WCAP-10167

WESTINGHOUSE CLASS 3

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EVALUATION OF THE ACCEPTABILITY OF THE REACTOR VESSEL HEAD LIFT RIG, REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL, AND LOAD CELL LINKAGE TO THE REQUIREMENTS OF NUREG 0612
for
PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SALEM GENERATING STATION
UNITS 1 AND 2

FEBRUARY, 1983

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ABSTRACT

An evaluation of the Salem reactor vessel head and internal lift rigs, load cell, and load cell linkage was performed to determine the acceptability of these devices to meet the requirements of NUREG 0612. The evaluation consists of: (1) a comparison report of the ANSI N14.6 requirements and the requirements used in the design and manufacture of these devices; (2) a stress report in accordance with the design criteria of ANSI N14.6; and (3) a list of recommendations to enable these devices to demonstrate compliance with the intent of NUREG 0612 and ANSI N14.6.

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A. Comparison of ANSI N14.6-1978 Requirements for Special Lifting Devices and the Requirements for the Reactor Vessel Head Lift Rig, Reactor Vessel Internals Lift Rig, Load Cell, and Load Cell Linkage for Public Service Electric and Gas Company, Salem Generating Station, Units 1 and 2.

B. Stress Report - Reactor Vessel Head Lift Rig, Reactor Vessel Internals Lift Rig, Load Cell, and Load Cell Linkage for Public Service Electric and Gas Company, Salem Generating Station, Units 1 and 2.

REFERENCES

1. George, H., Control of Heavy Loads at Nuclear Power Plants Resolution of Generic Technical Activity A-36, NUREG 0612, July, 1980.

2. ANSI N14.6-1978 Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More for Nuclear Material

3. ANSI B 30.9-1971. Slings, American National Standards Institute, New York, 1971

4. Westinghouse Drawing 685J059 - 3 Loop Head Lifting Rig General Assembly

5. Westinghouse Drawing 113E480 - 4 Loop Plants Lifting Rig Internals - General Assembly

SECTION 1
INTRODUCTION

The Nuclear Regulatory Commission (NRC) issued NUREG 0612 "Control of Heavy Load at Nuclear Power Plants"[1] in 1980 to address the control of heavy loads to prevent and mitigate the consequences of postulated accidental load drops. NUREG 0612 imposes various training, design, inspection and procedural requirements for assuring safe and reliable operation for the handling of heavy loads. In the containment building, NUREG 0612 Section 5.1.1(4) requires special lifting devices to meet the requirements of ANSI N14.6-1978-"American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More for Nuclear Materials".[2] In general, ANSI N14.6 contains detailed requirements for the design, fabrication, testing, maintenance, and quality assurance of special lifting devices. In addition, ANSI N14.6 requires that when wire rope or chain is used in the design of a special lifting device, the wire rope or chain shall be in conformance with ANSI B30.9-1971 "American National Standard Safety Standard for Slings".[3] The Salem Generating Station lifting devices which can be categorized as special lifting devices and which are contained in the scope of this report are:

1. Reactor vessel head lift rig

2. Reactor vessel internals lift rig

3. Load cell

4. Load cell linkage

This report contains the evaluation performed on these lifting devices to determine the acceptability of these devices to meet the above requirements.

1.1 BACKGROUND

The reactor vessel head lift rig, the reactor vessel internals lift rig, load cell, and load cell linkage were originally designed and built for the Salem Generating Station circa 1967-71. Subsequently, the Unit 2 internals lift rig was transferred to another plant site in 1975-76 and replaced in 1977 with an almost identical design. The actual design criteria is unknown for the lifting devices. It appears that Westinghouse used the design criteria that the resulting stress in the load carrying members, when subjected to the total combined lifting weight, should not exceed one fifth (1/5) of the ultimate strength of the material. These items were not classified as nuclear safety components and requirements for formal documentation of design requirements and stress reports were not applicable. Thus, stress reports and design specifications were not formally documented. Westinghouse defined the design, fabrication and quality assurance requirements on detailed manufacturing drawings and purchase order documents. Westinghouse also issued field assembly instructions for the reactor vessel head and internals lift rigs which included an initial load test followed by non-destructive surface examination of critical load bearing areas. Additionally, the new Unit 2 internals lift rig was load tested at the manufacturers shop at 125 percent of the maximum weight. Subsequent modifications (presently in progress) to the internals lifting rig include rotolock studs and inserts designed, manufactured, and tested to the requirements of ANSI N14.6.

SECTION 2
COMPONENT DESCRIPTION

2.1 REACTOR VESSEL HEAD LIFT RIG

The reactor vessel head lift rig[1] is a three-legged carbon steel structure, approximately 43 feet high and 14 feet in diameter, weighing approximately 28,000 pounds. It is used to handle the assembled reactor vessel head.

The three vertical legs and Control Rod Drive Mechanism (CRDM) platform assembly are permanently attached to the reactor vessel head lifting lugs. The tripod sling assembly is attached to the three vertical legs and is used when installing and removing the reactor vessel head. During plant operations, the sling assembly is removed and the three vertical legs and platform assembly remain attached to the reactor vessel head.

2.2 REACTOR VESSEL INTERNALS LIFT RIG

The reactor vessel internals lift rig[2] is a three-legged carbon and stainless steel structure, approximately 25 feet high and 14 feet in diameter weighing approximately 14,500 pounds. It is used to handle the upper and lower reactor vessel internals packages. It is attached to the main crane hook for all lifting, lowering and traversing operations. A load cell linkage is connected between the main crane hook and the rig to monitor loads during all operations. When not in use, the rig is stored on the upper internals storage stand.

The original rig design attaches to the internals packages by means of three engaging screws which are screwed into tapped holes in the internals flanges. These screws are manually operated from the manipulator crane walkway using a handling tool which is essentially a long wrench. The screws are normally spring retracted upward and are depressed to engage the tapped holes by the weight of the handling tool. Modifications to these rigs, presently in progress, include installation of an

operating platform, integral tools and a change to the type of engagement with internals to a rotolock stud and insert type. These rotolock studs are manually operated from the new internals lift rig platform using a handling tool which is an integral part of the rig. The studs are normally spring retracted upward and are depressed to engage the inserts. Rotating the mechanism locks it in both positions. Since these rotolock studs are in the process of being incorporated, both types of load carrying items are included in this report.

2.3 LOAD CELL AND LOAD CELL LINKAGE

The load cell is used to monitor the load during lifting and lowering the reactor vessel head or internals to ensure no excessive loadings are occurring. It is installed between the load cell linkage and the lifting device. The load cell is a strain gage (tension) type, rated at 400,000 pounds and built by W. C. Dillon and Co. The load cell linkage is an assembly of pins, plates and bolts which connect the polar crane main hook to the load cell.

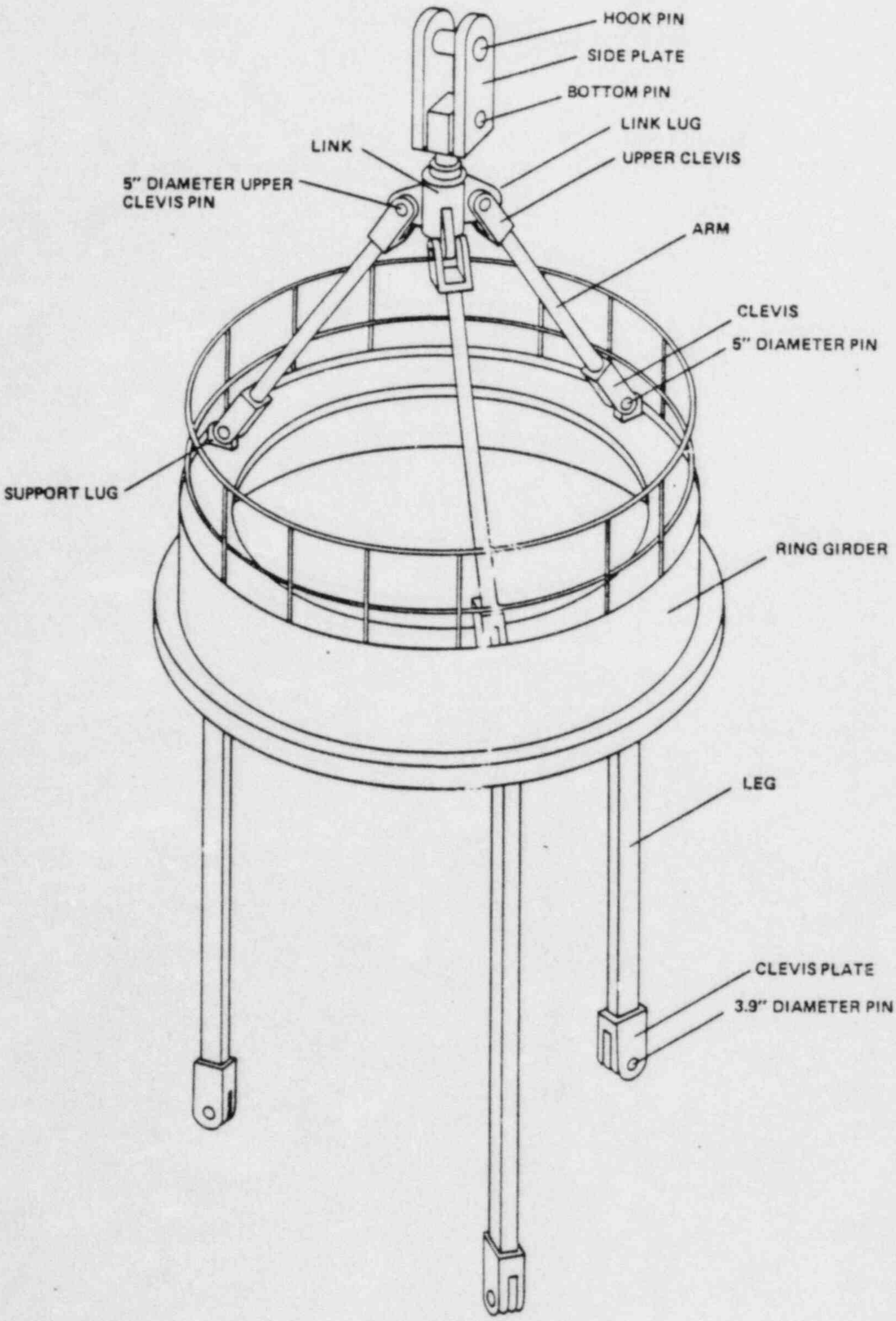

Figure 2-1. Reactor Vessel Head Lift Rig

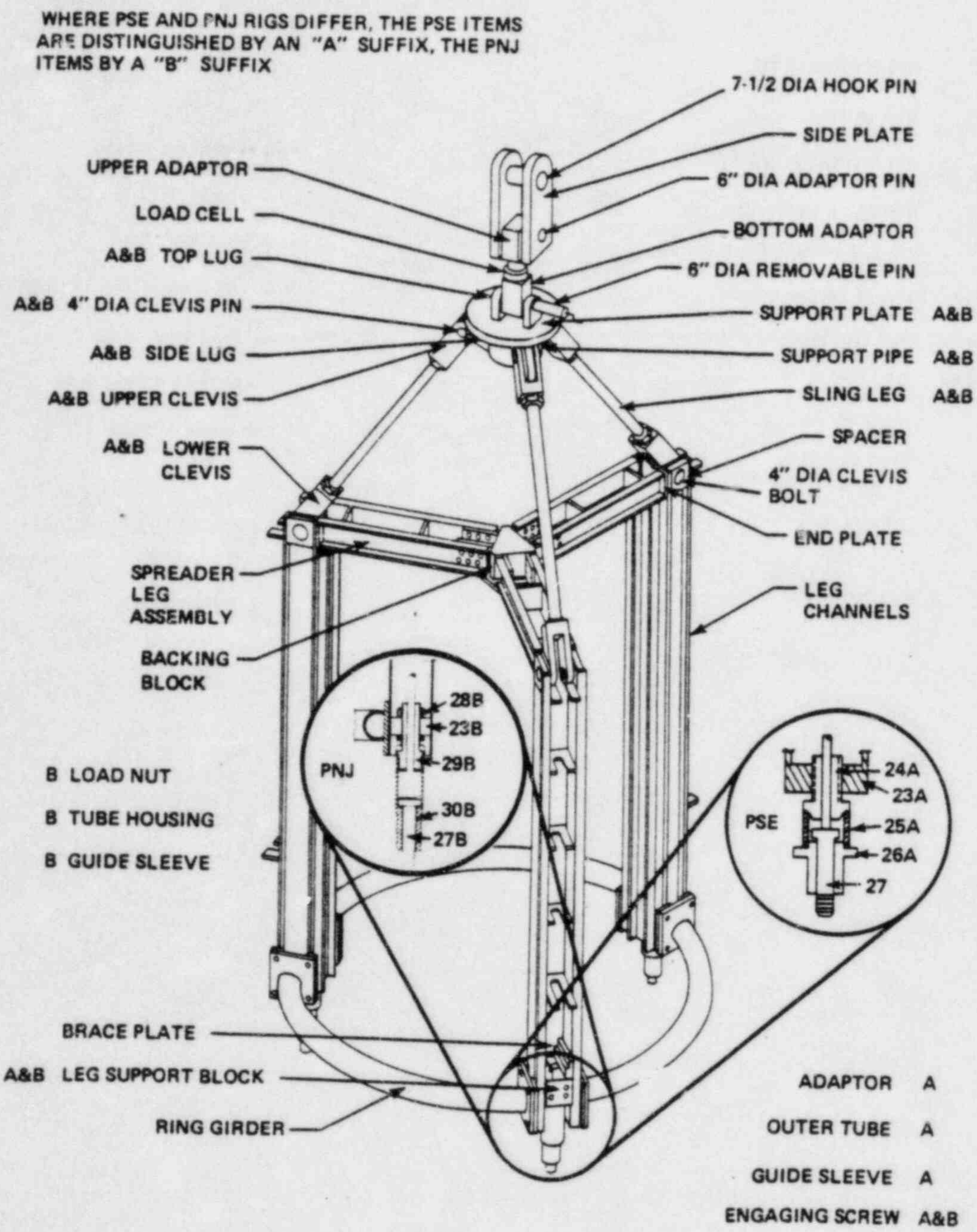

Figure 2-2. Reactor Vessel Internals Lift Rig

SECTION 3
SCOPE OF EVALUATION

The evaluation of these lifting devices consists mainly of three parts:

1. A detailed review of the ANSI N14.6 requirements

2. Preparation of a stress report

3. Recommendations to demonstrate compliance with NUREG 0612, Section 5.1.1(4).

Discussion of these items follows.

3.1 REVIEW OF ANSI N14.6-1978

A detailed comparison was made of the information contained in ANSI N14.6 with the information that was used to design, manufacture, inspect and test these special lifting devices. The detailed comparison is provided in three parts:

1. Overall item by item comparison of requirements

2. Preparation of a critical item list per ANSI N14.6 Section 3.1.2, and

3. Preparation of a list of nonconforming items.

This detailed analysis is contained in Attachment A to this report.

3.2 PREPARATION OF A STRESS REPORT

Section 3.1.3 of ANSI N14.6 and NUREG 0612 Section 5.1.1(4) require a stress report to be prepared. Special loads and allowable stress criteria are specified for this analysis. The stress report is Attachment B to this report.

3.3 RECOMMENDED ACTIONS

An obvious result from the previous evaluations is a list of items that can be performed to demonstrate to the NRC that these special lifting devices are in compliance with the guidelines of ANSI N14.6 and NUREG 0612 Section 5.1.1(4). These recommendations are identified in Section 6.

SECTION 4
DISCUSSION OF EVALUATIONS

4.1 STUDY OF ANSI N14.6-1978

A review of ANSI N14.6 identifies certain analyses to be performed and certain identifications that are required to be made to demonstrate compliance with this document. These are a preparation of a stress report in accordance with Section 3.2 and a preparation of a critical items list in accordance with Section 3.1.2. The stress report is Attachment B to this report. The critical items list has been prepared per Section 3.1.2 and is contained in Appendix A to Attachment A. This list identifies the critical load path parts and welds, the materials of these items, and the applied non-destructive volumetric and surface inspections that were performed. (Details of these non-destructive processes and acceptance standards are available at Westinghouse should they be needed.)

A detailed item by item comparison of all the requirements of ANSI N14.6 and those used for the design, manufacture and inspection of these lifting devices is contained as Table 2-1 of Attachment A. The comparison shows that these devices meet the intent of the ANSI document for design, fabrication and quality control. However, they do not meet the requirements of ANSI N14.6 for periodic maintenance, proof and functional testing. Thus, a tabulation of those ANSI N14.6 requirements that are incompatible with these lifting devices was prepared and is Appendix B to Attachment A. Included in Appendix B to Attachment A are recommended actions that may be used to demonstrate acceptability to the NRC.

4.2 STRESS REPORT

As part of the invoking of the ANSI N14.6 document, the NRC requested utilities to demonstrate their compliance with the stress criteria with some qualifying conditions. Attachment B is the stress report for these devices performed in accordance with the criteria of ANSI N14.6. A

discussion is included which responds to the NRC qualifying conditions of NUREG 0612. All of the tensile and shear stresses meet the design criteria of Section 3.2.1.1 of ANSI N14.6, requiring application of stress design factors of three and five with the accompanying allowable stress limits of yield and ultimate strength, respectively.

4.3 RECOMMENDATIONS

The recommendations identified in Section 6 require a review of plant maintenance and operating instructions to ensure that they contain information relative to the identification, maintenance and periodic testing required by ANSI N14.6. The extent of the periodic testing is also addressed and the recommendations identify procedures which are intended to fully meet the intent of NUREG 0612 and ANSI N14.6 with the least amount of perturbation to the refueling sequence. These recommendations do not involve any equipment changes unless stricter compliance becomes necessary, and then a change to the sling blocks is recommended.

SECTION 5
CONCLUSIONS

The following conclusions are apparent as a result of this evaluation:

1. The ANSI N14.6 requirements for design, fabrication and quality assurance are generally in agreement with those used for these special lift devices.

2. The ANSI N14.6 criteria for stress limits associated with certain stress design factors for tensile and shear stresses are adequately satisfied.

3. These devices are not in strict compliance only with the ANSI N14.6 requirements for acceptance testing, maintenance and verification of continuing compliance. Recommendations are included to identify actions that should enable these devices to be considered in compliance with the intent of ANSI N14.6.

4. The application of the ANSI N14.6 criteria for stress design factor of 3 and 5 are only for shear and tensile loading conditions. Other loading conditions are to be analyzed to other appropriate criteria.

SECTION 6
RECOMMENDATIONS

The following recommendations address the areas of ANSI N14.6 which are incompatible with the present lifting devices and which are considered most important in demonstrating the continued reliability of these devices. They consist of suggestions and proposed responses to identify compliance to the NRC and future considerations.

6.1 Review plant operating procedures to include consideration of ANSI N14.6 Sections 5.1.3 through 5.1.8. These sections include requirements for: scheduled periodic testing; special identification and marking; maintenance, repair, testing and use. Westinghouse remarks on addressing these sections are listed in Attachment A, Appendix B, Items 7, 8, and 9.

6.2 A proposed response to the requirement of ANSI N14.6 Section 5.2.1 requiring an initial acceptance load test prior to use equal to 150 percent of the maximum load is as follows:

After site assembly these special lifting devices were subject to a 100 percent load test followed by non-destructive testing of all critical areas. The Unit 2 internals lift rig was subject to a 125 percent load test followed by appropriate non-destructive testing of all critical areas. The new load path items will be tested to 150 percent of the maximum load prior to shipment.

6.3 A proposed response to ANSI N14.6 Section 5.3 which requires, annually, either a 150 percent maximum load test or dimensional, visual and non-destructive testing of major load carrying welds and critical areas follows. (Since the 150 percent load test is very impractical, the approach identified in the following recommendation is to perform a minimum of non-destructive testing.)

a. Reactor Vessel Head Lift Rig

Prior to use and after reassembly of the spreader assembly, lifting lug and upper lifting legs to the upper portion of the lift rig, visually check all welds. Raise the vessel head slightly above its support and hold for 10 minutes. During this time, visually inspect the sling block top lug to top plate weld, side lugs to support pipe welds, and spreader lug to spreader arm weld. If no problems are apparent, continue to lift, monitoring the load cell readout at all times.

b. Reactor Vessel Internals Lift Rig

Prior to use, visually inspect the rig components and welds while on the storage stand for signs of cracks or deformation. Check all bolted joints to ensure that they are tight and secure. After connection to the upper or lower internals, raise the assembly slightly off its support and hold for 10 minutes. During this time, visually inspect the sling block top lug to support plate weld, side lugs to support pipe welds, spacer to leg weld, and brace plate and leg support block to leg welds. If no problems are apparent, continue to lift, monitoring the load cell readout at all times.

The above actions do not include a non-destructive test of these welds because:

a. Access to the welds for surface examination is difficult. These rigs are in containment and some contamination is present.

b. All tensile and shear stresses in the welds are well within the allowable stress.

c. The items that are welded remain assembled and cannot be misused for any other lift other than their intended function.

d. To perform non-destructive tests would require:

(1) Removal of paint around the area to be examined which is contaminated.

(2) Performance of either magnetic particle inspection or liquid penetrant inspection and

(3) Repainting after testing is completed.

(4) Cleanup of contaminated items.

Performing non-destructive tests on these welds every refueling would increase the critical path refueling time.

Dimensional checking is not included since these structures are large (about 14 feet diameter by 30 feet high) and the results of dimensional checking would always be questionable. Other checks on critical load path parts such as pins, are also not included since an examination of these items would require disassembly of the special lift devices.

6.4 Recommend that a periodic non-destructive surface examination of critical welds and/or parts be performed once every ten years as part of an inservice inspection outage.

6.5 Recommend that the head and internals lift rig sling block be changed to a forged block with welded side lugs to reduce the number of welds and eliminate any concern, if any, of lamellar tearing, should the NRC require yearly surface inspection of welds and plates.

6.6 Recommend that no changes be made to the reactor vessel internals lift rig should the stresses, discussed in Attachment B, be considered excessive by others because:

a. The design weight used in the stress calculations is based on the weight of the lower internals. The lower internals are only removed when a periodic inservice inspection of the vessel is required (once/10 years).

b. Prior to removal of the lower internals, all fuel is removed. Thus the concern for handling over fuel is non-existent in this particular case.

c. Normal use of the rig is for moving the upper internals which weigh less than one-half of the lower internals. The design weight is based on lifting the lower internals. Thus all the stresses could be reduced by more than 50 percent and considered well within the ANSI N14.6 criteria for stress design factors.

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ATTACHMENT A
to WCAP-10167

Comparison of ANSI N14.6-1978 Requirements for Special Lifting Devices and the Requirements for the Reactor Vessel Head Lift Rig, Reactor Vessel Internals Lift Rig, Load Cell, and Load Cell Linkage
for
Public Service Electric and Gas Company
Salem Generating Station
Units 1 and 2

February 1983

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ABSTRACT

The requirements used in the original design, fabrication, testing, maintenance and quality assurance were compared to the ANSI N14.6-1978 requirements for the Salem reactor vessel head and internals lift rig, load cell and load cell linkage. A critical items list per ANSI N14.6 section 3.1.2 has been prepared and a tabulation of ANSI N14.6 requirements that are, at present, incompatible with the Salem lifting devices has been prepared.

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REFERENCES

1. Westinghouse Drawing 685J059 - Head Lifting Rig General Assembly

2. Westinghouse Drawing 113E480 - 4 Loop Plants Lifting Rig Internals General Assembly

SECTION 1
PURPOSE

The purpose of this report is to compare the requirements of the special lifting rigs used to lift the reactor vessel head, reactor vessel upper and lower internals with the requirements contained in ANSI N14.6 for special lifting devices.

SECTION 2

INTRODUCTION

ANSI N14.6-1978-"American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More for Nuclear Materials" contains detailed requirements for the design, fabrication, testing, maintenance and quality assurance of special lifting devices. NUREG 0612 "Control of Heavy Load at Nuclear Power Plants", paragraph 5.1.1(4), specifies that special lifting devices should satisfy the guidelines of ANSI N14.6-1978. Subsequently the Nuclear Regulatory Commission (NRC) has requested operating plants to demonstrate compliance with NUREG 0612. To demonstrate compliance with this document, a detailed comparison of the original design, fabrication, testing, maintenance and quality assurance requirements with those of ANSI N14.6 is necessary.

Thus, the ANSI N14.6 document has been reviewed in detail and compared to the requirements used to design and manufacture the reactor vessel head lift rig, the reactor vessel internals lift rig, load cell, load cell linkage and the reactor coolant pump motor lift sling. This comparison is listed in Table 2-1.

