ICI FLANGE ASSYS
FOR SAN ONOFRE # 2.
3/7/83

NOTE 7:

7 WITH ITEM 12 OR ITEM 32 IN PLACE, INSTALL 2 PACKINGS (ITEM 25) AND TAMP INTO POSITION. THREAD DRIVE NUT (ITEM 26) ONTO ITEMS 12 OR 32, AND TORQUE TO 80 ± 5 FT/LBS.



COMBUSTION ENGINEERING	CET NOZZLE ASSEMBLY (VERSION 2)	Figure 8

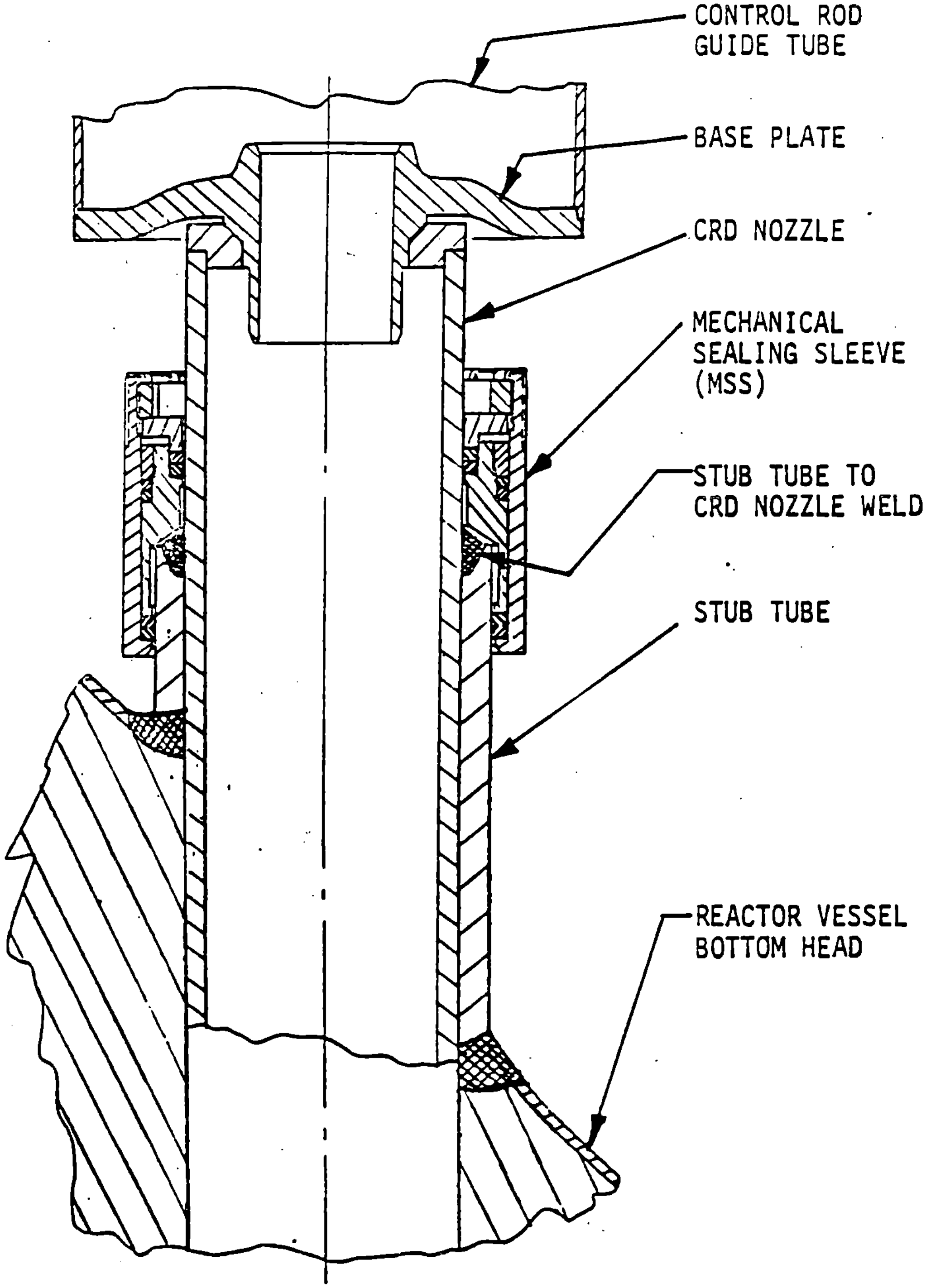


FIGURE 9

MECHANICAL SEALING SLEEVE INSTALLED ON CONTROL ROD DRIVE NOZZLE

GRAFOIL[R] SEALS IN C-E SUPPLIED NUCLEAR COMPONENTS

	Company	Plant	Component (1)	Grafoil (R) Seals Per Plant (2)	Installed Yes (Y)/NO (N)	No. of Reported Seal Leaks	NSSS Vendor
1.	Commonwealth Edison Company	Byron 1	HJTC	2	Y	NR (3)	W
		Byron 2	HJTC	2	Y	NR	W
		Briadwood 1	HJTC	2	Y	NR	W
		Briadwood 2	HJTC	2	Y	NR	W
2.	Northeast Utilities	Millstone 2	ICI	50	Y	NR	CE
		Millstone 2	HJCT	2	Y	NR	CE
		Connecticut Yankee	HJCT	2	Y	NR	W
		Connecticut Yankee	CETNA (Version 2)	4	N	--	W
		Millstone 3	HJTC	2	Y	NR	W
		Millstone 3	CETNA (Version 1)	4	Y	NR	W
3.	Southern California Edison Company	San Onofre 2	ICI	56	Y	NR	CE
		San Onofre 2	HJTC	2	Y	NR	CE
		San Onofre 3	ICI	50	Y	NR	CE
		San Onofre 3	HJTC	2	Y	NR	CE
4.	Texas Utilities Generating Company	Comanche Peak 1	HJTC	2	N	--	W
		Comanche Peak 2	HJTC	2	N	--	W
5.	Arizona Nuclear Power Project	Palo Verde 1	HJTC	2	Y	NR	CE
		Palo Verde 2	HJTC	2	Y	NR	CE
		Palo Verde 3	HJTC	2	Y	NR	CE