2.1 BACKGROUND

The reactor vessel head lift rig, the reactor vessel internals lift rig, load cell, and load cell linkage were originally designed and built for the the Salem Generating Station circa 1967-1971. Subsequently, the Unit 2 internals lift rig was transferred to another plant site in 1975-76 and replaced in 1977 with an almost identical design. The actual design criteria is unknown for the lifting devices. It appears that Westinghouse used the design criteria that the resulting stress in the load carrying members, when subjected to the total combined lifting weight, should not exceed one fifth (1/5) of the ultimate strength of the material. These items were not classified as nuclear safety components and requirements for formal documentation of design requirements and stress reports were not applicable. Thus, stress reports and design specifications were not formally documented. Westinghouse defined the

design, fabrication and quality assurance requirements on detailed manufacturing drawings and purchase order documents. Westinghouse also issued field assembly instructions for the reactor vessel head and internals lift rigs which included an initial load test followed by non-destructive surface examination of critical load bearing areas. Additionally, the new Unit 2 internals lift rig was load tested at the manufacturers shop at 125 percent of the maximum weight. Subsequent modifications (presently in progress) to the internals lifting rig include rotolock studs and inserts designed, manufactured, and tested to the requirements of ANSI N14.6.

2.2 COMPONENT DESCRIPTION

2.2.1 Reactor Vessel Head Lift Rig

The reactor vessel head lift rig[1] is a three-legged carbon steel structure, approximately 43 feet high and 14 feet in diameter, weighing approximately 28,000 pounds. It is used to handle the assembled reactor vessel head.

The three vertical legs and control rod drive mechanism (CRDM) platform assembly are permanently attached to the reactor vessel head lifting lugs. The tripod sling assembly is attached to the three vertical legs and is used when installing and removing the reactor vessel head. During plant operations, the sling assembly is removed and the three vertical legs and platform assembly remain attached to the reactor vessel head.

2.2.2 Reactor Vessel Internals Lift Rig

The reactor vessel internals lift rig[2] is a three-legged carbon and stainless steel structure, approximately 25 feet high and 14 feet in diameter weighing approximately 14,500 pounds. It is used to handle the upper and lower reactor vessel internals packages. It is attached to

the main crane hook for all lifting, lowering and traversing operations. A load cell linkage is connected between the main crane hook and the rig to monitor loads during all operations. When not in use, the rig is stored on the upper internals storage stand.

The original rig design attaches to the internals packages by means of three engaging screws which are screwed into tapped holes in the internals flanges. These screws are manually operated from the manipulator crane walkway using a handling tool which is essentially a long wrench. The screws are normally spring retracted upward and are depressed to engage the tapped holes by the weight of the handling tool. Modifications to these rigs, presently in progress, include installation of an operating platform, integral tools and a change to the type of engagement with the internals to a rotolock stud and insert type. These rotolock studs are manually operated from the new internals lift rig platform using a handling tool which is an integral part of the rig. The studs are normally spring retracted upward and are depressed to engage the inserts. Rotating the mechanism locks it in both positions. Since these rotolock studs are in the process of being incorporated, both types of load carrying items are included in this report.

2.2.3 Load Cell and Load Cell Linkage

The load cell is used to monitor the load during lifting and lowering the reactor vessel head or internals to ensure no excessive loadings are occurring. It is installed between the load cell linkage and the lifting device. The load cell is a strain gage (tension) type, rated at 400,000 pounds, built by W. C. Dillon and Co. The load cell linkage is an assembly of pins, plates and bolts which connect the polar crane main hook to the load cell.

TABLE 2-1

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
1 1.1 to 1.3 2	Scope and Definitions - These sections define the scope of the document and include pertinent definitions of specific items	These sections are definitive, and not requirements.
3 3.1 3.1.1 to 3.1.4	Design Designer's Responsibilities - This section contains requirements for preparing a design specification and its' contents, stress reports; repair procedures; limitations on use with respect to environmental conditions; marking and nameplate information; and critical items list.	A. No original design specification was written concerning these specific requirements. Subsequent modifications to the internals lift rig meet these requirements. However, assembly and detailed manufacturing drawings and purchasing documents contain the following requirements: (1) Material specification for most of the critical load path items to ASTM, ASME specifications or special listed requirements. (2) All welding, weld procedures and welds to be in accordance with ASME Boiler and Pressure Vessel Code - Section IX. (3) Special non-destructive testing for specific critical load path items to be performed to written and approved procedures in accordance with ASTM or specified requirements

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TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
		(4) All coatings to be performed to strict compliance with specified requirements. (5) Letters of compliance for materials and specifications were required for verification with original specifications. B. A stress report was not originally required but has been prepared and is Attachment B. C. Repair procedures were not identified. D. No limitations were identified as to the use of these devices under adverse environments. E. Markings and nameplate information was not addressed. F. Critical item lists have been prepared for each device and are identified as Appendix A to this Attachment A.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
3.2 3.2.1 3.2.6	Design Criteria Stress Design Factors - These sections contain requirements for the use of stress design factors of 3 and 5 for allowable stresses of yield and ultimate respectively for maximum shear and tensile stresses; high strength material stress design factors; special pins; wire rope and slings to meet ANSI B30.9-1971; and drop-weight tests and Charpy impact test requirements	1. The actual design criteria is unknown for the lifting devices. It appears that for the head lifting rig, internals lift rig and load cell, that in most cases the design criteria used was that the resulting stress in the load carrying members, when subjected to the total combined lifting weight, should not exceed one fifth (1/5) of the ultimate strength of the material. A stress report (Attachment B) has been generated which addresses the capability of these rigs to meet the ANSI design stress factors. 2. High strength materials are used in some of these devices (mostly for pins, loadcell). Although the fracture toughness was not determined, the material was selected based on it's excellent fracture toughness characteristics. However, the stress design factors of ANSI N14.6 Section 3.2.1 of 3 and 5 were used in the analysis and the resulting stresses are acceptable. 3. Where necessary, the weight of pins was considered for handling.

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TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
		4. Drop weight and Charpy impact tests were not required nor performed.
3.3 3.3.1 to 3.3.8	Design Considerations - These sections contain considerations for; materials of construction, lamellar tearing; decontamination effects; remote engagement provisions; equal load distribution; lock devices; position indication of remote actuators; retrieval of device if disengaged; and nameplates.	Decontamination was not specifically addressed. Lamellar tearing was considered in the design of the reactor vessel and internals lift rig sling blocks by requiring non-destructive tests (ultrasonic, magnetic particle and radiograph) of the base material and assembly welds. Even distribution of the load is evident from these designs. Locking plates, pins, etc. are used throughout these special lifting devices. Remote actuation is only used when engaging the internals lift rig with the internals, however, present modifications include positive position indication of engagement. All these items were considered and the designs reflect these requirements.
3.4 3.4.1 to 3.4.6	Design Considerations to Minimize Decontamination Efforts in Special Lifting Device Use - These sections contain fabrication, welding, finishes, joint and machining requirements to permit ease in decontamination.	Decontamination was not specifically addressed. However, the design and manufacture included many of these items, i.e. lock devices, pins, etc.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
3.5 3.5.1 to 3.5.10	<u>Coatings</u> - These sections contain provisions for ensuring proper methods are used in coating carbon steel surfaces and for ensuring non-contamination of stainless steel items.	The requirements for coating carbon steel surfaces are contained in a Westinghouse process specification referenced on the assembly and detail drawings. This specification requires a proven procedure, proper cleaning, preparation, application and final inspection of the coating. These requirements meet the intent of 3.5.1 through 3.5.8. No provisions were included in these designs for consideration of decontamination materials or the use of non-contaminating contact materials for use in stainless steel parts.
3.6 3.6.1 to 3.6.3	<u>Lubricants</u> - These sections contain requirements for special lubricants to minimize contamination and degradation of the lubricant and contacted surfaces or water pools	No specific lubrication requirements have been identified. However, neolube is recommended for use with the engaging screws in the internals lift device which are under water and silicone grease for the load cell pins which are out of water.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
4 4.1 4.1.1 to 4.1.12	Fabrication Fabricators Responsibilities -These sections contain specific requirements for proper quality assurance, document control, deviation control, procedure control, material identification and certificate of compliance.	A formal quality assurance program for the manufacturer was not specifically required. However, all the manufacturers welding procedures and non-destructive testing procedures were reviewed by Westinghouse prior to use. All critical load carrying members require letters of compliance for material requirements. Westinghouse performed certain checks and inspections during various steps of manufacturing. Final Westinghouse review includes visual, dimensional, procedural, cleanliness, personnel qualification, etc. and issuance of a quality release to ensure conformance with drawing requirements.
4.2 4.2.1 to 4.2.5	Inspectors Responsibilities -These sections contain requirements for a non-supplier inspector.	Westinghouse Quality Assurance personnel performed inprocess and final inspections similar to those identified in these sections. (Also see comments to Section 4.1 above)
4.3 4.3.1 to 4.3.3	Fabrication Considerations -These sections contain special requirements for ease in decontamination or control of corrosion.	General good manufacturing processes were followed in the manufacture of these devices. However, the information defined in these sections was not specifically addressed.

TABLE 2-1 (cont)

COMPARISON OF REQUIREMENT OF THE ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
5 5.1 5.1.1 to 5.1.8	<u>Acceptance Testing Maintenance, and Assurance of Continued Compliance Owner's Responsibilities</u> - Sections 5.1.1 and 5.1.2 require the owner to verify that the special lifting devices meet the performance criteria of the design specification by reviewing records and witness of testing.	Both of these rigs were load tested after initial assembly on site followed by non-destructive testing of critical load bearing areas. The new Unit 2 internals lift rig was also load tested to 125% of the design weight. However, the Westinghouse Quality Release may be considered an acceptable alternate to verify that the criteria for letters of compliance for materials and specifications required by the Westinghouse drawings and purchasing documents was satisfied.
	Section 5.1.3 requires periodic functional testing	Maintenance and inspection procedures should be revised to include a visual check of critical welds and parts during lifting to comply with this requirement for functional testing.
	Section 5.1.4 requires operating procedure	Operating instructions for the reactor vessel internals lift rig were furnished to the utility and operating procedures were prepared and are used.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
	Sections 5.1.5, 5.1.5.1 and 5.1.5.2 require special identification and marking to prevent misuse.	It is obvious from their designs that these rigs are special lifting devices and can only be used for their intended purpose. Specific identification of the rig can be made by marking, with stencils, the rig name and rated capacity, preferably on the spreader assembly.
	Sections 5.1.6, 5.1.7 and 5.1.8 require the owner to provide written documentation on the maintenance, repair, testing and use of these rigs.	Operating instructions and maintenance instructions should be reviewed to assure that they contain the requirements to address maintenance logs, repair and testing history, damage incidents etc.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND

SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
5.2 and 5.3 5.2.1 to 5.2.3 and 5.3.1 to 5.3.8	<u>Acceptance Testing and Testing to Verify Continuing Compliance</u> - These paragraphs require the rigs to be initially tested at 150% maximum load followed by non-destructive testing of critical load bearing parts and welds and also annual 150% load tests or annual non-destructive tests and examinations; qualification of replacement parts.	The head and internals lift rigs were load tested after field assembly. In addition, the new Unit 2 internals lift rig was load tested to 125% load at initial manufacture. The new load bearing modifications presently in progress will meet these requirements. It is suggested that a check of critical welds and parts be included in the maintenance procedures. Preferably, a visual check during initial lift should be acceptable. Further note that with the use of the load cell for the head and internals, lifting and lowering is monitored at all times. However, the load cell, cannot exceed the rated load by 20% without being inaccurate. This would preclude monitoring of a 150% load test with the present equipment. Replacement parts should be in accordance with the original or equivalent requirements.

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TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENT OF ANSI N14.6 AND SALEM SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
5.4 5.4.1 to 5.4.2	Maintenance and Repair - This section requires any maintenance and repair to be performed in accordance with original requirements and no repairs are permitted for bolts, studs and nuts.	Maintenance and repair procedure should contain, as much as possible, requirements that were used in the original fabrication. The critical items list of Appendix A contains the original type of non-destructive testing. The procedure should also define bolts, studs and nuts as non-repairable items.
5.5 5.5.1 to 5.5.2	Non-destructive Testing Procedures, Personnel Qualifications, and Acceptance Criteria - This section requires non-destructive testing to be performed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code	Liquid penetrant, magnetic particle, ultrasonic and radiograph inspections were performed on identified items. These were in accordance with Westinghouse process specifications or as noted on detailed drawings and provide similar results to the requirement of the ASME Code.
6 6.1 6.2 6.3	Special Lifting Devices for Critical Loads - These sections contain special requirements for items handling critical loads.	It is assumed that compliance with NUREG 0612, Section 5.1 has been demonstrated and therefore this section is not applicable to these devices.

SECTION 3
DISCUSSION

The reactor vessel head and internals lift rigs, load cell and load cell linkage generally meet the intent of the ANSI N14.6 requirements for design and manufacture. However, they are not in strict compliance with the ANSI N14.6 requirements for acceptance testing, maintenance and verification of continuing compliance.

Although no specific design specification was written, the assembly and detailed manufacturing drawings and purchase order documents contain equivalent requirements. A stress report has been prepared for these devices and the design criteria is considered satisfied. These devices, were manufactured under Westinghouse surveillance with identified hold points, procedure review and personnel qualification which adequately meet these related ANSI requirements. Acceptance testing as defined in ANSI N14.6 was not performed, but an initial 100 percent load test was conducted on these special lift devices followed by non-destructive testing of critical areas. In addition, the Unit 2 internals lift rig was 125 percent load tested. The new modifications of load bearing items will comply with ANSI N14.6. The load cell was calibrated in tension at its capacity of 400,000 pounds.

It is anticipated that a 100 percent load test, performed on each device, followed by a visual check of critical welds would be sufficient to demonstrate compliance. This may require modification of Salem operating and maintenance procedures.

SECTION 4
CONCLUSIONS

The review of the ANSI N14.6 requirements and comparison with the original Westinghouse requirements has shown that these items are generally in agreement for the design, fabrication and quality assurance of the lifting devices. However, the lifting devices are not in strict compliance with the ANSI N14.6 requirements for acceptance testing, maintenance and verification of continuing compliance. These specific requirements that are incompatible with the lifting devices are discussed in Appendix B with suggested actions. Westinghouse's objective was to provide a quality product and this product was designed, fabricated, assembled and inspected in accordance with internal Westinghouse requirements. In general, Westinghouse requirements meet the intent of ANSI N14.6 but not all the specific detailed requirements.

APPENDIX A

CRITICAL ITEMS LIST PER ANSI N14.6-1978

1. GENERAL

Section 3.1.2 of ANSI N14.6-1978 specifies that the design specification shall include a critical items list, which identifies critical components and defines their critical characteristics for material, fabrication, non-destructive testing and quality assurance.

"Critical items list" is further defined in ANSI N14.6, Section 2 as:

> "critical items list. A list that specifies the items of a special lifting device and their essential characteristics for which specified quality requirements shall apply in the design, fabrication, utilization, and maintenance of the device."

Load carrying members and welds of these special lifting devices are considered to be the critical items.

Tables A-1, A-2, A-3, and A-4, are the critical items list of parts and welds for the reactor vessel head lift rig, the reactor vessel internals lift rig, load cell and load cell linkage, respectively. These tables include the material identification, and the applicable volumetric and surface inspections that were performed in the fabrication of these special lifting devices. In some instances, non-destructive testing was not specified since the material selection and strength result in very low tensile stresses and thus, non-destructive testing was not justified.

The material selection for most critical load path items was made to ASTM, ASME or special material requirements. The material requirements were supplemented by Westinghouse imposed non-destructive testing, and/or special heat treating requirements for all of the critical items. Westinghouse required all welding, welders, and weld procedures

to be in accordance with ASME Boiler and Pressure Vessel Code Section IX for carbon steel welds. Westinghouse required certificates, or letters of compliance that the materials and processes used by the manufacturer were in accordance with the purchase order and drawing requirements. Westinghouse also performed final inspections on these devices and issued quality releases. The new modifications to the internals lift rig pertinent to critical items are also included.

TABLE A-1

REACTOR VESSEL HEAD LIFT RIG

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item[a]	Description	Material	Non-destructive Testing	
			Material	Finished
1,3,6,10, 15	Pins	ASTM A434 Class BD	Ultrasonic	Magnetic Particle
2	Side Plate	ASTM A514 or USS-T1	Ultrasonic	Magnetic Particle
4,5	Sling Assembly Link and Lug	ASTM A237 Class A	Ultrasonic	Magnetic Particle
7,9	Clevis	ASTM A237 Class BD	Ultrasonic	Magnetic Particle
8	Arm	ASTM A306 Grade 70	Ultrasonic	Magnetic Particle
11	Support Lug	ASTM A515 Grade 70	Ultrasonic Magnetic Particle	
12	Ring Girder	ASTM A285 Grade C		
13	Leg	ASTM A36		
14	Clevis Plate	ASTM A515 Grade 70	Ultrasonic Magnetic Particle	

(a)See figure A-1

TABLE A-2

REACTOR VESSEL HEAD LIFT RIG

CRITICAL ITEMS LIST OF WELDS

PER ANSI N14.6-1978

Item[a]	Weld Description	Non-destructive Testing	
		Root Pass	Final
4,5	Link Lugs to Link (full penetration)		Radiograph Magnetic Particle
11,12	Ring Girder to Support Lug (fillet)		Magnetic Particle
13,14	Clevis Plate to Leg (fillet)	Visual	Magnetic Particle

[a] See figure A-1.

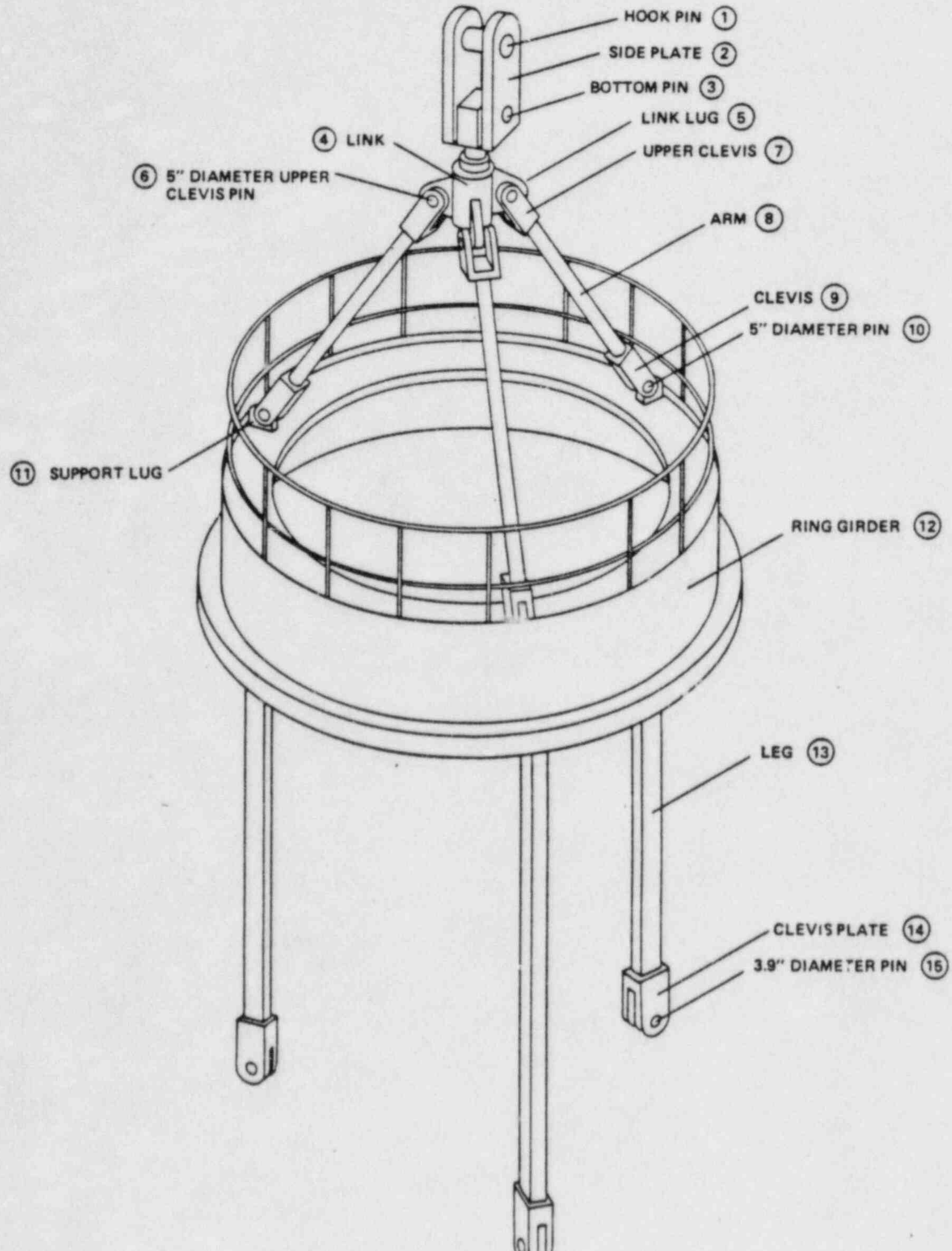

Figure A-1. Reactor Vessel Head Lift Rig

TABLE A-3

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item(1)	Description	Material	Non-destructive Testing	
			Material	Finished
1,3,7, 12	7-1/2" Dia. Hook Pin 6" Dia. Adaptor Pin 6" Dia. Removable Pin 4" Dia. Clevis Pin	ASTM A434 Class BD AISI 4340	Ultrasonic	Magnetic Particle
2	Load Cell Linkage Side Plates	ASTM A515 Grade 70	Ultrasonic	
4,6	Adaptors	AISI 4340	Ultrasonic	Magnetic Particle
5	Load Cell	17-4 pH Stain- less Steel, Condition H- 1100	Ultrasonic	Liquid Particle
8a, 10a(2)	Top Lug Support Plate	ASTM A515 Grade 70	Magnetic Particle Ultrasonic	
8b,10b(2)	Top Lug Support Plate	ASTM 533 Grade B Class 1	Magnetic Particle Ultrasonic	
11a(2)	Side Lug	ASTM A515 Grade 70	Magnetic Particle Ultrasonic	
11b(2)	Side Lug	ASTM A588 Grade A Class 1	Ultrasonic Magnetic Particle	

(1) See figure A-2

(2) Subscript (a) refers to Unit 1 only, while subscript (b) refers to Unit 2; no subscript means identical to both units.

TABLE A-3 (cont)

REACTOR VESSEL INTERNALS LIFT RIG

LOAD CELL AND LOAD CELL LINKAGE

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item(1)	Description	Material	Non-destructive Testing	
			Material	Finished
13a,15a(2)	Clevis	SA508 Class 2	Ultrasonic	Magnetic Particle
13b,15b(2)	Clevis	ASTM A668 AISI 4340 Class M	Ultrasonic	Magnetic Particle
14a(2)	Sling Leg	AISI 1117 Hot Rolled AISI 1020 Cold Rolled		
14b(2)	Sling Leg	ASTM A434 Class BC AISI 4340	Ultrasonic	Magnetic Particle
16	4" Dia. Clevis Bolt	ASTM A434 Class BD AISI 4340	Ultrasonic	
20	Spacer	ASTM A588 Grade A or B		
21,22	Leg Channel Brace Plate	ASTM A36		
23	Leg Support Block	AISI 8620	Ultrasonic Magnetic Particle	

(1)See figure A-2

(2)Subscript (a) refers to Unit 1 only, while subscript (b) refers to Unit 2; no subscript means identical to both units.

TABLE A-3 (cont)

REACTOR VESSEL INTERNALS LIFT RIG

LOAD CELL AND LOAD CELL LINKAGE

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item[1]	Description	Material	Non-destructive Testing	
			Material	Finished
24a[3], 26a[3]	Adaptor Guide Sleeve	ASTM A276 Type 304 Condition A		
25a[3]	Outer Tube	ASTM A312 Type 304 Seamless		
27[3]	Engaging Screw	ASTM A564 Grade 630, Cond. 1100	Ultrasonic	Liquid Penetrant
28b[2]	Load Nut	ASTM A276 Type 304 Cond. A		
29b[3]	Tube Housing	ASTM A276 Type 304 Cond. A		
30b[3]	Guide Sleeve	ASTM A276 Type 304 Cond. A		

(1) See figure A-2

(2) Subscript (a) refers to Unit 1 only, while subscript (b) refers to Unit 2; no subscript means identical to both units.

(3) These items will be replaced in the forthcoming modifications.

TABLE A-3 (cont)

REACTOR VESSEL INTERNALS LIFT RIG

LOAD CELL AND LOAD CELL LINKAGE

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item[1]	Description	Material	Non-destructive Testing	
			Material	Finished
31a[4]	Load Nut	ASTM A276, Type 304 SS Condition A	Ultrasonic	
32[4]	Rod Housing	ASTM A276 Type 304 SS Condition A	Ultrasonic	
33[4]	Guide Sleeve	ASTM A276 Type 304 SS Condition A	Ultrasonic	Liquid Penetrant
34[4]	Rotolock Stud	ASTM A564, Type 630, 17-4 pH, H1100	Ultrasonic	Liquid Penetrant
35[4], 36[4]	Upper and Lower Internals Inserts	ASTM A637 Grade 688 Type 2 Inconel X-750	Ultrasonic	Liquid Penetrant

(1)See figure A-2, A-3
(4)These items are the new items to be installed.

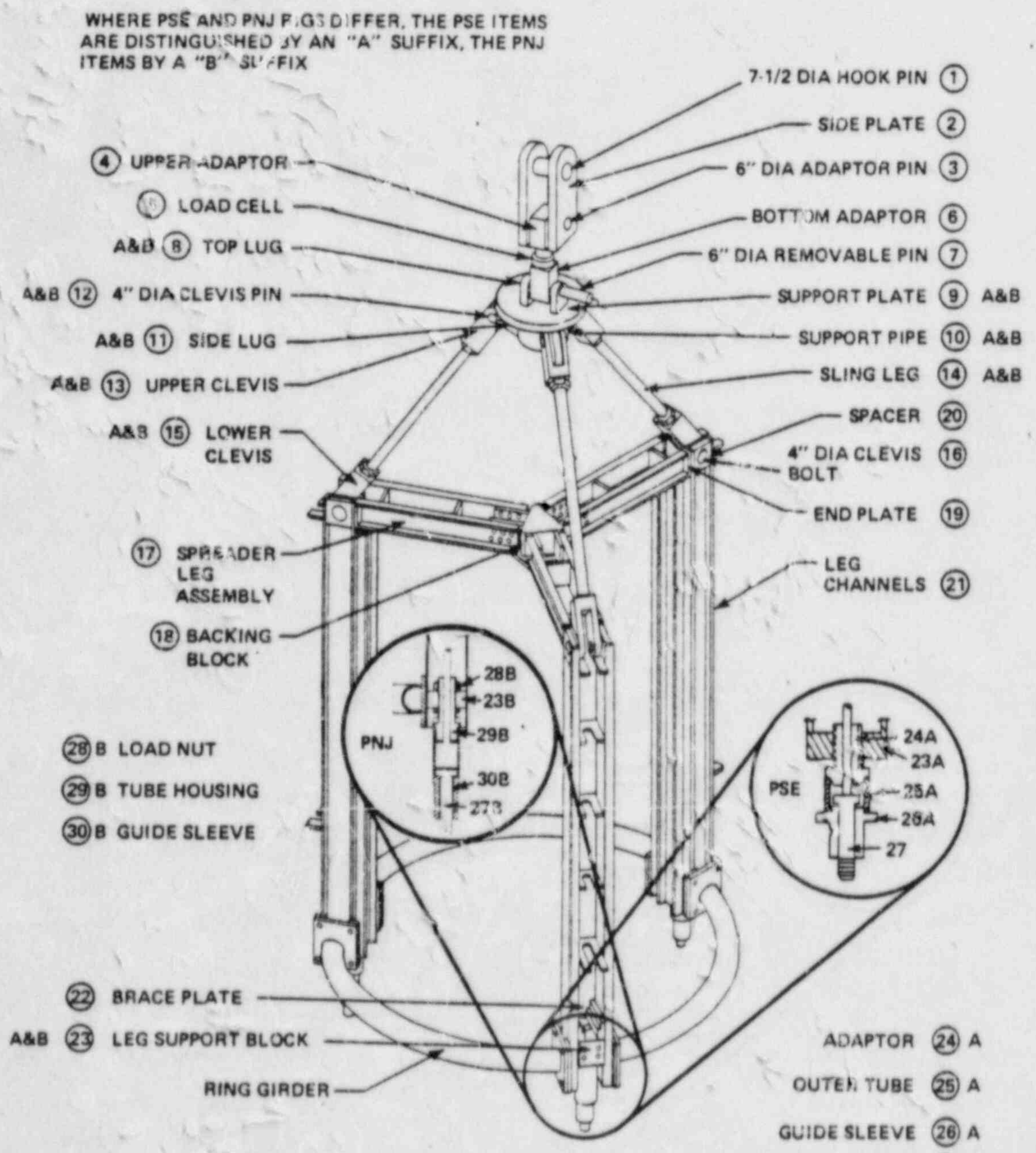

Figure A-2 Reactor Vessel Internals Lift Rig

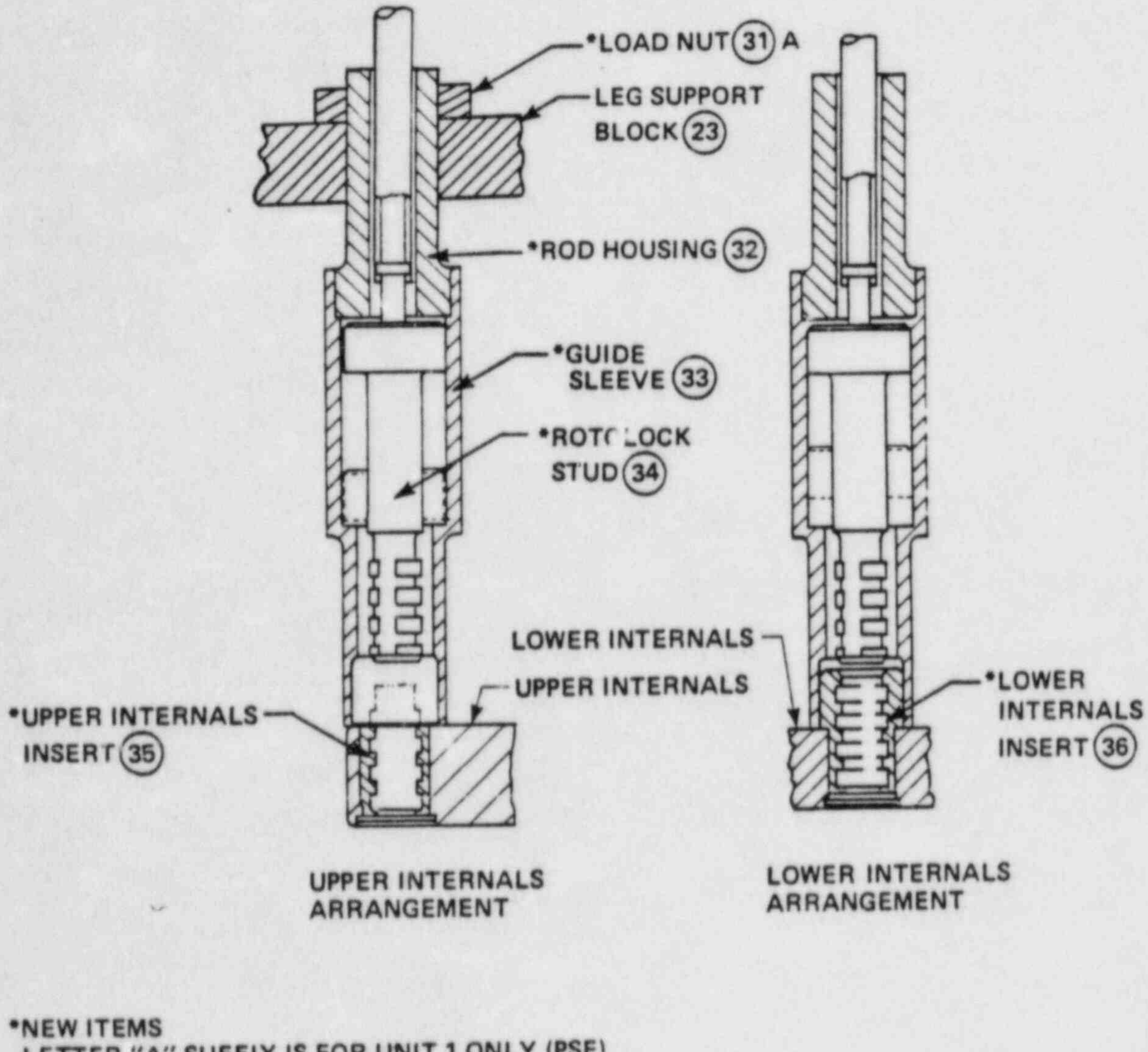

Figure A-3. Rotolock Studs and Inserts Arrangement

TABLE A-4

REACTOR VESSEL INTERNALS LIFT RIG

LOAD CELL AND LOAD CELL LINKAGE

CRITICAL ITEMS LIST OF WELDS

PER ANSI N14.6-1978

Item	Weld Description	Non-destructive Testing	
		Root Pass	Final
8,10	Sling Block Top Lugs to Support Plate (full penetration)	Magnetic Particle	Ultrasonic Magnetic Particle
9,11	Side Lugs to Support Pipe (full penetration)	Magnetic Particle	Radiograph Magnetic Particle
20	Spacer to Leg Weld (Top and Bottom) (full penetration)	Magnetic Particle	Visual Magnetic Particle
24a[(1)], 25a	Torque Tube Adapter to Outer Tube (full penetration)	Liquid Penetrant	Liquid Penetrant
21,22,23	Brace Plate and Leg Support Block to Leg Weld (fillet)	Magnetic Particle	Visual Magnetic Particle

(1)Subscript (a) refers only to Unit 1.

APPENDIX B

TABULATION OF ANSI N14.6-1978 REQUIREMENTS INCOMPATIBLE WITH THE SALEM LIFTING DEVICES

1. GENERAL

The comparison of the various ANSI N14.6 requirements and those of these lifting devices has shown that these devices are not in strict compliance with all the ANSI N14.6 requirements. Listed below is a tabulation of those sections of ANSI N14.6 considered most important in demonstrating the continued load handling reliability of these special lifting devices. Associated Westinghouse remarks are also listed and could be used as suggested actions and/or responses to demonstrate compliance to the NRC.

1a. Requirement:
Para. 3.1.4 - requires the designer to indicate permissible repair procedures and acceptance criteria for the repair.

1b. Remarks:
Any repair to these special lifting devices is considered to be in the form of welding. Should pins, bolts or other fasteners need repair, they should be replaced, in lieu of repair, in accordance with the original or equivalent requirements for material and non-destructive testing. Weld repairs should be performed in accordance with the requirements identified in NF-4000 and NF-5000 (Fabrication and Examination) of the ASME Boiler and Pressure Vessel Code, Section III, Division 1 Subsection NF.

2a. Requirement:
Para. 3.2.1.1 - requires the design, when using materials with yield strengths above 80 percent of their ultimate

strengths, to be based on the material's fracture toughness and not the listed design factors.

2b. Remarks:

High strength materials are used in these devices. Although the fracture toughness was not determined, the material was selected based on it's excellent fracture toughness characteristics. However, in lieu of a different stress design factor, the stress design factors listed in 3.2.1 of 3 and 5 were used in the analysis and the resulting stresses are considered acceptable.

3a. Requirement:

Para. 3.2.6 requires material for load-bearing members to be subjected to drop-weight or Charpy impact tests.

3b. Remarks:

Fracture toughness requirements were not identified for the material used in these special lifting devices except for the upper and lower clevises of the internals lift rig. The applicable specification for these items is an ASME specification which requires Charpy tests. However, all material selection was based on its excellent fracture toughness characteristics.

4a. Requirement:

Para. 3.3.6 requires an indication that an actuating mechanism is engaged.

4b. Remarks:

The original reactor vessel internals lift rig design employs a long handled tool to engage the rig and the internals. The tool depresses a spring loaded tube and turns the engaging screw into the internals. No specific position indication is identified, except for scribe marks on the tool, and the visual difference in the top of the

spring loaded tube is considered sufficient indication that the internals are engaged. However, the new modifications, presently in progress, include an integral tool with indication of engagement.

5a. Requirement:
Para. 4.1.6 requires a formal quality assurance program for the manufacturer and para. 4.1.7 requires certification and identification of materials.

5b. Remarks:
A formal quality assurance program for the manufacturer was not required for all items. However, the manufacturers welding procedures and non-destructive testing procedures were reviewed by Westinghouse prior to use. All of the critical load carrying members require letters of compliance for material requirements. Westinghouse performed certain checks and inspections during various steps of manufacturing. Final Westinghouse review includes visual, dimensional, procedural, cleanliness, personnel qualification, etc. and issuance of a quality release to ensure conformance with drawing requirements.

6a. Requirement:
Para. 5.1 lists Owner Responsibilities and 5.1.2 requires the owner to verify that the special lifting devices meet the performance criteria of the design specification by records and witness of testing.

6b. Remarks:
There wasn't any design specification for these rigs. Load testing was performed on these lifting devices after field assembly. These were 100 percent load tested and non-destructive testing was conducted on critical welds following the test. In addition, the new Unit 2 internals

lift rig was load tested at assembly to 125 percent of the design weight. However, the Westinghouse Quality Release may be considered an acceptable alternate to verify that the criteria for letters of compliance for materials and specifications required by the Westinghouse drawings and purchasing document were satisfied.

7a. Requirement:
Para. 5.1.3 requires periodic functional testing and a system to indicate continued reliable performance.

7b. Remarks:
Maintenance and inspection procedures should include a visual check of critical welds and parts during lifting to comply with this requirement for functional testing.

8a. Requirement:
Para. 5.1.5, 5.1.5.1 and 5.1.5.2 require special identification and marking to prevent misuse.

8b. Remarks:
It is obvious, from their designs, that these rigs are specific lifting devices and can only be used for their intended purpose and parts are not interchangeable. Specific identification of the rig can be made by marking with stencils, the rig name and rated capacity, preferably on the spreader assembly.

9a. Requirement:
Para. 5.1.6, 5.1.7 and 5.1.8 require the owner to provide written documentation on the maintenance, repair, testing and use of these rigs.

9b. Remarks:
Operating instructions and maintenance instructions should be reviewed to assure that they contain the requirements

to address maintenance logs, repair and testing history, damage incidents and other items mentioned in these paragraphs.

10a. Requirement:

Para 5.2.1 requires the rigs to be initially tested at 150 percent maximum load followed by non-destructive testing of critical load bearing parts and welds.

10b. Remarks

The head lift rig and internals lift rig were all load tested at assembly to 100 percent of the load followed by non-destructive testing of critical welds. In addition, the new Unit 2 internals lift rig was 125 percent load tested at assembly.

11a. Requirement:

Para 5.2.2 requires replacement parts to be individually qualified and tested.

11b. Remarks

Replacement parts, should they be required, should be made of identical (or equivalent) material and inspections as originally required. Only pins, bolt and nuts are considered replacement parts for the reactor vessel head and internal lift rigs.

12a. Requirement:

Para 5.3 requires testing to verify continuing compliance and annual 150 percent load tests or annual non-destructive tests and examinations to be performed.

12b. Remarks

These special lifting devices are used during plant refueling which is approximately once per year. During plant operation these special lifting devices are

inaccessable since they are permanently installed and/or remain in the containment. They cannot be removed from the containment unless they are disassembled and no known purposes exist for disassembly. Load testing to 150 percent of the total weight before each use would require special fixtures and is impractical to perform. It is suggested that a check (visual) of critical welds and parts be conducted at initial lift prior to moving to full lift and movement for these devices. Preferably, a visual check during initial lift should be acceptable. Further note that with the use of the load cell for the head and internals lift rigs, all lifting and lowering is monitored at all times.

2. SUMMARY

The requirements for periodic checking and functional load testing appear to be the ANSI N14.6 requirements that are most difficult to demonstrate compliance. It is almost impractical to perform the 150 percent load test prior to each use. It is suggested that the proposal to the NRC include a 100 percent load test to be performed with a minimum of non-destructive testing, (visual-only) in the critical parts and welds.

WESTINGHOUSE CLASS 3

ATTACHMENT B to
WCAP-10167

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STRESS REPORT
REACTOR VESSEL HEAD LIFT RIG, REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE FOR PUBLIC SERVICE ELECTRIC AND GAS COMPANY SALEM GENERATING STATION UNITS 1 AND 2

February 1983

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6126B:1/030283

ABSTRACT

A stress analysis of the Salem reactor vessel head and internal lift rigs, load cell and load cell linkage was performed to determine the acceptability of these devices to meet the design requirements of ANSI N14.6.

ACKNOWLEDGMENT

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J. W. Richard, P.E.

J. S. Urban

F. Peduzzi

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REFERENCES

1. George, H., Control of Heavy Loads at Nuclear Power Plants Resolution of Generic Technical Activity A-36, NUREG 0612, July, 1980.

2. ANSI N14.6-1978, "Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500kg) or More for Nuclear Material," American National Standards Institute, New York, 1978.

3. ANSI B-30.9-1971, "Slings," American National Standards Institute, New York, 1971.

4. Westinghouse Drawing 113E775 - 3 Loop Head Lifting Rig General Assembly

5. Westinghouse Drawing 1099E84 - General Assembly - Lifting Rig Internals

6. Lin, C. W., "Approximate Evaluation of Dynamic Load Factors for Certain Types of Load Factors for Certain Types of Loading," ASME Paper 70-WA/NE-2.

7. Biggs, J. M., Introduction to Structural Dynamics, McGraw-Hill, New York, 1964.

8. Gwinn, Jr., J. T., "Stop Over-Designing for Impact Loads," Machine Design, 33, pp. 105-113 (1961).

9. Timoshenko, S., Strength of Materials, Part 1, Elementary Theory and Problems, D. Van Nostrand Company, Inc. Third Edition April 19[illegible]5, pp. 263-279.

10. ASME Boiler and Pressure Vessel Code, Section III, Division 1, "Nuclear Power Plant Components," American Society of Mechanical Engineers, New York, 1980.

11. Manual of Steel Construction, Seventh Edition, American Institute of Steel Construction, New York, 1973.

SECTION 1

INTRODUCTION

The Nuclear Regulatory Commission (NRC) issued NUREG 0612 "Control of Heavy Load at Nuclear Power Plants"[1] in 1980 to address the control of heavy loads to prevent and mitigate the consequences of postulated accidental load drops. NUREG 0612 imposes various training, design, inspection and procedural requirements for assuring safe and reliable operation for the handling of heavy loads. In the containment building, NUREG 0612 requires special lifting devices to meet the requirements of ANSI N14.6-1978 "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More for Nuclear Materials".[2] In general, ANSI N14.6 contains detailed requirements for the design, fabrication, testing, maintenance and quality assurance of special lifting devices. In addition, ANSI N14.6 requires that when wire rope or chain is used in the design of a lifting device, the wire rope or chain shall be in conformance with ANSI B30.9-1971 "American National Standard Safety Standard for Slings".[3] The NRC has requested operating plants to demonstrate compliance with these requirements.

This report contains the stress analysis performed on the Salem reactor vessel head lift rig, reactor vessel internals lift rig, load cell and load cell linkage to determine the acceptability of these devices to meet these requirements.

1.1 BACKGROUND

The reactor vessel head lift rig, the reactor vessel internals lift rig, load cell, and load cell linkage were originally designed and built for the Salem Generating Station circa 1967-1971. Subsequently, the Unit 2 internals lift rig was transferred to another plant site in 1975-76 and replaced in 1977 with an almost identical design. The actual design criteria is unknown for the lifting devices. It appears that Westinghouse used the design criteria that the resulting stress in the load carrying members, when subjected to the total combined lifting

weight, should not exceed one fifth (1/5) of the ultimate strength of the material. These items were not classified as nuclear safety components and requirements for formal documentation of design requirements and stress reports were not applicable. Thus, stress reports and design specifications were not formally documented. Westinghouse defined the design, fabrication and quality assurance requirements on detailed manufacturing drawings and purchase order documents. Westinghouse also issued field assembly instructions for the reactor vessel head and internals lift rigs which included an initial load test followed by non-destructive surface examination of critical load bearing areas. Additionally, the new Unit 2 intenals lift rig was load tested at the manufacturers shop at 125 percent of the maximum weight. Subsequent modification (presently in progress) to the internals lifting rig include rotolock studs and inserts designed, manufactured and tested to the requirement of ANSI N14.6.

SECTION 2
COMPONENT DESCRIPTION

2.1 REACTOR VESSEL HEAD LIFT RIG

The reactor vessel head lift rig[4] is a three-legged carbon steel structure, approximately 43 feet high and 14 feet in diameter, weighing approximately 28,000 pounds. It is used to handle the assembled reactor vessel head.

The three vertical legs and control rod drive mechanism (CRDM) platform assembly are permanently attached to the reactor vessel head lifting lugs. The tripod sling assembly is attached to the three vertical legs and is used when installing and removing the reactor vessel head. During plant operations, the sling assembly is removed and the three vertical legs and platform assembly remain attached to the reactor vessel head.

2.2 REACTOR VESSEL INTERNALS LIFT RIG

The reactor vessel internals lift rig[5] is a three-legged carbon and stainless steel structure, approximately 25 feet high and 14 feet in diameter weighing approximately 14,500 pounds. It is used to handle the upper and lower reactor vessel internals packages. It is attached to the main crane hook for all lifting, lowering and traversing operations. A load cell linkage is connected between the main crane hook and the rig to monitor loads during all operations. When not in use, the rig is stored on the upper internals storage stand.

The original rig design attaches to the internals packages by means of three engaging screws which are screwed into tapped holes in the internals flanges. These screws are manually operated from the manipulator crane walkway using a handling tool which is essentially a long wrench. The screws are normally spring retracted upward and are depressed to engage the tapped holes by the weight of the handling tool. Modifications to these rigs, presently in progress, include

installation of an operating platform, integral tools and a change to the type of engagement with the internals to a rotolock stud and insert type. These rotolock studs are manually operated from the new internals lift rig platform using a handling tool which is an integral part of the rig. The studs are normally spring retracted upward and are depressed to engage the inserts. Rotating the mechanism locks it in both positions. Since these rotolock studs are in the process of being incorporated, both types of load carrying items are included in this report.

2.3 LOAD CELL AND LOAD CELL LINKAGE

The load cell is used to monitor the load during lifting and lowering the reactor vessel head or internals to ensure no excessive loadings are occurring. It is installed between the load cell linkage and the lifting device. The load cell is a strain gage (tension) type, rated at 400,000 pounds, built by W. C. Dillon and Co. The load cell linkage is an assembly of pins, plates and bolts which connect the polar crane main hook to the load cell.

SECTION 3
DESIGN BASIS

3.1 DESIGN CRITERIA

NUREG 0612, paragraph 5.1.1(4) states that special lifting devices should satisfy the guidelines of ANSI N14.6. Further, NUREG 0612, 5.1.1(4) states: "In addition, the stress design factor stated in Section 3.2.1.1 of ANSI N14.6 should be based on the combined maximum static and dynamic loads that could be imparted on the handling device based on characteristics of the crane which will be used. This is in lieu of the guideline in Section 3.2.1.1 of ANSI N14.6 which bases the stress design factor on only the weight (static load) of the load and of the intervening components of the special handling device".

It can be inferred from this paragraph that the stress design factors specified in Section 3.2.1.1 of ANSI N14.6 (3 and 5) are not all inclusive. Also, it can be inferred that the specified ANSI N14.6 stress design factors should be increased by an amount based on the crane dynamic characteristics. The dynamic characteristics of the crane would be based on the main hook and associated wire ropes holding the hook. Most main containment cranes use sixteen (16) or more wire ropes to handle the load. Should the crane hook suddenly stop during the lifting or lowering of a load, a shock load could be transmitted to the connected device. Because of the elasticity of the sixteen or more wire ropes, the dynamic factor for a typical containment crane is not much larger than 1.0. The maximum design factor that is recommended by most design texts[6,7,8] is a factor of 2 for loads that are suddenly applied. The stress design factors required in Section 3.2.1.1 of ANSI N14.6 are:

$$3\ (\text{weight}) < \text{Yield Strength}$$
$$5\ (\text{weight}) < \text{Ultimate Strength}$$

The factor of 3 specified, certainly, includes consideration of suddenly applied loads for cases where the dynamic impact factor may be as high

as 2.0. Thus, we feel that the use of the design criteria in ANSI N14.6 satisfies the NUREG requirement.

To provide flexibility on stress design factor, the summary table list the stresses with stress design factors of 1, 3 and 5. Thus, any stress design factor may be easily applied to satisy any concerns.