6.	Florida Power & Light Company	St. Lucie 1	ICI	45	Y	NR	CE
		St. Lucie 1	HJTC	2	Y	NR	CE
		St. Lucie 2	ICI	56	Y	NR	CE
		St. Lucie 2	HJTC	2	Y	NR	CE
		Turkey Point 3	HJTC	2	Y	NR	W
		Turkey Point 4	HJTC	2	Y	NR	W
7.	Louisiana Power & Light	Waterford 3	ICI	50	Y	NR	CE
		Waterford 3	HJTC	2	Y	NR	CE

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GRAFOIL[R] SEALS IN C-E SUPPLIED NUCLEAR COMPONENTS

	Company	Plant	Component(1)	Grafoil(R) Seals Per Plant(2)	Installed Yes (Y)/NO (N)	No. of Reported Seal Leaks	NSSS Vendor
8.	Omaha Public Power Supply System	Fort Calhoun	ICI	28	Y	NR	CE
		Fort Calhoun	HJTC	2	Y	NR	CE
9.	Baltimore Gas & Electric Company	Calvert Cliffs 1	HJTC	2	Y	NR	CE
		Calvert Cliffs 2	HJTC	2	Y	NR	CE
10.	Houston Light and Power Company	South Texas Project 1	HJTC	2	Y	NR	W
		South Texas Project 2	HJTC	2	N	--	W
11.	Alabama Power Company	Farley 1	HJTC	2	Y	NR	W
		Farley 2	HJTC	2	Y	NR	W
12.	Arkansas Power & Light	ANO 2	ICI	50	Y	NR	CE
13.	Duke Power Company	Catawba 2	CETNA (Version 1)	5	Y	NR	W
14.	Pacific Gas & Electric	Diablo Canyon 1	CETNA (Version 2)	5	N	--	W
		29 Units		455 SEALS	440 SEALS INSTALLED	0 REPORTED SEAL LEAKS	

(1) HJTC = Heated Junction Thermocouple System

ICI = InCore Instrument System

(2) Function: Seals Reactor Pressure Boundary Penetration

(3) NR = None Reported

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