3.2 DESIGN WEIGHTS

The following design weights were used in the analysis of the lifting devices:

3.2.1 Reactor Vessel Head Lift Rig

The design weight is 345,000 pounds which is the total weight of the reactor vessel head, its attachment and the lift rig.

3.2.2 Reactor Vessel Internals Lift Rig, Load Cell, and Load Cell Linkage

(a) The design weight for the internals lift rig is 285,000 pounds which is the total weight of the lifting device and the lower internals.

(b) The design weight is 285,000 pounds for the load cell and load cell linkage.

SECTION 4
MATERIALS

4.1 MATERIAL DESCRIPTION

The materials and material properties for the reactor vessel head lift rig, the reactor vessel internals lift rig, load cell and load cell linkage are listed in Tables 4-1 and 4-2.

TABLE 4-1

REACTOR COOLANT HEAD LIFT RIG MATERIAL AND MATERIAL PROPERTIES

Item[a]	Description	Materials	Yield Strength S_y (ksi)	Ultimate Strength S_{ult} (ksi)
1 15 6,10 3	7 1/2" Diameter Pin 3.9" Dia. Bottom Clevis Pin 5" Dia. Clevis Pins 8" Dia. Pin	ASTM A434 Class BD	100 110 105 100	130 140 135 130
11	Support Lug	ASTM A515 or Gr. 70	38	70
2	Side Plate	ASTM A514 or USS-T1	90	100
4,5	Sling Assembly Link, Lug	ASTM A237 Class A	50	80
13	Leg	ASTM A36	38	70
12	Ring Girder	ASTM A285 GR. C	30	55
7,9	Upper Clevis Clevis	ASTM A237 Cl. A	50	80
8	Arm	ASTM A306 Gr. 70	35	70
14	Clevis Plate	ASTM A515 Gr. 70	38	70

(a)See figure 5-1

TABLE 4-2

REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE MATERIAL AND MATERIAL PROPERTIES

Item(1)	Description	Material	Yield Strength	Ultimate Strength
			S_y (ksi)	S_{ult} (ksi)
1,3,7, 12	7 1/2" Dia. Hook Pin, 6" Dia. Adaptor Pin, 6" Dia. Removable Pin 4" Dia. Clevis Pin	ASTM A434 AISI 4340 Class BD	120	135
2	Side Plate	ASTM A515 Grade 70	38	70
4,6	Load Cell Adaptors	AISI 4340	120	135
5	Load Cell	17-4 pH s/s Cond. H1100	115	140
8a(2) 10a(2) 11a(2)	Top Lug, Support Plate Side Lug	ASTM A515 Grade 70	38	70
8b(2) 10b(2)	Top Lug Support Plate	ASTM 533 Grade B Class 1	50	80
9	Support Pipe	ASTM A106	30	48
11b(2)	Side Lug	ASTM A588 Grade A Class 1	50	70
13a(2) 15a(2)	Upper Clevis, Lower Clevis	ASME SA 508 Class 2	50	80
13b(2) 15b(2)	Upper Clevis Lower Clevis	ASTM A668 AISI 4340 Class M	110	135

(1) See figures 5-2 and 5-3

(2) Subscript(a) refers to Unit 1 only, while subscript(b) refers to Unit 2; no subscript means identical to both units

TABLE 4-2 (cont)

REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE MATERIAL AND MATERIAL PROPERTIES

Item[1]	Description	Material	Yield Strength S_y (ksi)	Ultimate Strength S_{ult} (ksi)
27[3]	Engaging Screw	ASTM A564 Grade 630 Cond. 1100	115	140
28b[2]	Load Nut	ASTM A276 Type 304 Cond. A	30	75
29b[2,3]	Tube Housing	ASTM A276 Type 304 Cond. A	30	75
30b[2,3]	Guide Sleeve	ASTM A276 Type 304 Cond. A	30	75
31a[2,4]	Load Nut	ASTM A276 Type 304 SS Condition A	30	75
32[4]	Rod Housing	ASTM A276 Type 304 SS Cond. A	30	75
33[4]	Guide Sleeve	ASTM A276 Type 304 SS Cond. A	30	75
34[4]	Rotolock Stud	ASTM A564, Type 630, 17-4 Ph, H1100	115	140
35[4], 36[4]	Upper and Lower Internals Inserts	ASTM A637 Grade 688 Type 2 Inconel X-750	115	140

(1) See figure 5-2 and 5-3.
(2) Subscript(a) refers to Unit 1 only, while subscript(b) refers to Unit 2; no subscript means identical to both units.
(3) These items will be replaced in the forthcoming modifications.
(4) These items are the new items to be installed.

SECTION 5
SUMMARY OF RESULTS

Tables 5-1 and 5-2, summarize the stresses on each of the parts which make up the reactor vessel head and internals lift rig, load cell, and load cell linkage respectively. All of the tensile and shear stresses meet the design criteria of section 3.2.1.1 of ANSI N14.6, requiring application of stress design factors of three and five with the accompanying allowable stress limits of yield and ultimate strength, respectively. Application of the ANSI N14.6 criteria to structural members subject to compression, bearing, or combined loads result in some stresses exceeding this criteria. However, when using more appropriate criteria, the resulting stresses are considered acceptable.

5.1 DISCUSSION OF RESULTS

5.1.1 Application of ANSI N14.6 Criteria

The design criteria of section 3.2.1.1 of ANSI N14.6, requiring application of stress design factors of three and five with the accompanying allowable stresses, are to be used for evaluating load bearing members of a special lifting device when subjected to loading conditions resulting in shear or tensile stresses. Application of these design load factors to other loading conditions is not addressed in ANSI N14.6. However, these two stress design factors have been used to determine the stresses of the load carrying members when subject to other loading conditions, viz. bearing, bending, buckling. This is an extremely conservative approach and in some cases the resulting stresses exceed the accompanying allowable stress limit.

Structural elements loaded in compression are analyzed by the empirical equations of the ASME and/or AISC rules. Allowable stresses for compression members are based on the estimate that the upper limit of elastic buckling failure is defined by an average column stress equal to one-half of the yield stress. These equations do not determine the limiting stresses of members in buckling but indicate whether or not the calculated stress is or is not within the allowable values. Instead, the ultimate load carrying capability of the member is the determining factor in the structural member's acceptability.

Timoshenko[9] notes that the ultimate load for short struts is equal to the material yield point. Calculation of the ultimate load results in this load being larger than the nominal design load and thus, these members are considered acceptable.

5.1.2 Bearing Stresses

For the internals lifting rig, several of the parts do not meet this criteria. However, since they are localized stresses, they can, if necessary, be considered under section 3.2.1.2, which states that the stress design factors of 3.2.1.1 are not intended to apply to situations where high local stresses are relieved by slight yielding. None of the bearing stresses reach the yield stress, and in fact, all of the bearing stresses meet the design criteria of the AISC[11] code of 0.9 yield.

5.1.3 Combined Stresses

The combined tensile stress from bending and tension, in the lower sling rod clevis (item 15), of the internals lift rig exceed the section 3.2.1.1 criteria. Bending is not a uniform stress, but is at a maximum at the outermost fiber. Bending contributes to the major portion of the stress shown in the table, and, as a result, the tensile stress without the bending is extremely low and well within the section 3.2.1.1 criteria. The combined stresses also meet the AISC code criteria.

5.1.4 Fillet Weld Stresses

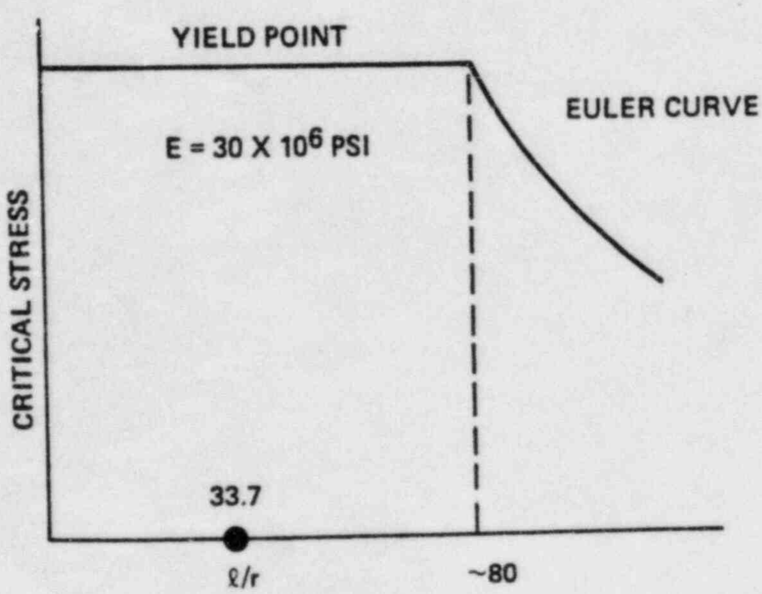
The fillet weld stress at the leg support block to leg weld on the internals lift rig meets the ASME criteria for weld stresses based on base material properties. However, when applying the ANSI N14.6 5W criteria to the nominal stress value, the ASME allowable stress value is exceeded. However, the ANSI N14.6 criteria is satisfied for this weld and thus it is considered acceptable.

5.1.5 Structures Loaded in Compression

The spreader assembly of the reactor vessel internals lift rig, when analyzed for axial compression loadings, does not meet the allowable stresses of the AISC code. However, it does meet the 3W and 5W criteria of the ANSI N14.6 criteria. It is well known that care should be taken when addressing members in compression to ensure elastic stability. Thus, structures loaded in compression are analyzed by the empirical equations of the [10] ASME Boiler and Pressure Vessel Code Section III, Appendix XVII or the AISC [11] Part 5 rules.

If we were designing a new structure, the material and member size would be changed to ensure these allowable stresses would be satisfied for all loading conditions. However, these calculations are being applied to an existing structure and since these conditions are not satisfied then the ultimate load carrying capability must be determined.

The column under consideration is relatively short ($\frac{k}{r}$ = 33.7). Timoshenko[9] states that experiments show that short columns buckle when the compressive strength reaches the material yield point. (The horizontal line on the figure below).



COLUMN BUCKLING

Therefore the total stress

$$\sigma = \frac{P}{A}$$

must be less than or equal to the material yield stress.

For the case of the internals lift rig spreader;

$$Q_{Total} = \frac{P}{A} = 6530 \text{ psi}$$

which is less than the material yield strength (S_y)

Then to find the ultimate column load, let $\sigma_{max} = S_y = 36,000$ psi

Then the maximum column load is the ratio of

$$\sigma_{max}/\sigma_{total} = \frac{36,000}{6,530} = 5.5$$

Thus the ultimate column load is 5.5 times the nominal value.

The internals lift rig spreader members are considered acceptable for this condition of axial compression.

5.2 CONCLUSION

Application of the ANSI N14.6 criteria of (3 and 5) to these special lifting devices results in acceptable stress limits for tensile and shear stresses. Application of this criteria to all structural members subject to other types of loadings tend to result in oversimplified convervatism and with some stresses exceeding the accompanying allowable limits. However, when using the more appropriate criteria for those cases not addressed by the ANSI N14.6 criteria the stresses are within the appropriate allowable limits. Further, these calculations are being applied to an existing structure and if we were designing a new structure, the materials and member sizes would be changed to ensure

these limits would be satisifed for all loading conditions. In conclusion, these special lift devices adequately meet the ANSI N14.6 criteria for tensile and shear stresses and meet other appropriate criteria for loading conditions that result in combined, bearing, and buckling stresses.

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TABLE 5-1
SUMMARY OF RESULTS
REACTOR VESSEL HEAD LIFT RIG

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
1	7 1/2" Dia. Hook Pin ASTM A434 Class BD	Bending	13.3	39.9	66.5	100	130
		Shear	3.9	11.7	19.5		
		Bearing on Pin	5.8	17.4	29.0		
		Bearing on Side Plate	7.7	23.1	38.5		
2	Side Plate ASTM A514 or USS T1	Tension @ 8" Dia. Hole	6.9	20.7	34.5	90	100
		Shear @ 8" Dia. Hole	6.9	20.7	34.5		
		Bearing @ 7 1/2" Dia. Hole	7.7	23.1	38.5		

(a) See figure 5-1 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-1 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL HEAD LIFT RIG

Item[(a)] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[(b)]	3W	5W	S_y[(c)]	S_{ult}[(d)]
3	8" Dia. Bottom Pin	Bending	10.9	32.7	54.5	100	130
	ASTM A434	Snear	3.4	10.2	17.0		
	Class BD	Bearing on Lug	5.4	16.2	27.0		
		Bearing on Side Plate	7.2	21.6	36.0		
4	Sling Assembly Link	Tension @ Hole	5.0	15.0	25.0	50	80
		Shear @ Hole	5.0	15.0	25.0		
	ASTM A237	Bearing @ Hole	5.4	16.2	27.0		
	Class A	Tension @ Shank	6.6	19.8	33.0		

(a) See figure 5-1 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-1 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL HEAD LIFT RIG

Item[a]	Part Name	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
No.	And Material	Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
5	Link Lug	Tension @ Hole	4.0	12.0	20.0	50	80
	ASTM 237	Shear Tearout @ Hole	4.0	12.0	20.0		
	Class A	Bearing @ Hole	6.3	18.9	31.5		
		Maximum Tension @ Root of Lug	3.7	11.1	18.5		
		Vertical Shear @ Root of Lug	1.4	4.2	7.0		
6	5" Dia.	Bending	10.5	31.5	52.5	105	135
	Clevis Pin	Shear	3.2	9.6	16.0		
	ASTM A434	Bearing on Clevis	5.3	15.9	26.5		
	Class BD	Bearing on Lug	6.3	18.9	31.5		

(a) See figure 5-1 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

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TABLE 5-1 (cont)
SUMMARY OF RESULTS
REACTOR VESSEL HEAD LIFT RIG

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
7	Upper Clevis ASTM A237 Class A	Tension @ Hole	3.2	9.6	16.0	50	80
		Shear @ Hole	3.2	9.6	16.0		
		Bearing @ Hole	5.3	15.9	26.5		
		Thread Shear	2.3	6.9	11.5		
8	Arm ASTM A306 Gr. 70	Thread Tension	7.1	21.3	35.5	35	70
		Thread Shear	2.3	6.9	11.5		
9	Bottom Clevis ASTM A237 Class A	Stresses are the same as Item 7.	Same as Item 7	Same as Item 7	Same as Item 7	50	80

(a) See figure 5-1 for location of item numbers and section
(b) W is the total static weight of the component and the lifting device
(c) S_y is the yield strength of the material (ksi)
(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-1 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL HEAD LIFT RIG

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y [c]	S_{ult} [d]
10	5" Dia. Bottom Clevis Pin ASTM A434 Class BD	Stresses are the same as Item 6	Same as Item 6	Same as Item 6	Same as Item 6	105	135
11	Support Lug ASTM A515 Gr. 70	Tension @ Hole	4.0	12.0	20.0	38	70
		Shear @ Hole	4.0	12.0	20.0		
		Bearing @ Hole	6.5	19.5	32.5		
12	Ring Girder ASTM A285 Gr. C	Total Shear	3.2	9.6	16.0	30	55
		Maximum Bending	2.6	7.8	13.0		
		Maximum Tensile Stress	4.8	14.4	24.0		
		Ring Girder to Support Weld	3.2	9.6	16.0	18[e]	

(a) See figure 5-1 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(e) Stress limit for fillet weld from ASME Boiler & Pressure Vessel Code, Section III, Division 1 - Subsection NF 1980 Edition, Table NF - 3292.1-1 page 50

TABLE 5-1 (cont)
SUMMARY OF RESULTS
REACTOR VESSEL HEAD LIFT RIG

Item[a] No.	Part Name And Material	Calculated Stresses (ksi) Designation	Value W[b]	3W	5W	Material Allowable (ksi) S_y[c]	S_{uit}[d]
13	Leg ASTM A36	Tension	9.7	29.1	48.5	38	70
14	Clevis Plate ASTM A515 Gr. 70	Weld	5.6	16.8	28.0	18[e]	
		Tension	3.2	9.6	16.0	38	70
		Shear	3.2	9.6	16.0		
		Bearing	7.3	21.9	36.5		
15	3.9" Diameter Pin ASTM A434 Class BD	Bending	18.9	56.7	94.5	110	140
		Shear	4.7	14.1	23.5		
		Bearing on Lug	7.3	21.9	36.5		
		Bearing on Clevis	7.0	21.0	35.0		

(a) See figure 5-1 for location of item numbers and section
(b) W is the total static weight of the component and the lifting device
(c) S_y is the yield strength of the material (ksi)
(d) S is the ultimate strengt

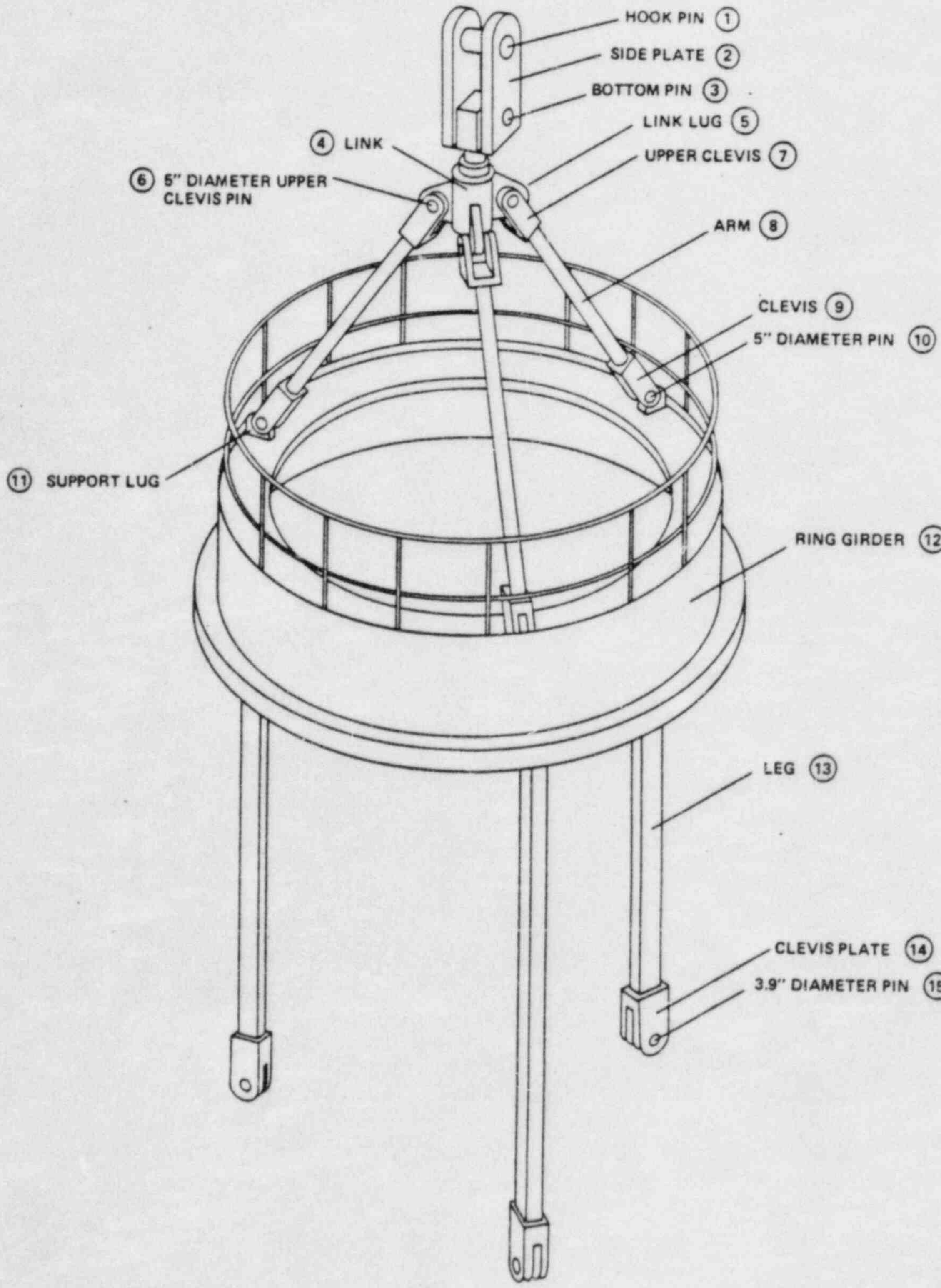

Figure 5-1. Reactor Vessel Head Lift Rig

TABLE 5-2

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
1	Hook Pin ASTM A434 AISI 4340	Shear	3.6	10.8	18.0	120	135
		Bearing (Hook)	5.2	15.6	26.0		
		Bearing (Side Plate)	10.9	32.7	54.5		
		Bending	12.1	36.3	60.5		
2	Side Plate ASTM A515 Gr. 70	Tension @ 7 1/2" Dia. hole	10.9	32.7	54.5	38	70
		Bearing @ 6" Dia. hole	13.6	40.8	68.0		
		Shear Tear-out	14.0	42.0	70.0	41[e]	77[e]

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(e) Actual certified mechanical properties

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TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
3	Adaptor Pin	Shear	5.7	17.1	28.5	120	135
	ASTM A304	Bearing (Adaptor)	6.5	19.5	32.0		
	AISI 4340	Bearing (Side Plate)	13.6	40.8	68.0		
		Bending	23.7	71.1	118.5		
4	Upper Adaptor	Tension @ Pin Hole	14.8	44.4	74.0	120	135
	AISI 4340	Bearing @ Pin Hole	6.4	19.2	32.0		
		Tension @ Thread Relief	5.7	17.1	28.5		
		Thread Shear	13.7	41.1	68.5		
		Shear Tear-out	6.8	20.4	34.0		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

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TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
5	Load Cell 17-4-pH s/s Cond H-1100	Tension @ Thread	23.9	71.7	119.5	115	140
		Thread Shear	13.7	41.1	68.5		
6	Lower Adaptor AISI 4340	Tension @ Pin Hole	15.9	47.7	79.5	120	135
		Bearing @ Pin Hole	8.5	25.5	42.5		
		Tension @ Thread Relief	7.4	22.2	37.0		
		Thread Shear	13.7	41.1	68.5		
		Shear Tear-out	8.7	26.1	43.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
7	Removable Pin	Shear	5.0	15.0	25.0	120	135
	ASTM A304	Bearing on Adaptor	7.6	22.8	38.0		
	AISI 4340	Bearing on Top Lug	7.9	23.7	39.5		
		Bending	21.0	63.0	105.0		
8_a	Top Lug	Tension @ Hole	8.0	24.0	40.0	8_a 38	70
	ASTM A515	Bearing @ Hole	7.9	23.7	39.5		
	Gr. 70	Tension @ Weld	4.0	12.0	20.0		
		Shear Tear-out	8.0	24.0	40.0		
8_b	ASTM A533					8_b 50	80
	Gr. B, Cl 1						

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
9	Support Pipe ASTM A106	Tension	3.1	9.3	15.5	30	48
10_a	Support Plate ASTM A515 Gr. 70	Tension	.7	2.1	3.5	38	70

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
10_b	ASTM A533 Gr. B, Cl. 1	Tension	1.1	3.3	5.5	50	80
11_a	Side Lug ASTM A515 Gr. 70	Tension @ Hole	5.1	15.3	25.5	38	70
		Combined Stress @ Weld	6.5	19.5	32.5		
		Shear @ Weld	2.0	6.0	10.0		
		Bearing @ Hole	7.5	22.5	37.5		
		Shear Tear-out	4.5	13.5	22.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
11_b	Side Lug ASTM A588 Gr. A, Cl. 1	Tension @ Hole	5.2	15.6	26.0	50	80
		Combined Stress @ weld	6.7	20.1	33.5		
		Shear @ Weld	2.0	6.0	10.0		
		Bearing @ Hole	7.7	23.1	38.5		
		Shear Tear-out	4.5	13.5	22.5		
12	Clevis Pin ASTM A434 AISI 4340	Shear	4.7	14.1	23.5	120	135
		Bearing On Side Lug	7.5	22.5	37.5		
		Bearing on Upper Clevis	7.5	22.5	37.5		
		Bending	19.2	57.6	96.0		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

6126B:1/030783

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
13_a	Upper Clevis	Tension @ Pin Hole	7.7	23.1	38.5	13_a 50	80
	SA-508 Cl. 2	Bearing on Pin	7.5	22.5	37.5	13_b 110	135
13_b	ASTM A668	Thread Shear	3.3	9.9	16.5		
	AISI 4340	Tear-out Shear	7.7	23.1	38.5		
	Cl. M						

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
14_a	Sling Leg	Thread Shear	3.2	9.6	16.0	45	69
	AISI 1117	Tension @ Thread	10.7	32.1	53.5	or	
	Hot Rolled or					32	60
	1018 Cold Rolled						
14_b	Sling Leg	Thread Shear	3.2	9.6	16.0	85	110
	ASTM A434	Tension @ Thread	11.6	34.8	58.0		
	Cl. BC						
	AISI 4340						

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
15_a	Lower Clevis	Thread Shear	3.3	9.9	16.5	15_a 50	80
	SA-508 Cl. 2	Combined Stress	30.6	91.8	153.0	15_b 110	135
	ASTM A668		0.87[f]			Ratio <1.0[f]	
15_b	AISI 4340						
	Cl. M						

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(e) Actual certified mechanical properties

(f) Stress ratio Limit for combined bending and tension from AISC manual Chapter 5, Sect. 1.6.2

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value: W[b]	3W	5W	S_y[c]	S_{ult}[d]
16	Clevis Bolt	Shear	5.6	16.8	28.0	85	110
	ASTM A434	Bending	7.8	23.4	34.0		
	Cl. BC	Bearing	14.9	44.7	74.5		
	AISI 4340						
17	Spreader Leg	Compression	6.5	19.5	32.5	36	58
	ASTM A36					F_a = 18.9[g]	

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(g) F_a is the compressive buckling strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
18	Backing Block ASTM A276 Type 304 Cond. A	Bearing on Spreader Leg	11.7	35.1	58.5	30	75
		Compression in Block	7.9	23.7	39.5		
19	End Plate ASTM A36	Bearing on Channel	6.5	19.5	32.5	36	58

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y [c]	S_{ult} [d]
20	Spacer	Bearing	14.9	44.7	74.5	50	70
	ASTM A588	Combined Stress @ Hole	25.3	75.9	126.5	61.5[e]	88.6[e]
	Gr. A and B		0.995			Ratio	<1.0[f]
		Shear in Weld	1.8	5.4	9.0		
21	Leg Channel	Bearing	14.9	44.7	74.0	36	58
	ASTM A36	Tension @ Cross-section	8.7	26.1	43.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(e) Actual certified mechanical properties

(f) Stress ratio Limit for combined bending and tension from AISC manual Chapter 5, Sect. 1.6.2

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
22,23$_a$	Leg Support Block AISI 8620 Brace Plate ASTM A36	Shear (weld)	4.8	14.4	24.0	18[h]	
		Bearing on Adaptor Nut	8.8	26.4	44.0	36	58

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(h) Stress limit for fillet weld from ASME Boiler & Pressure Vessel Code, Section III, Division 1-Subsection NF 1980 Edition, Table NF-3292.1-1 page 50

TABLE 5-2 (cont)
SUMMARY OF RESULTS
REACTOR VESSEL INTERNALS LIFT RIG,
LOAD CELL AND LOAD CELL LINKAGE

Item[(a)] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			$W^{(b)}$	3W	5W	S_y[(c)]	S_{ult}[(d)]
24_a[(i)]	Adaptor ASTM A276 Type 304 Cond. A	Thread Shear	2.3	6.9	11.5	30	75
		Tension @ Thd Relief	8.3	24.9	41.5		
25_a[(i)]	Outer Tube ASTM A312 Type 304	Thread Shear	5.7	17.1	28.5	30	70
		Tension @ Thd Relief	9.6	28.8	48.0		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(i) These items will be replaced in the forthcoming modifications

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
26_a [i]	Guide Sleeve	Bearing On Engaging Screw	17.0	51.0	85.0	30	75
	ASTM A276	Thread Shear	5.7	17.1	28.5		
	Type 304	Compression	10.1	30.3	50.5		
	Cond. A						
27_a [i]	Engaging Screw	Bearing on Guide Sleeve	17.0	51.0	85.0	115	140
	ASTM A564	Tension @ Thread Relief	12.6	37.8	63.0		
	Grade 630	Thread Shear	6.6	19.8	33.0	158[e]	168[e]
	Cond. 1100						
27_b [i]		Bearing on Guide Tube	12.4	37.2	62.0		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(e) Actual certified mechanical properties

(i) These items will be replaced in the forthcoming modifications

61268:1/022883

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value W[b]	3W	5W	S_y[c]	S_{ult}[d]
28_b	Load Nut ASTM A276 Type 304 Cond. A	Bearing	8.8	26.4	44.0	30	75
		Thread Shear	4.7	14.1	23.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(i) These items will be replaced in the forthcoming modifications

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
29_b (i)	Tube Housing ASTM A276 Type 304 Cond. A	Thread Shear	4.1	12.3	20.5	30	75
		Tension	9.0	27.0	45.0		
30_b (i)	Guide Sleeve ASTM A276 Type 304 Cond. A	Thread Shear	4.1	12.3	20.5	30	75
		Tension	10.3	30.9	51.5		
		Bearing	12.4	36.8	62.0		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(i) These items will be replaced in the forthcoming modifications

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi) Designation	Value $W^{(b)}$	3W	5W	Material Allowable (ksi) S_y [c]	S_{ult} [d]
31_a [j]	Load Nut ASTM A276 Type 304	Bearing to Mounting Block	8.7	26.1	43.5	30	75
		Thread Shear	4.5	13.5	22.5		
32_a [j]	Rod Housing ASTM A276 Type 304	Tension @ Thread Relief	9.1	27.3	45.5	30	75
		Thread Shear on Upper Threads	4.5	13.5	22.5		
		Lower Threads Shear	4.5	13.5	22.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(j) These items are the new items to be installed

61268:1/002283

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			$W^{(b)}$	3W	5W	S_y [c]	S_{ult} [d]
32_b [j]	Rod Housing ASTM A276 Type 304	Tension @ Thd Relief	7.8	23.4	39.0	30	75
		Thread Shear in Upper Threads	4.2	12.6	21.0		
		Lower Threads - Shear	4.5	13.5	22.5		
33[j]	Guide Sleeve ASTM A276 Type 304 SST	Thread Shear	4.5	13.5	22.5	30	75
		Tension @ Thread Relief	9.7	29.1	48.5		
		Bearing to Stud	9.9	29.7	49.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(j) These items are the new items to be installed

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[(a)] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[(b)]	3W	5W	S_y[(c)]	S_{ult}[(d)]
34[(j)]	Rotolock Stud ASTM A564 Type 630 17-4 pH H1100	Tensile Stress @ Cross-Section	27.7	83.1	138.5	115	140
		Shear Stress on Land Root	9.7	29.1	48.5		
		Bearing on Land Surfaces	50.3	150.9	251.5		
		Bearing on Guide Sleeve	25.9	77.7	129.5		
		Bending in Lands	9.9	29.7	49.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

(j) These items are the new items to be installed

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG,

LOAD CELL AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
			Value				
		Designation	W[b]	3W	5W	S_y[c]	S_{ult}[d]
35	Upper Internal	Bending In Lands	13.7	41.1	68.5	115	170
	Insert	Shear Stress on Land Root	5.6	16.8	28.0		
	ASTM A637	Bearing on Land Surfaces	41.5	124.5	207.5		
	Gr 688	Thread Shear	2.3	6.9	11.5		
	Type 2						
36	Lower Internal	Bending Stress	19.8	59.4	99.0	115	170
	Insert						
	ASTM A637	Shear Stress on Land Root	8.1	24.3	40.5		
	Gr 688	Bearing on Land Surfaces	59.9	179.7	299.5		
	Type 2	Thread Shear	6.9	20.7	34.5		

(a) See figure 5-2 for location of item numbers and section

(b) W is the total static weight of the component and the lifting device

(c) S_y is the yield strength of the material (ksi)

(d) S_{ult} is the ultimate strength of the material (ksi)

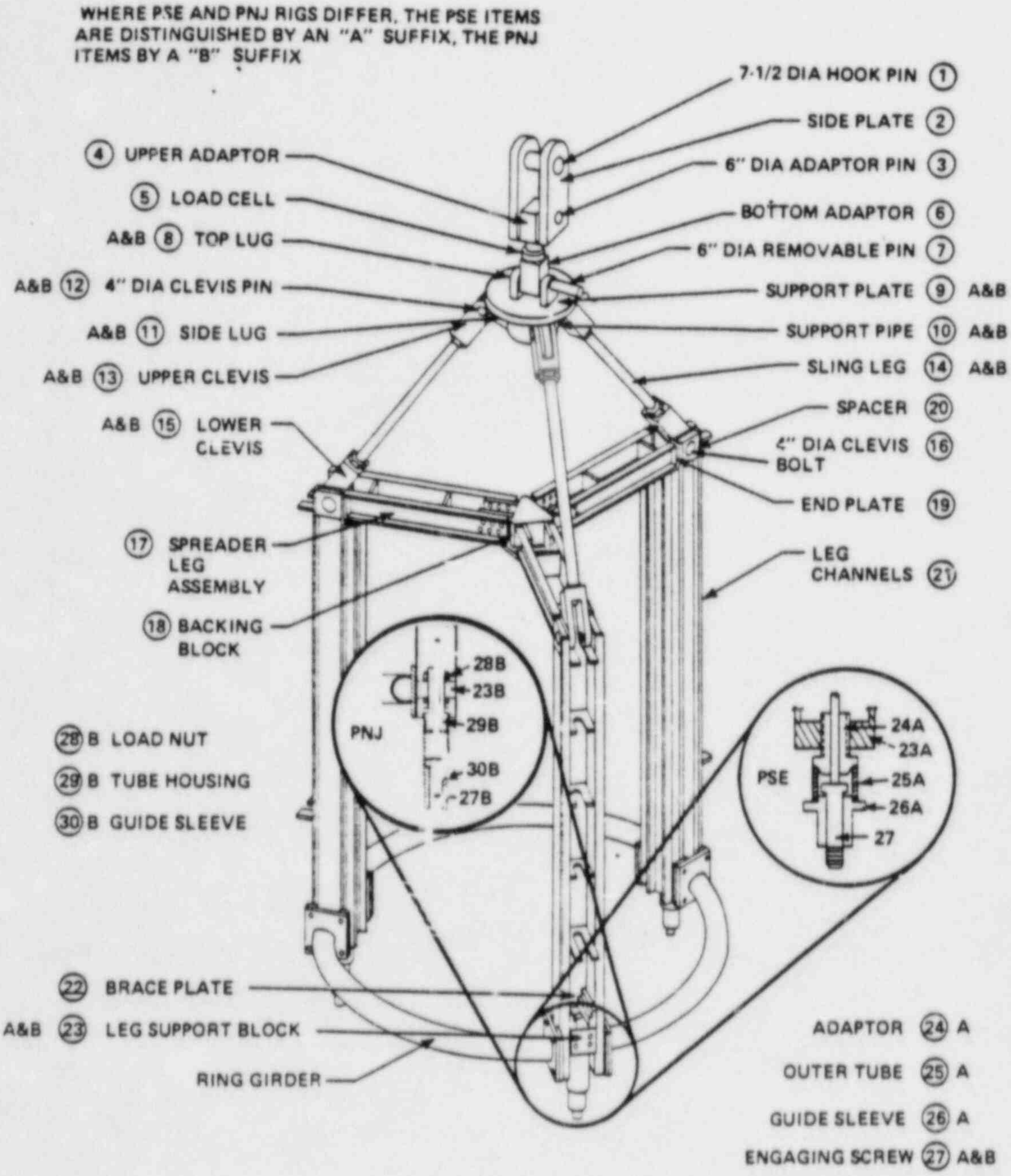


Figure 5-2. Reactor Vessel Internals Lift Rig, Load Cell, and Linkage

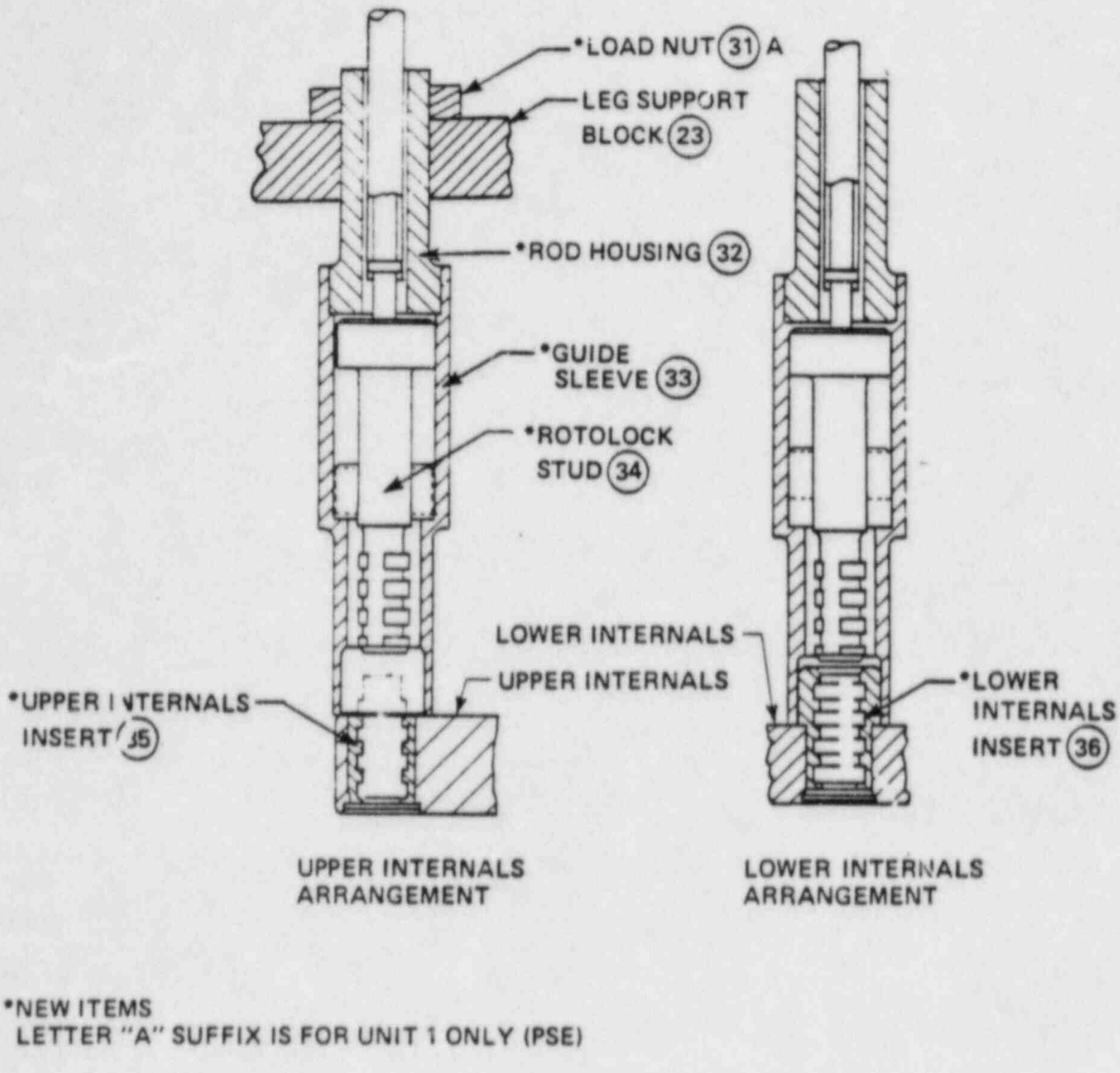


Figure 5-3. Rotolock Studs and Inserts Arrangement

APPENDIX A

DETAILED STRESS ANALYSIS - REACTOR VESSEL HEAD LIFT RIG

This appendix provides the detailed stress analysis for the Salem reactor vessel head lift rig in accordance with the requirements of ANSI N14.6. Acceptance criteria used in evaluating the calculated stresses are based on the material properties given in section 4.

SKETCH SHEET
WESTINGHOUSE FORM 54202

S.O.	PROJECT	PAGE
PTNP-188 ·	Salem Units I and II	1 of 33

TITLE	CALCULATIONS NO.
R.V. Head Lift Rig Assembly	PDC-

AUTHOR & DATE	CHECKED BY & DATE
F. Peduzzi F.C. Peduzzi 1/83	J. Richard J. W. Richard 1/83

PURPOSE AND RESULTS:

1. The purpose of this analysis is to determine the acceptability of this rig to the requirements of ANSI N14.6.

2. The results show that all stresses are within the allowable stresses.

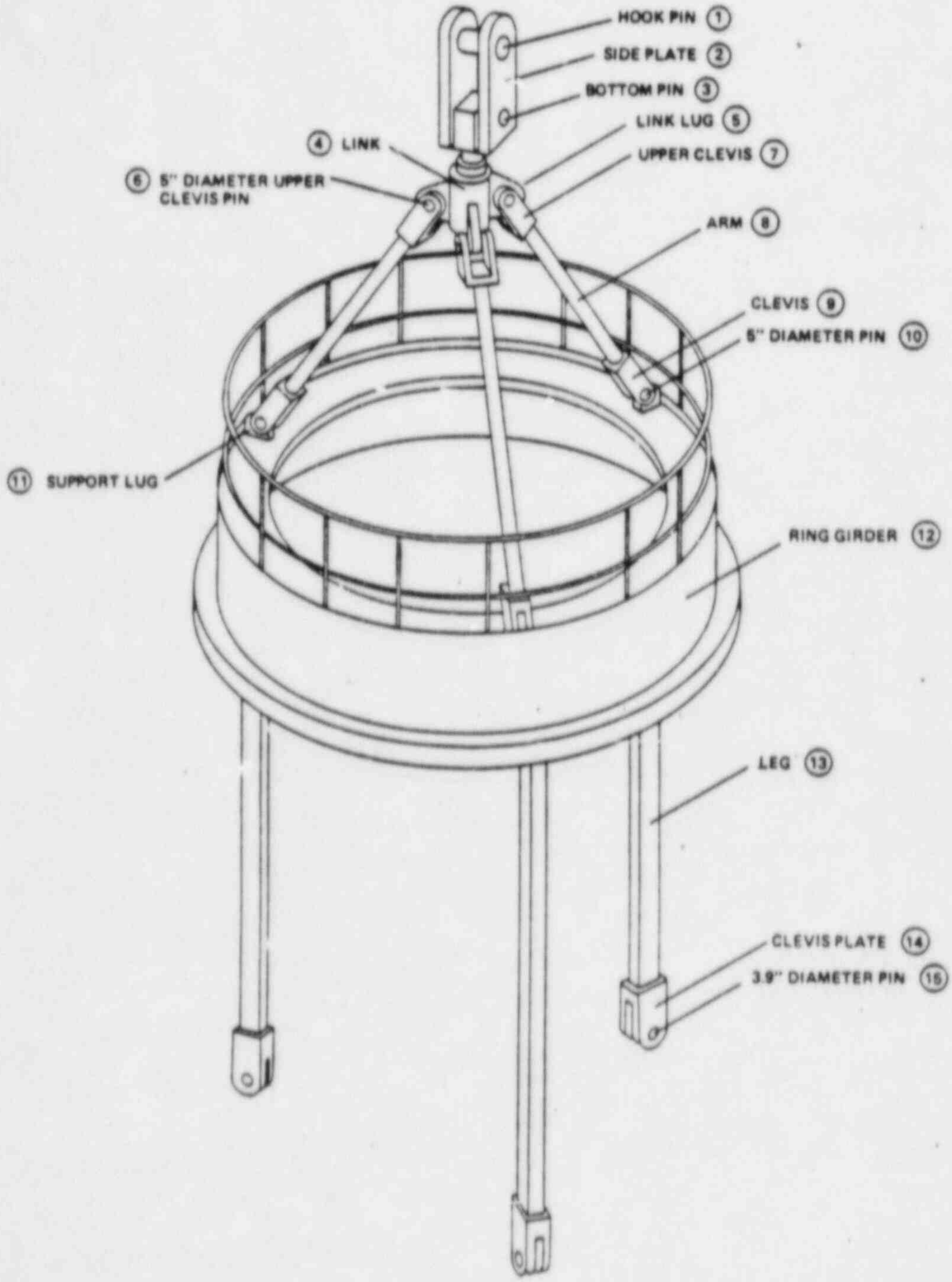
COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JOSEPH W. RICHARD
ENGINEER
NO. 007167-E

J. W. Richard

REVISION NO.	DATE	DESCRIPTION	BY
		Original Issue	

RESULTING REPORTS, LETTERS OR MEMORANDA:

TITLE			PAGE
R. V. Head Lift Rig			2 OF 33
PROJECT PSE/PNJ	AUTHOR F.C. Peduzzi DATE 1/82	CHK'D. BY DATE	CHK'D. BY DATE
S.O. PTNP-188	CALC. NO.	FILE NO.	GROUP CHE



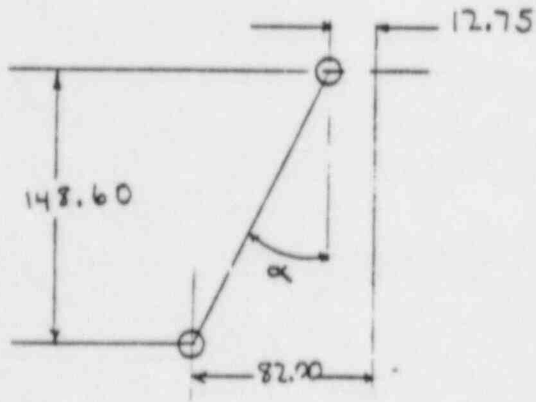
REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

TITLE			PAGE
R. V. Head Lift Rig			3 OF 33
PROJECT: PSE/PNJ	AUTHOR: F.C. [signature] DATE: 1/83	CHK'D. BY: J.W. Richard DATE: 1/83	CHK'D. BY DATE
S.O.: PTNP-188	CALC. NO.	FILE NO.	GROUP: CHE

DESIGN WEIGHT

310,000 lbs from ASSY DWG (625J058)
28,000 lbs Rig weight
7,000 lbs contingencies
345,000 lbs

SLING LEG ANGLE



$$\tan\alpha = \frac{(82.00-12.75)}{147.60} = \frac{69.25}{147.60} = .4660$$

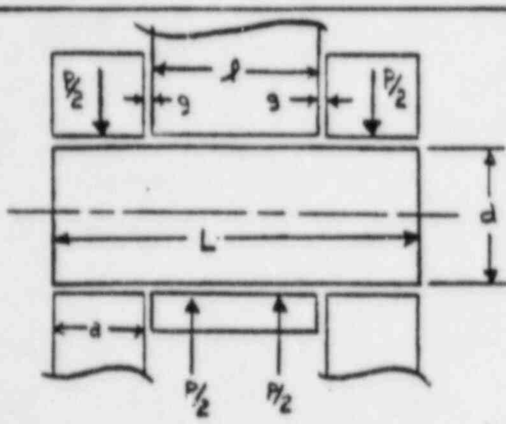
$\alpha = 25°$

REV. NO	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

TITLE			PAGE
R. V. Head Lift Rig			4 OF 33
PROJECT: PSE/PN	AUTHOR: F. C. Peduzzi DATE: 1/83	CHK'D. BY: J. W. Richard DATE: 1/83	CHK'D. BY: DATE:
S.O.: PTNP-188	CALC. NO.	FILE NO.	GROUP: CHE

7.5" DIA PIN (1)

MAT'L: ASTM A 434 CLASS BD



P = force acting on assembly, lb.
d = diameter of pin, in.
l = length of bearing surface of center body, in.
a = length of bearing surface one side of outer body, in.
g = gap between bearing surfaces, in.
L = total active length of pin, in
= l + 2(a + g)

P = 345,000 lb.
d = 7.495 in.
l = 8.00 in
a = 3.00 in
g = .1875 in
[14.375 - 2(3.00) - 8]/2

SHEAR STRESS

$f_v = P/2A_v$
P = 345,000
$A_v = \pi d^2/4$
$A_v = \pi (7.495)^2/4$
$A_v = 44.120\ in^2$

$f_v = (345,000)/(2 * 44.120)$

$f_v = 3910$ PSI

BEARING STRESS

$f_c = P/A_v$
P = 345,000

INNER
$A_v = d l = (7.495)(8.00)$
$= (59.96)\ in^2$
$f_c = (345,000)/(59.96)$

$f_c = 5754$ PSI

OUTER
$A_v = 2ad = 2(3.00)(7.495)$
$= (44.97)\ in^2$
$f_c = (345,000)/(44.97)$

$f_c = 7672$ PSI

REV. NO.	REV. DATE	AUTHOR	DATE	CHK'D. BY	DATE	CHK'D. BY	DATE

TITLE R. V. Head Lift Rig			PAGE 5 OF 33
PROJECT PSE/PNJ	AUTHOR G.C. Pedruzzi DATE 1/83	CHK'D. BY J.W. Richard DATE 1/83	CHK'D. BY DATE
S.O. PTNP-188	CALC. NO.	FILE NO.	GROUP CHE

PIN (1)

BENDING STRESS (1)

$M_m = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}l\right)$

$f_b = Mc/I$

$I = \pi d^4/64$

$c = d/2$

$f_b = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}l\right)\left(\frac{d}{2}\right)\left(\frac{64}{\pi d^4}\right)$

$= 16P\left(\frac{1}{3}a + g + \frac{1}{4}l\right)/(\pi d^3)$

$= 16P\left(\frac{3.00}{3} + .1875 + \frac{5.00}{4}\right)/\pi 7.495^3$

$fb = P\ (.03856)$

$= 345{,}000\ (.03856)$

$= 13{,}303$ psi

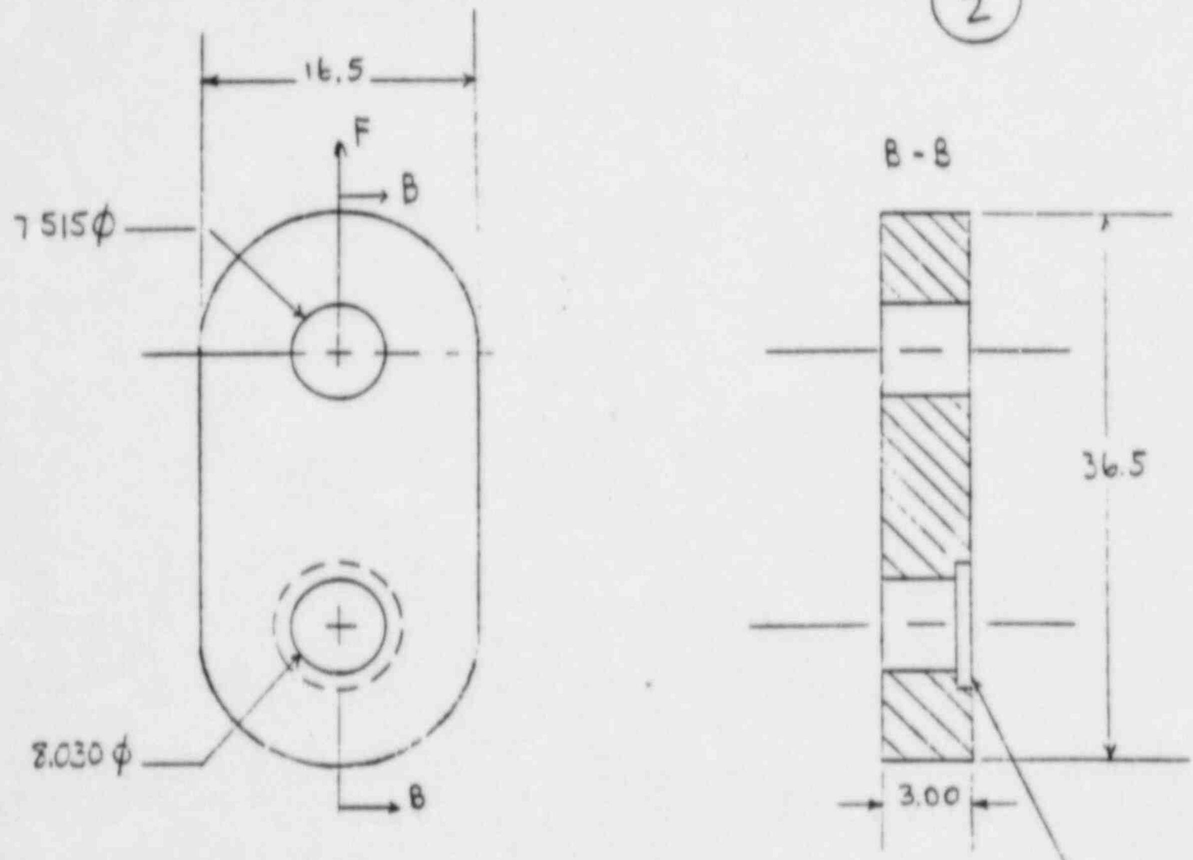
(1) ADAPTED FROM FASTENING AND JOINING, 4th Ed, A REFERENCE ISSUE OF MACHINE DESIGN, PENTON PUBLISHERS PAGE 27

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE R. V. Head Lift Rig			PAGE 6 OF 33
PROJECT PSE/PNJ	AUTHOR J.C. Pedruzzi DATE 1/83	CHK'D BY J.W. Richards DATE 1/83	CHK'D BY DATE
S.O. PTNP-188	CALC NO.	FILE NO.	GROUP CHE

SIDE PLATE ASTM A-514 or USS -T1 (2)



Tension at 8.030 Hole

$F = \frac{345,000}{2} = 172,500$

$A = (16.5 - 8.030)(3.00) - (8.56 - 8.03)(.50) = 25.145 \text{ in}^2$

$f_t = \frac{F}{A} = \frac{172,500}{25.145}$

$f_t = 6860$ psi

REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

TITLE R. V. Head Lift Rig			PAGE 7 OF 33
PROJECT PSE/PNJ	AUTHOR F.C. Pedruzzi DATE 1/83	CHK'D. BY J.W. Richard DATE 1/83	CHK'D. BY DATE
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Shear at 8.030 Hole

$$f_v = \frac{F}{2A_v} \quad A_v = \left(\frac{16.50 - 8.030}{2}\right)(3.00) - \left(\frac{8.56 - 8.030}{2}\right)(.50)$$

$$f_v = \frac{172{,}500}{2(12.573)}, \quad A_v = 12.573 \text{ in}^2$$

f_v = 6860 PSI

Bearing at 7.515" φ Hole

The maximum bearing stress is the same as the outer bearing stress on the hook pin ①.

f_c = (345,000) / 44.97 = 7672 PSI

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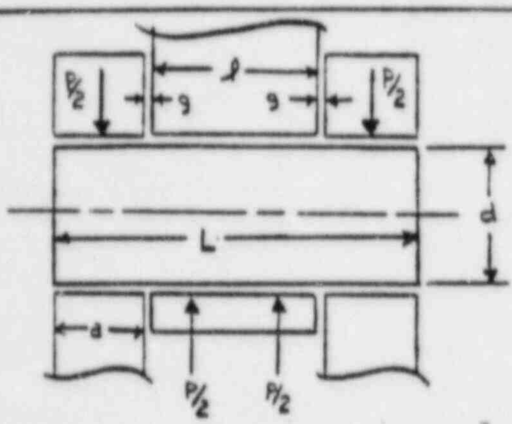
8" DIA. PIN (3)

MAT'L: ASTM A434 CLASS BD



P = force acting on assembly, lb.
d = diameter of pin, in.
ℓ = length of bearing surface of center body, in.
a = length of bearing surface one side of outer body, in
g = gap between bearing surfaces, in.
L = total active length of pin, in
= ℓ + 2(a + g)

P = 345,000 lb.
d = 8.00 in.
ℓ = 8.06 in 9.15 − 2(0.45)
a = 3.00 in
g = .1575 in
[14.375 − 2(3.00) − 8.06]/2

SHEAR STRESS

$f_v = P/2A_v$
$P = 345,000$
$A_v = \pi d^2/4$
$A_v = \pi(8.000)^2/4$
$A_v = 50.27\ in^2$

$f_v = (345,000)/(2 \cdot 50.27)$

$f_v = 3431$ PSI

BEARING STRESS

$f_c = P/A_v$
$P = 345,000$

INNER

$A_v = d\ell = (8.00)(8.06)$
$= (64.48)\ in^2$
$f_c = (345,000)/(64.48)$

$f_c = 5350$ PSI

OUTER

$A_v = 2ad = 2(3.00)(8.00)$
$= (48.0)\ in^2$
$f_c = (345,000)/(48.0)$

$f_c = 7188$ PSI

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PIN (3)

BENDING STRESS (1)

$$M_{max} = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}\ell\right)$$

$$f_b = Mc/I$$
$$I = \pi d^4/64$$
$$c = d/2$$

$$f_b = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}\ell\right)\left(\frac{d}{2}\right)\left(\frac{64}{\pi d^4}\right)$$
$$= 16P\left(\tfrac{1}{3}a + g + \tfrac{1}{4}\ell\right)/(\pi d^3)$$
$$= 16P\left(\frac{3.00}{3} + .1575 + \frac{8.06}{4}\right)/\pi\, 8.00^3$$
$$= P\,(.03156)$$
$$= 345{,}000\,(.03156)$$
$$f_b = 10{,}888 \text{ PSI}$$

(1) ADAPTED FROM <u>FASTENING AND JOINING</u>, 4th Ed, A REFERENCE ISSUE OF MACHINE DESIGN, PENTON PUBLISHERS PAGE 27

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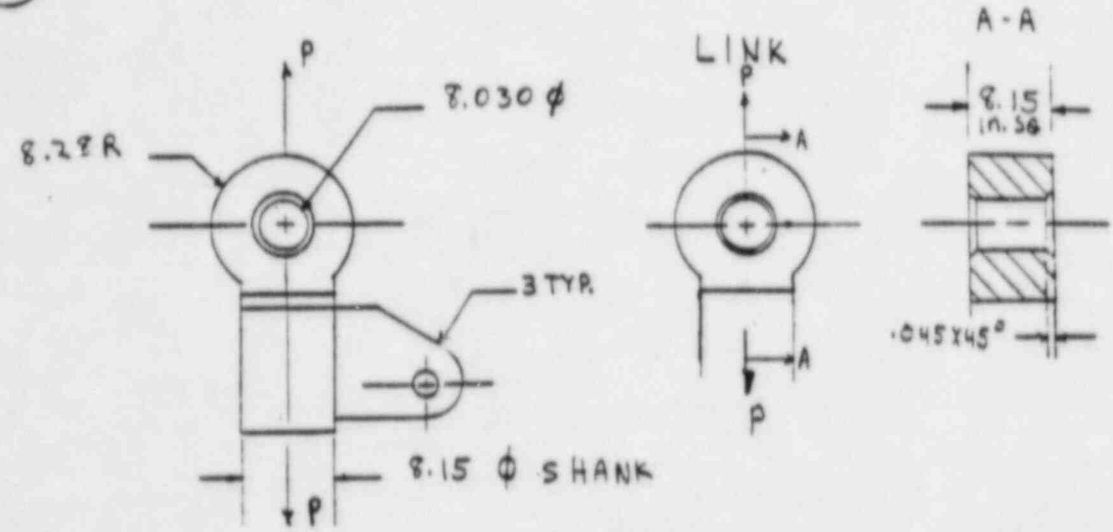
④ SLING ASSEMBLY LINK ASTM A-237 CLASS A



TENSION at 8.030ϕ Hole

$f_t = \frac{P}{A_t}$ $A_t = (8.28 - 4.015)(8.15)(2) - \frac{1}{2}4(.045)^2 = 69.515 \text{ in}^2$

$F_t = \frac{345,000}{69.515}$

$F_t = 4963$ PSI

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Shear at 8.030 ⌀ Hole

$f_v = \frac{P}{A_v}$ $A_v = (8.28 - 4.015)(8.15)(2) - \frac{1}{2}4(.045)^2 = 69.515 \text{ in}^2$

$f_v = \frac{345{,}000}{69.515} = 4963 \text{ PSI}$

Bearing on 8.00 ⌀ Pin

The bearing stress is the same as the inner bearing stress on the bottom pin connected through the side plate. The pin is item ③.

$f_c = 345{,}000 / 64.48 = 5350 \text{ PSI}$

Tension at cylindrical section

$f_t = \frac{P}{A_t}$ $A_t = \pi \frac{(8.15)^2}{4} = 52.168 \text{ in}^2$

$f_t = \frac{345{,}000}{52.168} = 6613 \text{ PSI}$

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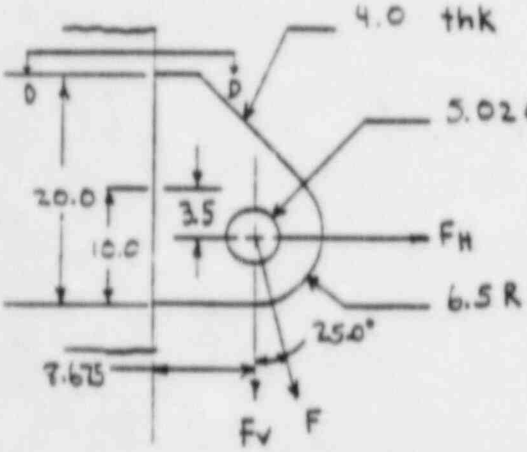
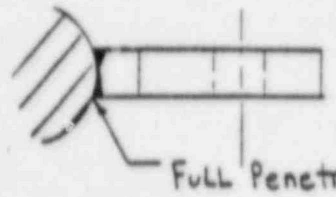
(5)

LINK LUG ASTM A237 CLASS A





$F_V = \frac{345{,}000}{3} = 115{,}000$ lbs

$F = \frac{F_V}{\cos 25°} = 126{,}888$ lbs

$F_H = F_V \tan 25° = 53{,}625$ lbs

Tension at 5.02" ϕ Hole

$f_t = \frac{F}{A_t}$ $A_t = 2(6.5 - 2.51)4.0 = 31.92\ in^2$

$f_t = \frac{126{,}888}{31.92} = 3975$ PSI

Shear Tear at hole

$f_v = \frac{F}{A_v} = \frac{126{,}888}{31.92}$ $A_v = 2(6.5 - 2.51)4 = 31.92\ in^2$

$f_v = 3975$ PSI

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Bearing at 5.02" ϕ hole

The bearing stress is the same as the inner bearing stress on the upper clevis pin (6).

$f_c = 126{,}888 / 20.01 = 6341$ PSI

Combined Stress from Tension and Bending

$M = 8.675\,F_V - 3.5\,F_H$

$M = (8.675)(115{,}000) - (3.5)(53{,}625)$

$M = 809{,}938$ in-lb.

$f_t = \frac{F_H}{A} + \frac{M}{Z}$

$A_t = (4)(20) = 80\,in^2$

$Z = \frac{1}{6}(4)(20)^2 = 267\,in^3$

$f_t = \frac{53625}{80} + \frac{809938}{267}$

$f_t = 670 + 3033$

$f_t = 3703$ PSI

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vertical Shear at FULL Penetration weld

$f_v = \frac{F_v}{A_v}$ $A_v = (4)(20) = 80 \text{ in}^2$

$f_v = \frac{115,000}{80} = 1438$ PSI

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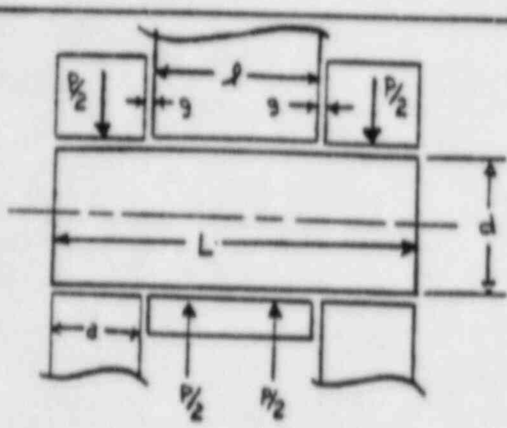
Upper Clevis PIN (6)

MAT'L: ASTM A-434 CLASS BD



P = force acting on assembly, lb.
d = diameter of pin, in.
l = length of bearing surface of center body, in.
a = length of bearing surface one side of outer body, in.
g = gap between bearing surfaces, in.
L = total active length of pin, in
= l + 2(a + g)

P = 126,888 lb.
d = 5.0025 in.
l = 4.00 in
a = 2.40 in 2.49 - 2(.045)
g = .240 in
[9.37 - 2(2.49) + 2(.045) - 4.00] / 2

SHEAR STRESS

$f_v = P/2A_v$
$P = 126,888$
$A_v = \pi d^2/4$
$A_v = \pi(5.0025)^2/4$
$A_v = 19.65$ in²

$f_v = (126,888)/(2 \cdot 19.65)$

$f_v = 3229$ PSI

BEARING STRESS

$f_c = P/A_v$
$P = 126,888$

INNER

$A_v = d\,l = (5.0025)(4.00)$
$= (20.01)$ in²
$f_c = (126,888)/(20.01)$

$f_c = 6341$ PSI

OUTER

$A_v = 2ad = 2(2.40)(5.0025)$
$= (24.012)$ in²
$f_c = (126,888)/(24.012)$

$f_c = 5284$ PSI

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PIN (6)

BENDING STRESS [1]

$$M_m = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}l\right)$$

$$f_b = Mc/I$$

$$I = \pi d^4/64$$

$$c = d/2$$

$$f_b = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}l\right)\left(\frac{d}{2}\right)\left(\frac{64}{\pi d^4}\right)$$

$$= 16P\left(\frac{1}{3}a + g + \frac{1}{4}l\right)/(\pi d^3)$$

$$= 16P\left(\frac{2.40}{3} + .240 + \frac{4}{4}\right)/\pi 5.0025^3$$

$$= 126,888(.08299)$$

$$= 10531 \text{ PSI}$$

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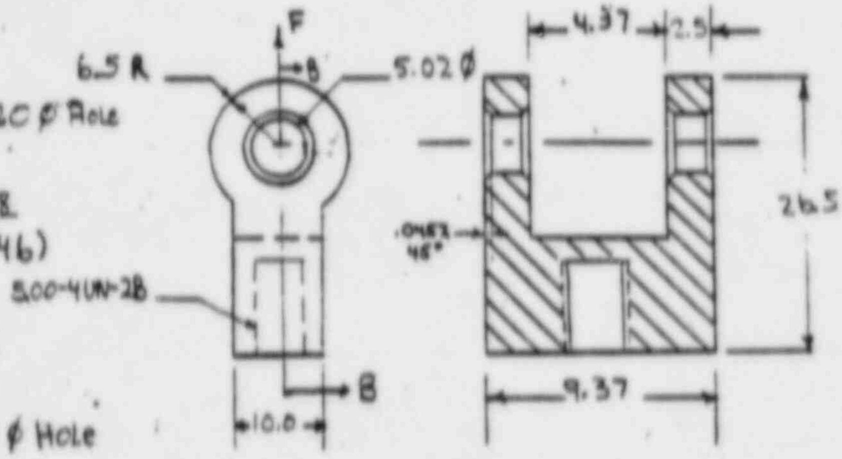
(7) (9) UPPER & BOTTOM CLEVIS ASTM A-237 CLASS BD



Tension at 5.020 Ø Hole

$f_t = \frac{F}{2A_t} = \frac{126,888}{2(19.946)}$

f_t = 3181 PSI

Shear at 5.020 Ø Hole

$f_v = \frac{F}{4A_v} = \frac{126,888}{4(9.173)}$

f_v = 3181 PSI

Bearing at 5.02" Ø Hole

$A_t = (13 - 5.02)(2.5) - 4(\frac{1}{2})(.045)^2$

$A_t = 19.946\ in^2$

$A_v = (6.5 - \frac{5.02}{2})(2.5) - 2(\frac{1}{2})(.045)^2$

$A_v = 9.973\ in^2$

The bearing stress is the same as the outer bearing stress on the clevis pin (6) for both (7) and (9).

f_c = 126,888/24.012 = 5284 PSI

The thread shear is the same as the thread shear for the arm (8) for both (7) and (9).

f_v = 126,888/55.092 = 2303 PSI

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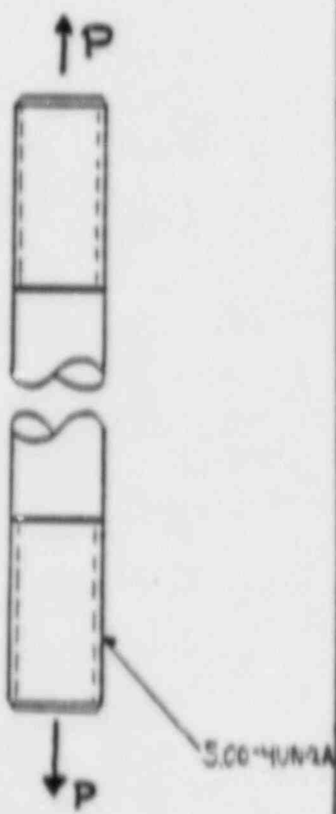
ARM (8)

MAT'L: ASTM - A306 GR.70



THREAD SHEAR

$f_v = P/A_v$

$A_v = D_{pitch} \pi l/2$

FOR AN EXTERNAL THREAD

$D_{pitch} = D_{nom} - .64952/n$

$D_{pitch} = (5) - .64952/(4)$

$= (4.8376)$ in.

D_{nom} = major diameter of external thread

n = number of threads/in

l = length of thread engagement = 7.25

THEREFORE $A_v = (55.092)\ in^2$

P = 126,888 lbs

f_v = 2303 PSI

THREAD TENSION

$f_t = P/A_t$

FOR EXTERNALLY THREADED PARTS

$A_t = \pi/4 (D_{nom} - .9743/n)^2$

$= \pi/4 (5 - .9743/4)^2 = 17.769\ in^2$

$f_t = (126.888)/(17.769)$

=

f_t = 7141 PSI

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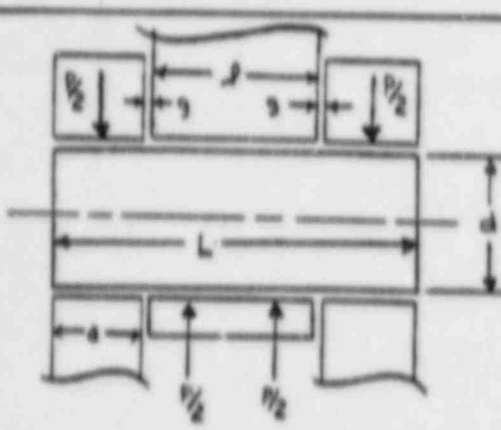
Bottom Clevis (10)

5" DIA. PIN

MAT'L: ASTM A434 CLASS BD



P = force acting on assembly, lb.

d = diameter of pin, in.

l = length of bearing surface of center body, in.

a = length of bearing surface one side of outer body, in.

g = gap between bearing surfaces, in.

L = total active length of pin, in

= l + 2(a + g)

P = 126,888 lb.

d = 5.0025 in.

l = 3.91 in. 2(1.25)+1.50−2(.045)

a = 2.40 in 2.49 − 2(.045)

g = .285 in

[9.37 − 2(2.49) + 2(.045) − 3.91]/2

SHEAR STRESS

$f_v = P/2A_v$

$P = 126,888$

$A_v = \pi d^2/4$

$A_v = \pi(5.0025)^2/4$

$A_v = 19.65 \text{ in}^2$

$f_v = (126,888)/(2 \cdot 19.65)$

$f_v = 3229 \text{ PSI}$

BEARING STRESS

$f_c = P/A_v$

$P = 126,888$

INNER

$A_v = d\,l = (5.0025)(3.91)$

$= (19.560) \text{ in}^2$

$f_c = (126,888)/(19.560)$

$f_c = 6477 \text{ PSI}$

OUTER

$A_v = 2ad = 2(2.40)(5.0025)$

$= (24.012) \text{ in}^2$

$f_c = (126,888)/(24.012)$

$f_c = 5284 \text{ PSI}$

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PIN (10)

BENDING STRESS (1)

$M_{max} = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}l\right)$

$f_b = Mc/I$

$I = \pi d^4/64$

$c = d/2$

$f_b = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}l\right)\left(\frac{d}{2}\right)\left(\frac{64}{\pi d^4}\right)$

$= 16P\left(\frac{1}{3}a + g + \frac{1}{4}l\right)/(\pi d^3)$

$= 16P\left(\frac{2.40}{3} + .285 + \frac{3.91}{4}\right)/\pi 5.0025^3$

$= 126,877(.08391)$

$= 10,647$ PSI

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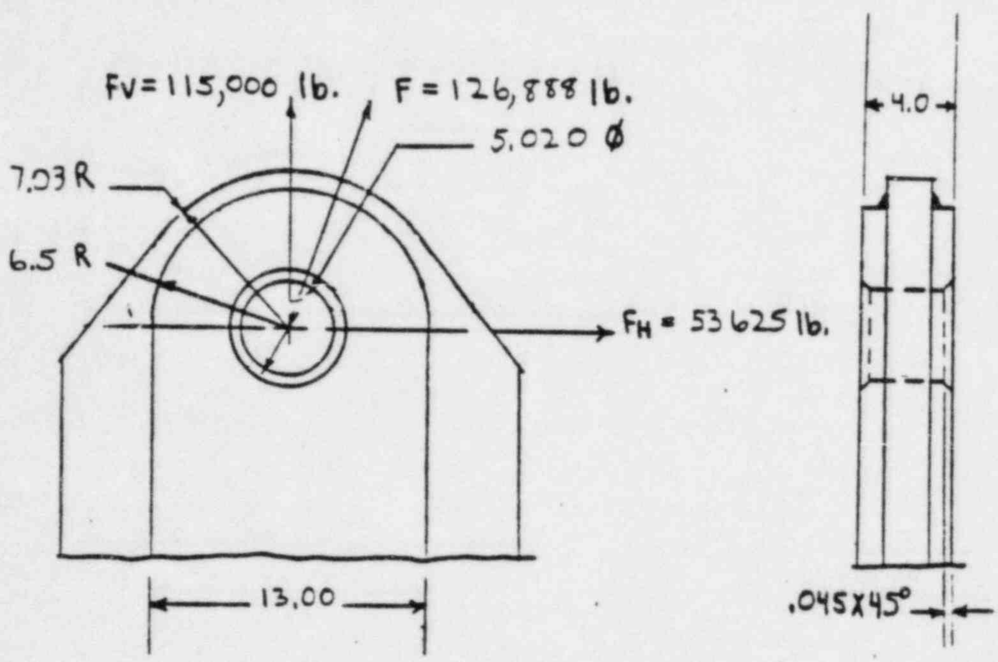
(11) SUPPORT LUG ASTM A-515 GR. 70 N&T



Tension at Pin Hole

$f_t = \frac{F}{A_t}$ $A_t = (13.00 - 5.02)4 - 4(\frac{1}{2})(.045)^2 = 31.916\,in^2$

$f_t = \frac{126,888}{31.916} = 3976$ PSI

Shear at Pin Hole

$f_s = \frac{F}{2A_v} = \frac{126,888}{31.916} = 3976$ PSI, $A_v = (6.5 - 2.51)(4) - 2(\frac{1}{2})(.045)^2$

$A_v = 15.957\,in^2$

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Bearing at 5.02" hole

The bearing stress is the same as the inner bearing stress on the clevis pin (10).

$f_c = 126{,}888 / 19.560 = 6487$ PSI

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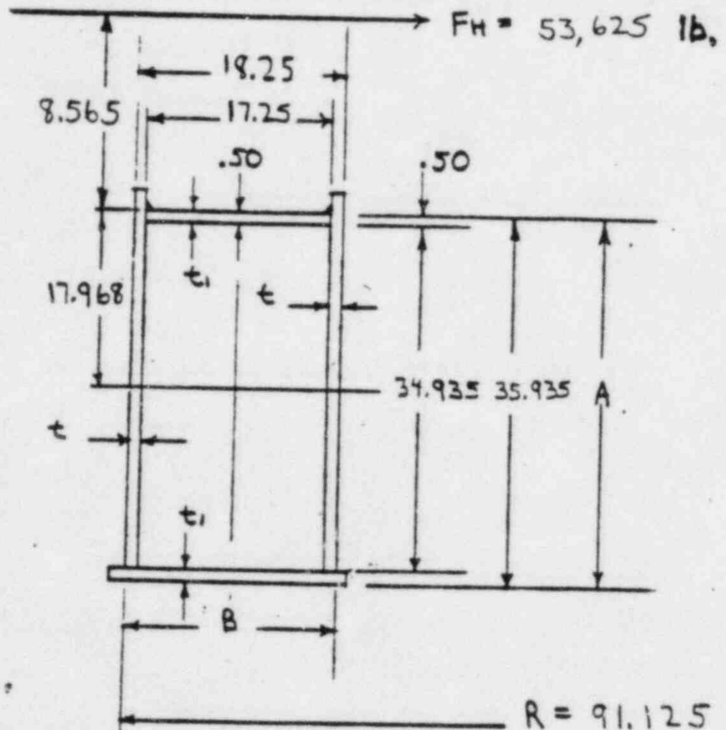
(12)

RING GIRDER ASTM A-285 GR. C



Torsion

$$f_{TOR} = \frac{T}{2t(A-t)(B-t_1)}$$ ROARK 3RD EDITION Page 176, Case 11

$T = (8.565 + 17.968)(53,625)$

$T = 1,422,832$ lb-in.

$$F_{TOR} = \frac{1,422,832}{(2)(.5)(35.435-.5)(18.25-.50)} = 2262 \text{ PSI}$$

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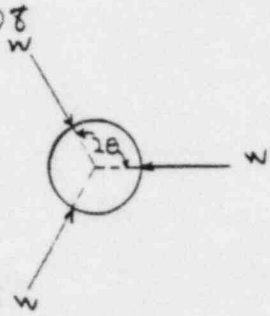
Shear

$$f_v = \frac{E_H}{A} = \frac{53625}{(35.935)(18.25) - (34.935)(17.25)} = \frac{53625}{53.185}$$

$f_v = 1008$ PSI

Total Shear = $f_{TOR} + f_v = 2262 + 1008$

Total Shear = 3270 PSI



Bending stress Roark p.158, Case 9

$$f_{M\,max} = \frac{1}{2} W R \left(\frac{1}{S} - \frac{1}{\theta}\right)$$ Between Loads

$$M_{max} = \frac{1}{2}(53625)(91.125)\left(\frac{1}{\sin\theta} - \frac{1}{\theta}\right)$$

$\theta = 60°$, $\theta = 1.047$ Rad. $\frac{1}{\sin\theta} = 1.154$ $\frac{1}{\theta} = .955$ Rad.

$M_{max} = (53625)(91.125)(1.154 - .955)$

$M_{max} = 972429$ lb-in.

$$-M_{max} = -\frac{1}{2} W R \left(\frac{1}{\theta} - \cot\theta\right),$$ at each load

$\theta = 60°$; $\theta = 1.047$ Rad, $\frac{1}{\theta} = .955$ Rad.

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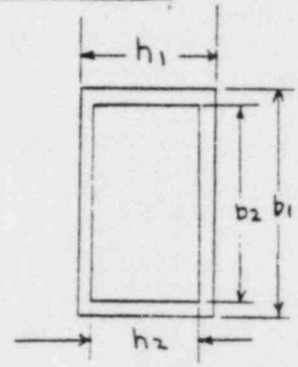
$\cot\theta = .577$

$-M_{max} = -\frac{1}{2}(53625)(91.125)(.955 - .577)$

$-M_{max} = -923563$ lb-in.

$Z = \frac{b_1h_1^3 - b_2h_2^3}{12(h_1/2)} = \frac{(35.935)(17.25)^3 - (34.935)(17.25)^3}{(6)(18.25)}$



$Z = 357$ in^3

$f_B = \frac{M_{max}}{Z} = \frac{923563}{357} = 2587$ PSI

Maximum Tensile Stress

$f_{max} = \frac{f_B}{2} + \sqrt{\left(\frac{f_B}{2}\right)^2 + (f_v)^2}$

$f_{max} = \frac{2587}{2} + \sqrt{\left(\frac{2587}{2}\right)^2 + (3270)^2}$

$f_{max} = 1293.5 + \sqrt{1673142 + 10692900}$

$f_{max} = 1293.5 + 3517$

$f_{max} = 4811$ PSI

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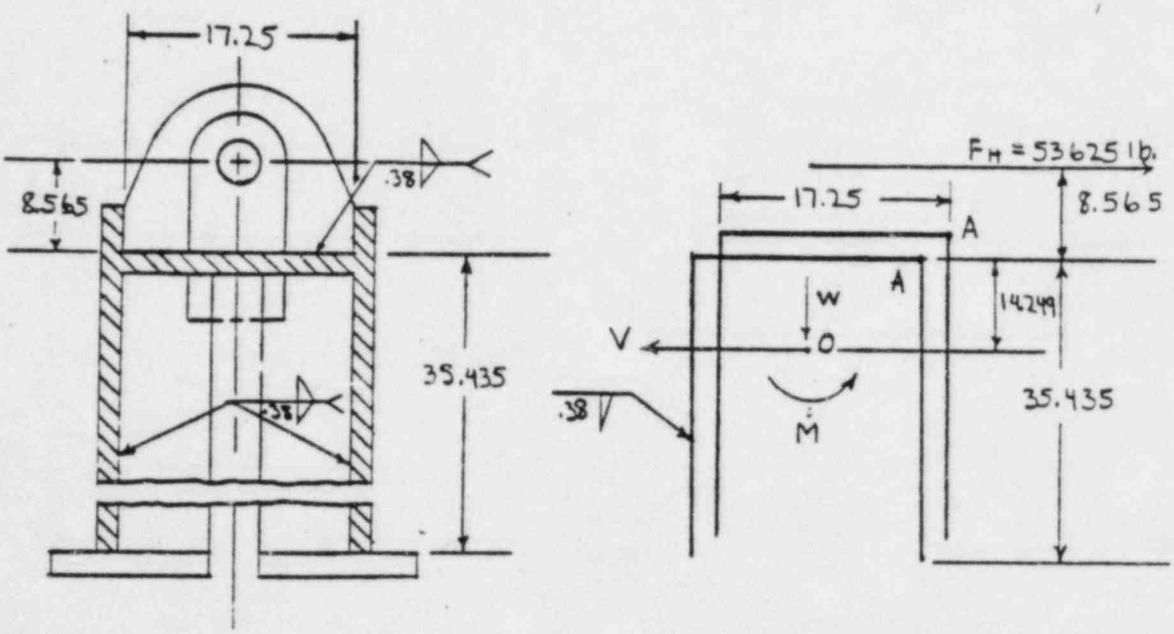
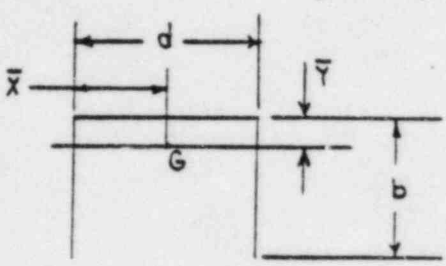
WELD OF SUPPORT LUG TO RING GIRDER



Ref.: Shigley's Mechanical Engineering Design 3RD Edition



From Table 7-1

$$\bar{y} = \frac{b^2}{2b+d} = \frac{35.435^2}{2(35.435)+17.25} = 14.249 \text{ in.}$$

$$\bar{X} = \frac{d}{2} = \frac{17.25}{2} = 8.625 \text{ in.}$$

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$M = (F_H)(14.249 + 8.565)$

$M = (53625)(22.814) = 1223400$ lb.-in.

$$J = \frac{2b^3 + 6bd^2 + d^3}{12} - \frac{b^4}{2b+d}$$

$b = 35.435''$, $d = 17.25''$

$$J_v = \frac{8(35.435)^3 + 6(35.435)(17.25)^2 + 17.25^3}{12} - \frac{35.435^4}{2(35.435)+17.25}$$

$J_v = 35362 - 17892 = 17470\ in^3$

$J = [.707\,w\,J_v]\,2$

w = .38 fillet weld

$J = .707(.38)(17470)2$

$J = 9387\ in^4$

$A_w = .707\,w(2b + d)$

$A_w = (.707)(.38)[2(35.435) + 17.25]\,2 = 47.35\ in^2$

$$\tau'_x = \frac{F_H}{A_w} = \frac{53625}{47.35} = 1133\ PSI$$

$$\tau'_y = \frac{W}{A_w} = \frac{5000}{47.35} = 106\ PSI$$

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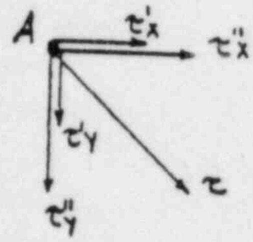
w = 5000 (downward load)

$$\tau_y'' = \frac{M r_x}{J} = \frac{(1223400)(8.625)}{9387} = 1124 \text{ PSI}$$

$$\tau_x'' = \frac{M r_y}{J} = \frac{(1223400)(14.249)}{9387} = 1857 \text{ PSI}$$



Resultant stress in weld

$$\tau = \sqrt{\tau_y^2 + \tau_x^2}$$

$$\tau = \sqrt{(106 + 1124)^2 + (1133 + 1857)^2}$$

$$\tau = 3233 \text{ PSI}$$

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(13) LEG ASTM A-36

Tension in Leg Tubing

$$f_t = \frac{F}{A_t}$$

For 8" X 6" X .50" wall Tubing, $A_t = 11.9 \text{ in}^2$ (AISC)

$$f_t = \frac{115{,}000}{11.9 \text{ in}^2} = 9664 \text{ PSI}$$

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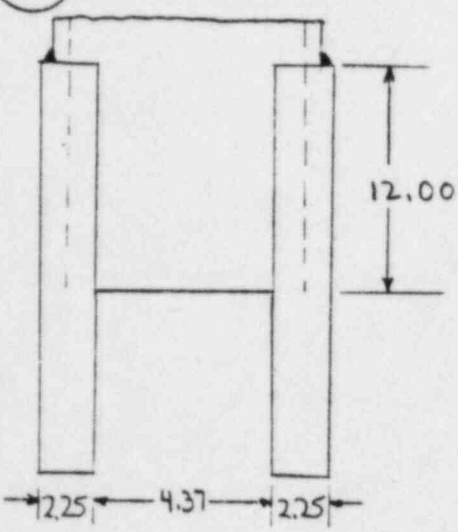
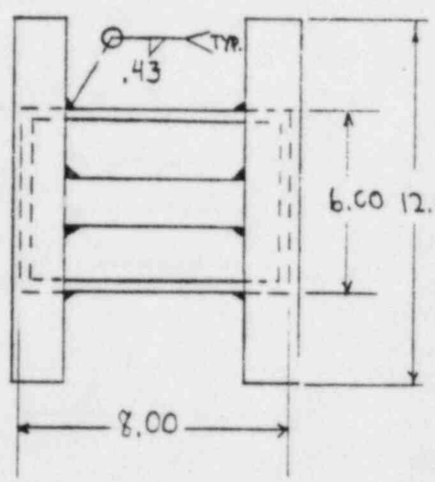
(14) CLEVIS PLATE A-515 GR. 70 Q + T





WELD OF CLEVIS PLATE TO LEG

Length of Available Weld

$$l_a = 4(12) + 4(2.25 - .435) + 2(6) = 67.26$$

$$f_w = \frac{P}{l_a} = \frac{115{,}000}{67.26} = 1710 \text{ lb/in}$$

$$S_w = \frac{f_w}{(.707)(.43)} = \frac{1710}{(.707)(.43)} = 5625 \text{ PSI}$$

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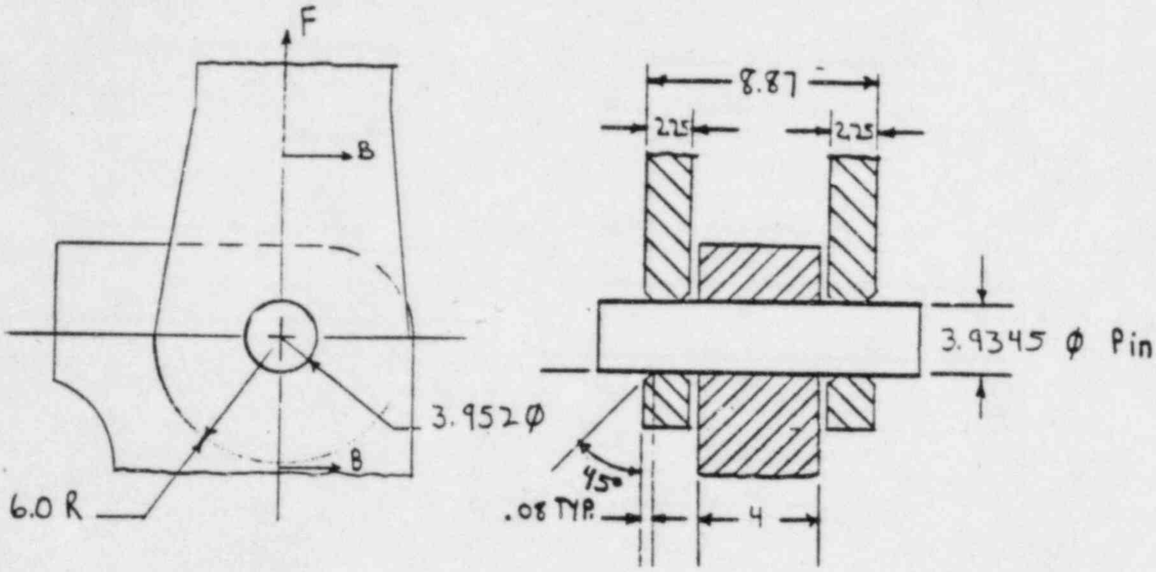

Tension at Pin Hole

$$f_t = \frac{F}{A_t}, \quad A_t = ((12 - 3.952)(2.25) - 4(\tfrac{1}{2})(.08)^2)2 = 36.19 \text{ in}^2$$

$$f_t = \frac{115,000}{36.19} = 3178 \text{ PSI}$$

Shear at Pin Hole

$$f_v = \frac{F}{2A_v}, \quad A_v = ((6 - 1.976)(2.25) - 2(\tfrac{1}{2})(.08)^2)2 = 18.09 \text{ in}^2$$

$$f_v = \frac{115,000}{2(18.09)} = 3178 \text{ PSI}$$

The Bearing stress is the same as the outer bearing stress on the 3.9345 PIN (15) $f_c = 7307$ PSI

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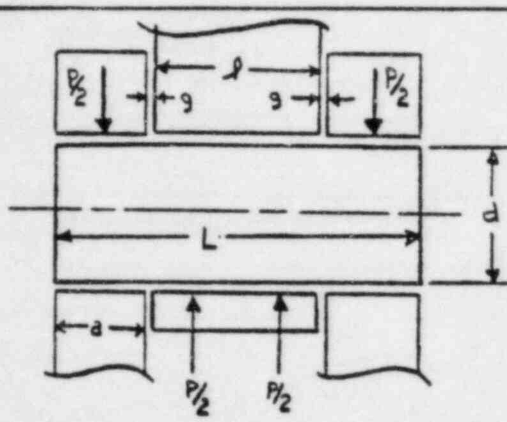
(15)

3.9345" φ PIN

MAT'L: ASTM A434 CLASS BD



P = force acting on assembly, lb.
d = diameter of pin, in.
ℓ = length of bearing surface of center body, in.
a = length of bearing surface one side of outer body, in
g = gap between bearing surfaces, in.
L = total active length of pin, in
= ℓ + 2(a + g)

P = 115,000 lb.
d = 3.9345 in.
ℓ = 4.00 nom. in
a = 2.09 in 2.25 − 2(.08)
g = .265 in
[4.37 + 2(.08) − 4] / 2

SHEAR STRESS

$f_v = P/2A_v$
$P = 115,000$
$A_v = \pi d^2/4$
$A_v = \pi (3.9345)^2/4$
$A_v = 12.158 \text{ in}^2$

$f_v = (115,000)/(2 * 12.158)$

$f_v = 4729$ PSI

BEARING STRESS

$f_c = P/A_v$
$P = 115,000$

INNER

$A_v = d\ell = (3.9345)(4.00)$
$= (15.738) \text{ in}^2$
$f_c = (115,000)/(15.738)$

$f_c = 7307$ PSI

OUTER

$A_v = 2ad = 2(2.09)(3.9345)$
$= (16.446) \text{ in}^2$
$f_c = (115,000)/(16.446)$

$f_c = 6993$ PSI

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PIN (15)

BENDING STRESS (1)

$$M_{max} = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}\ell\right)$$

$$f_b = Mc/I$$
$$I = \pi d^4/64$$
$$c = d/2$$

$$f_b = \frac{P}{2}\left(\frac{1}{3}a + g + \frac{1}{4}\ell\right)\left(\frac{d}{2}\right)\left(\frac{64}{\pi d^4}\right)$$
$$= 16P\left(\frac{1}{3}a + g + \frac{1}{4}\ell\right)/(\pi d^3)$$

$$f_b = 16P\left(\frac{2.09}{3} + .265 + \frac{4}{4}\right)/\pi\, 3.9345^3$$

$$f_b = 115{,}000(.16403)$$

$$f_b = 18{,}863 \text{ PSI}$$

(1) ADAPTED FROM FASTENING AND JOINING, 4th Ed, A REFERENCE ISSUE OF MACHINE DESIGN, PENTON PUBLISHERS PAGE 27

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APPENDIX B

DETAILED STRESS ANALYSIS - REACTOR VESSEL INTERNALS LIFT RIG, LOAD CELL AND LINKAGE

This appendix provides the detailed stress analysis for the Salem reactor vessel internals lift rig, load cell and linkage, in accordance with the requirements of ANSI N14.6. Acceptance criteria used in evaluating the calculated stresses are based on the material properties given in section 4.

SKETCH SHEET
WESTINGHOUSE FORM 54202

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R.V. Internals Lift Rig	PDC-

AUTHOR & DATE	CHECKED BY & DATE
J. S. Urban J.S. Urban 2/83	J. Richard J. Richard 2/83

PURPOSE AND RESULTS:

1. The purpose of this analysis is to determine the acceptability of this rig to the requirements of ANSI N14.6.
2. The results show that all stresses are within the allowable stresses.

COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL ENGINEER
JOSEPH W. RICHARD
NO. 007167-E

J.W. Richard

REVISION NO.	DATE	DESCRIPTION	BY
		Original Issue	J. Urban

RESULTING REPORTS, LETTERS OR MEMORANDA:

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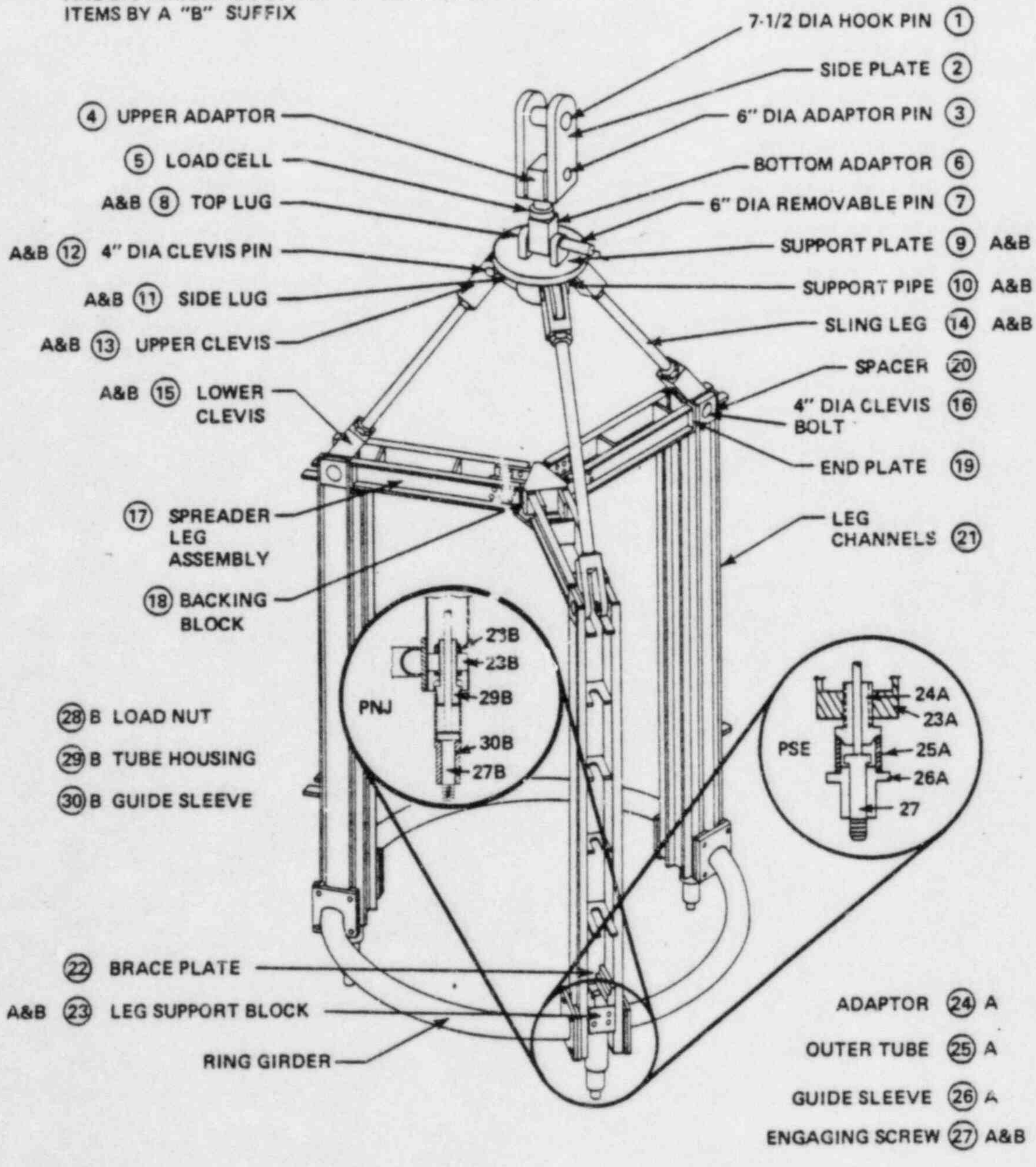
WHERE PSE AND PNJ RIGS DIFFER, THE PSE ITEMS ARE DISTINGUISHED BY AN "A" SUFFIX, THE PNJ ITEMS BY A "B" SUFFIX



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DESIGN WEIGHTS:

WEIGHT OF LOWER INTERNALS =	260,000#
INTERNALS LIFTING RIG WEIGHT	14,500#
CONTINGENCIES	10,000#
	284,500#

THE DESIGN WEIGHT FOR ITEMS 1 THROUGH 6 WILL BE 320,000 lb AS THEY ARE ALSO USED TO MONITOR THE HEAD LIFT RIG LIFT

NOMENCLATURE:

- A = area, in^2
- c = distance from center of flexure to extreme fibers, in
- d = diameter, in.
- f_b = bending stress, psi
- f_c = bearing stress, psi
- f_t = tensile stress, psi
- f_v = shear stress, psi
- I = moment of inertia, in^4
- K = outward force exerted by spreader, = 71,752#
- L = tension in lifting leg = 94,833#
- M = moment, in-lb
- P = general force, lb.
- T = tension in sling leg, = 118,916#
- W = design weight
- α = angle sling leg makes to vertical

The nomenclature of references or variables defined at a calculation may be used as supplements to the above list. Where this is so, the meanings of the terms are defined where the calculations are made.

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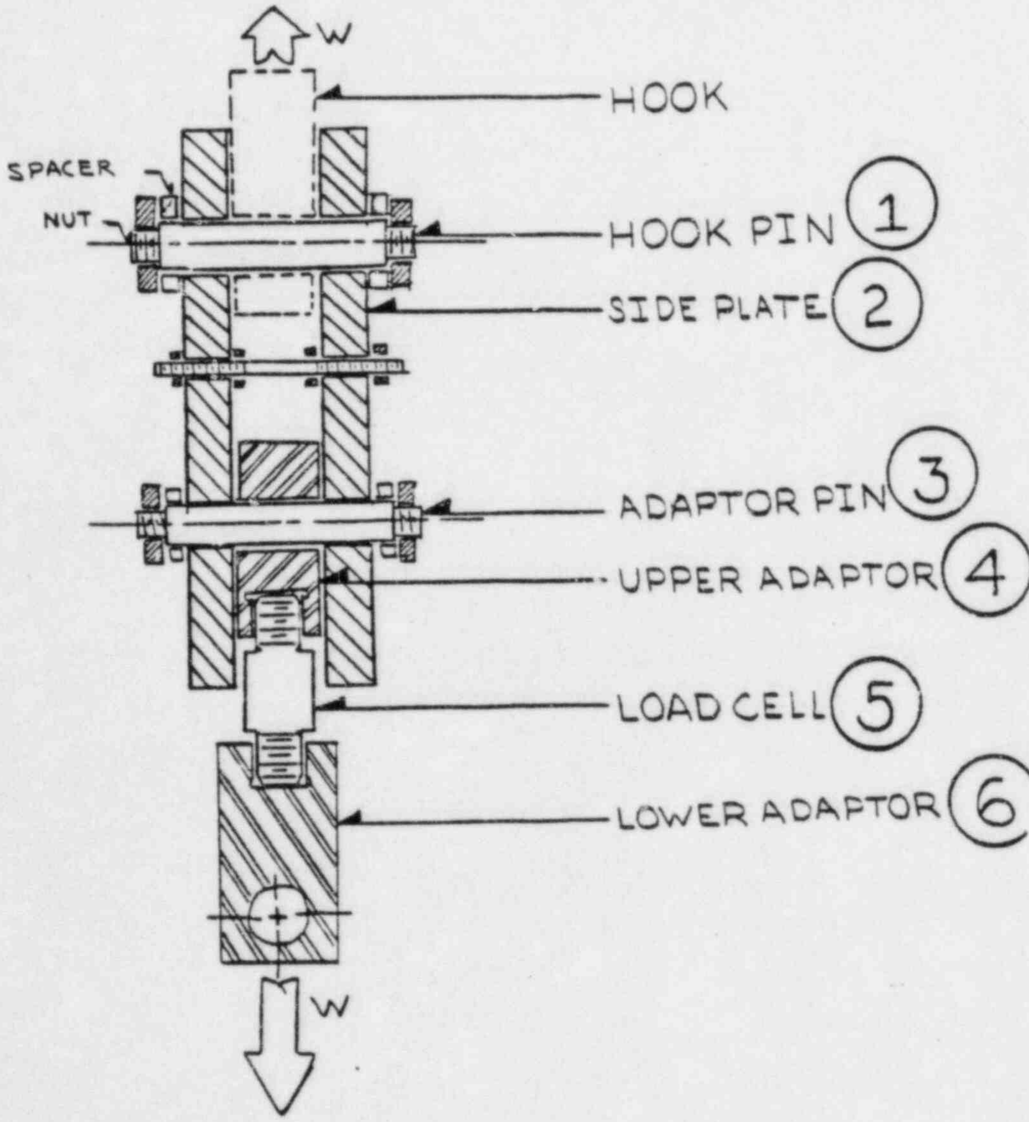
LOAD CELL LINKAGE ASSEMBLY



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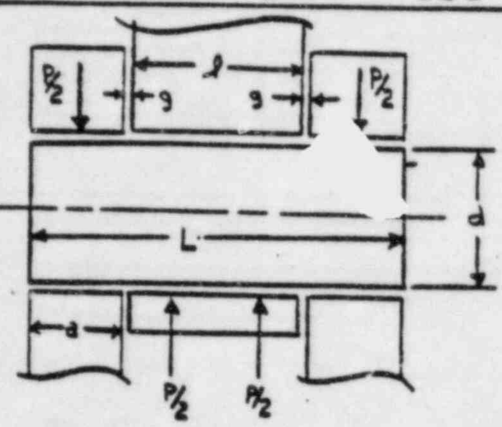
HOOK PIN (1)

MAT'L: ASTM A 434 CLASS BD
AISI 4340 STEEL



P = force acting on assembly, lb.
d = diameter of pin, in.
ℓ = length of bearing surface of center body, in
a = length of bearing surface one side of outer body, in.
g = gap between bearing surfaces, in.
L = total active length of pin, in.
= ℓ + 2(a + g)

P = W lb. = 320,000#
d = 7.500/7.492 in.
ℓ = 8.23 in
a = 2.04/1.96 in
g = 0.08 in
L = 13.77/13.72 in

SHEAR STRESS

$f_v = P/2A_v$
P = W
$A_v = \pi d^2/4$
$A_v = \pi(7.492)^2/4$
$A_v = 44.084$ in²

$f_v = (W)/(2 \cdot 44.084)$
$= W(0.011342)$
$f_v = 3629$ PSI

BEARING STRESS

$f_c = P/A_v$
P = W

INNER
$A_v = d\ell = (7.492)(8.23)$
$= (61.66)$ in²
$f_c = (W)/(61.66)$
$= W(0.016218)$
$f_c = 5190$ PSI

OUTER
$A_v = 2ad = 2(1.96)(7.492)$
$= (29.369)$ in²
$f_c = (W)/(29.369)$
$= W(0.03405)$
$f_c = 10,896$ PSI

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BENDING STRESS*

$f_b = (P/2)(a/2 + g + \ell/4)\frac{32}{\pi d^3}$

$f_b = (W)/2 \cdot (1.96/2 + 0.08 + 8.23/4) \cdot 32/(\pi(7.492)^3) = W(0.003776)$

$\underline{\underline{f_b = 12{,}082 \text{ PSI.}}}$

MISCELLANEOUS CALCULATIONS

$2g = L - \ell - 2a - 2$ spacers thickness

$2g = 13.77 - (8.23) - 2(1.96) - 2(.73)$

$g = 0.08$

* EQUATION DERIVED ON P(7)

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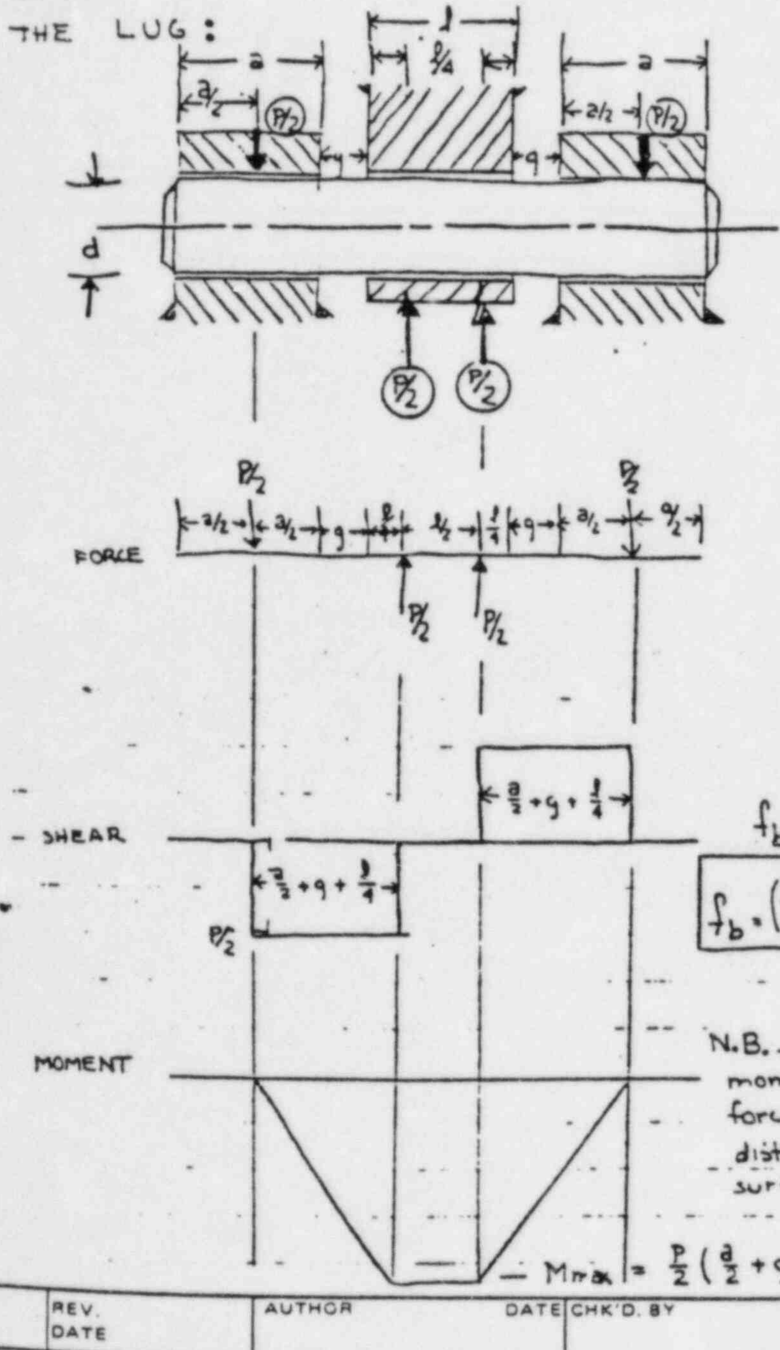
— BENDING STRESS FORMULA DERIVATION —

ASSUMING FORCES IN DOUBLE LUG TO ACT AT THE LUG CENTERS AND THE FORCE IN THE CENTER LUG TO ACT AT TWO PLACES 1/4 WAY INTO THE LUG:



g = gap between bearing surfaces

a = length of one side of double-lug bearing surface

l = length of bearing surface of center lug

P = force acting on assembly

d = diameter of pin

$$f_b = \frac{Mc}{I}$$

$$c = d/2$$

$$I = \pi d^4/64$$

$$f_b = M_{max}[c/I]$$

$$f_b = \left(\frac{P}{2}\right)\left(\frac{a}{2}+g+\frac{l}{4}\right)\frac{32}{\pi d^3}$$

N.B. — This same maximum moment also occurs when the forces are assumed evenly distributed across the lug surfaces

$$M_{max} = \frac{P}{2}\left(\frac{a}{2}+g+\frac{l}{4}\right)$$

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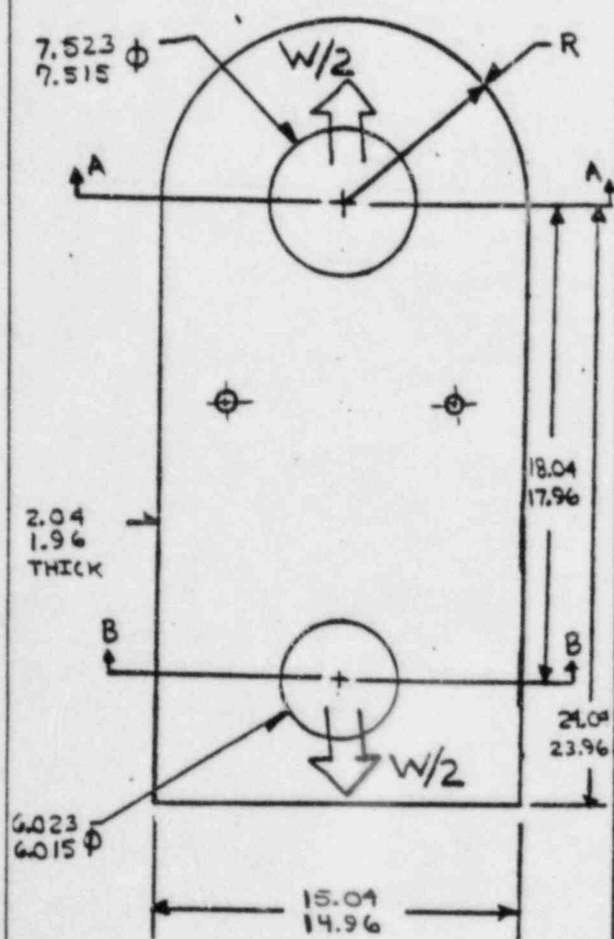
SIDE PLATE (2)

MAT'L: ASTM-A515 GR. 70
QUENCHED AND TEMPERED.



W = 320,000 #

TENSION @ SEC A-A

$f_t = P/A_t$

$P = W/2$

$A_t = (14.96 - 7.523)\,1.96$

$= 14.577\ in^2$

$f_t = W(0.0343)$

$f_t = 10{,}976$ PSI

BEARING @ SEC B-B

THE BEARING STRESS @ SEC B-B IS THE SAME AS THE OUTER BEARING STRESS ON THE ADAPTER PIN

$f_c = W(0.04257)$

$f_c = 13{,}622$ PSI

SHEAR TEAR-OUT @ B-B

CONSERVATIVELY USING THE CROSS-SECTION BELOW THE AXIS OF THE HOLE

$f_v = P/2A_v$

$P = W/2$

$A_v = (23.96 - 18.04 - 6.023/2)\,1.96$

$f_v = W(.04385)$

$f_v = 14{,}033$ PSI

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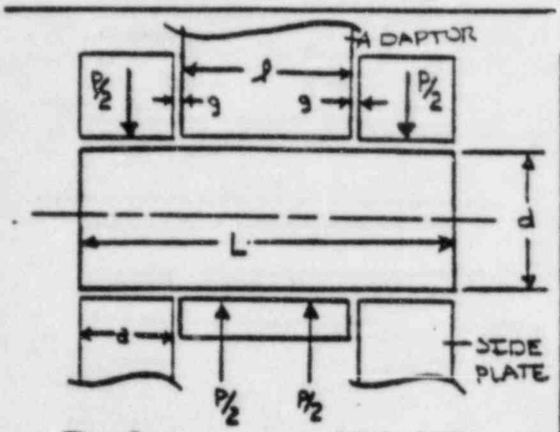
ADAPTOR PIN (3)

MAT'L: ASTM A434 CLASS BD
AISI 4340 STEEL



P = force acting on assembly, lb.
d = diameter of pin, in.
ℓ = length of bearing surface of center body, in.
a = length of bearing surface one side of outer body, in.
g = gap between bearing surfaces, in.
L = total active length of pin, in
= ℓ + 2(a + g)

P = W lb. = 320,000 #
d = 6.000//5.992 in.
ℓ = 8.27//8.23 in
a = 2.00±.04 in
g = 0.08 in
L = 13.77//13.73 in

SHEAR STRESS

$f_v = P/2A_v$
$P = W$
$A_v = \pi d^2/4$
$A_v = \pi(5.992)^2/4$
$A_v = 28.199$ in²

$f_v = (W)/(2 \cdot 28.199)$
$f_v = W(0.01773)$
$f_v = 5674$ PSI

BEARING STRESS

$f_c = P/A_v$
$P = W$

INNER
$A_v = d\ell = (5.992)(8.23)$
$= (49.314)$ in²
$f_c = (W)/(49.314)$
$= W(0.02028)$
$f_c = 6490$ PSI

OUTER
$A_v = 2ad = 2(1.96)(5.992)$
$= (23.49)$ in²
$f_c = (W)/(23.49)$
$= W(0.04257)$
$f_c = 13622$ PSI

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BENDING STRESS*

$$f_b = (P/2)(a/2 + g + \ell/4)\frac{32}{\pi d^3}$$

$f_b = (W)/2 * (1.96/2 + 0.08$
$+ 8.23/4) * 32/(\pi(5.992)^3)$
$= W(0.07380)$

$f_b = 23,616$ PSI.

* EQUATION DERIVED ON P(7)

MISCELLANEOUS

$2g = L - \ell - 2(a) - 2$ spacer thicknesses

$2g = 13.77 - 8.23 - 2(1.96) - 2(.73)$

$g = 0.08$

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LOWER ADAPTOR AND UPPER ADAPTOR (4/6)

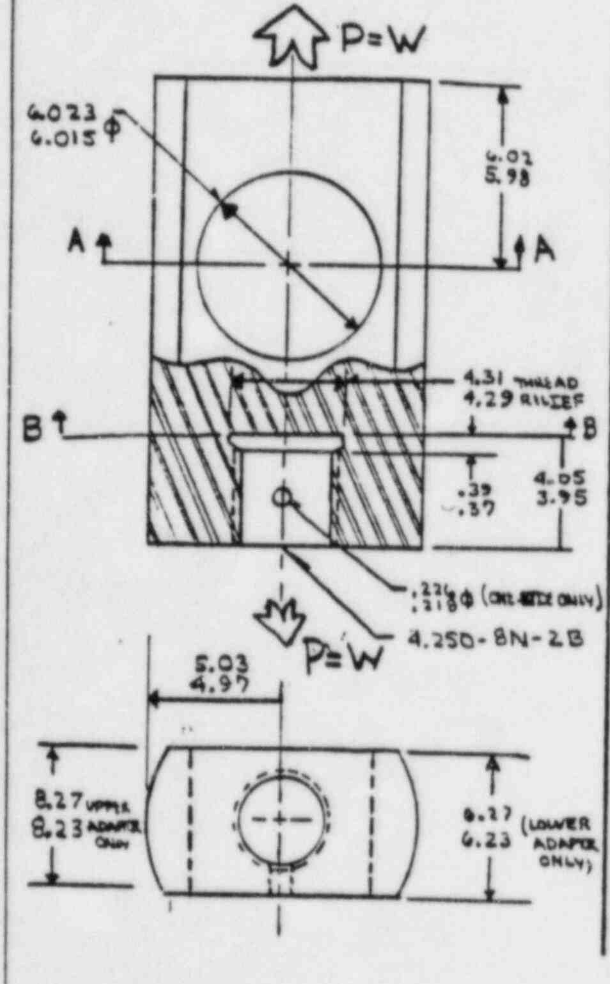
DWG 108D058 H01 AND H02

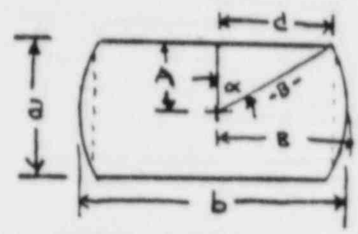
MAT'L: AISI 4340

QUENCHED AND TEMPERED

YIELD: 120,000 PSI

TENSILE STRENGTH: 135,000 PSI.





BODY AREA

$$A_B = 2AC + \pi(2B)^2/4 \cdot \frac{360-4\alpha}{360}$$

$$\cos\alpha = A/B$$

$$C = \sqrt{B^2 - A^2}$$

$$A = \tfrac{1}{2}a \quad B = \tfrac{1}{2}b$$

$$A_B = \frac{a}{2}\sqrt{b^2 - a^2} + \pi b^2\left(\frac{360-4\alpha}{4(360)}\right)$$

$$\cos\alpha = a/b$$

FOR LOWER ADAPTOR

$a = 6.23$

$b = 9.94$

$\therefore\ \alpha = 51.19°$

$A_B = 57.59\ in^2$

FOR UPPER ADAPTOR

$a = 8.23$

$b = 9.94$

$\alpha = 34.11°$

$A_B = 71.13\ in^2$

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LOWER ADAPTOR AND UPPER ADAPTOR (4/6)

$W = 320{,}000$ #

TENSILE STRESS @ A-A

$A_t = A_B - A_{hole}$

UPPER: $A_t = 71.13 - 6.023(8.23)$

LOWER: $A_t = 57.59 - 6.023(6.23)$

$f_t = P/A_t$

$P = W$

$f_{t\,upper} = W(0.04638)$

$f_{t\,upper} = 14{,}842$ PSI

$f_{t\,lower} = W(0.04983)$

$f_{t\,lower} = 15{,}946$ PSI

BEARING STRESS @ A-A

$f_c = P/A_c$

$P = W$

$A_{c\,upper} = 6.023(8.23)$

$= 49.569\ in^2$

$f_{c\,upper} = W(0.02~~017~~)$

$f_{c\,upper} = 6454$ PSI

$A_{c\,lower} = 6.023(6.23)$

$= 37.52\ in^2$

$f_{c\,lower} = W(0.02665)$

$f_{c\,lower} = 8528$ PSI

TENSILE STRESS @ B-B

$f_t = P/A_t$

$A_t = A_B - \pi d^2/4$

$d_{relief} = 4.31$

$A_{t\,upper} = 71.13 - \pi(4.31)^2/4 = 56.54$

$A_{t\,lower} = 57.59 - \pi(4.31)^2/4 = 43.00$

$P = W$

$f_{t\,upper} = W(0.017687)$

$f_{t\,upper} = 5660$ PSI

$f_{t\,lower} = W(0.02326)$

$f_{t\,lower} = 7443$ PSI

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LOWER ADAPTOR AND UPPER ADAPTOR (4/6)

THREAD SHEAR

$f_v = P/A_v$

$A_v = \pi D_{PITCH} * l/2$

FROM MARK'S HANDBOOK FOR M.E.'s 8th ED, SEC 8, FOR A 4¼-8N-2B

$D_{PITCH} = 4.1688$

$l = 3.95 - .39 = 3.56$ in

$A_v = \pi(4.1688)3.56/2$

$= 23.31$ in^2

$P = W$

$f_v = W(0.04290)$

$f_v = 13728$ PSI

SHEAR TEAR-OUT

$f_v = P/2A_v$

CONSERVATIVELY, LET A_v BE THE AREA OF THE CROSS-SECTION DIRECTLY ABOVE THE AXIS.

FOR THE LOWER ADAPTOR

$A_v = (5.98 - 6.023/2)(6.23)$

$= 18.494$ in^2

FOR THE UPPER ADAPTOR THE WIDTH OF THE MACHINED SURFACE IS $2(4.97^2 - (8.23/2)^2)^{1/2}$

$= 5.574$ in. THIS IS LESS THAN THE HOLE $\phi = 6.023$, SO LET THE THICKNESS BE

$2(4.97^2 - (6.023/2)^2)^{1/2} = 7.907$ in

INSTEAD OF 8.23 in.

$A_v = (7.907)(5.98 - 6.023/2)$

$= 23.47$ in^2

$P = W$

$f_{v\,UPPER} = W/(2 * 23.47)$

$f_{v\,UPPER} = W(0.02130)$

$f_{v\,UPPER} = 6816$ PSI

$f_{v\,LOWER} = W/(2 * 18.494)$

$f_{v\,LOWER} = W(0.02704)$

$f_{v\,LOWER} = 8653$ PSI.

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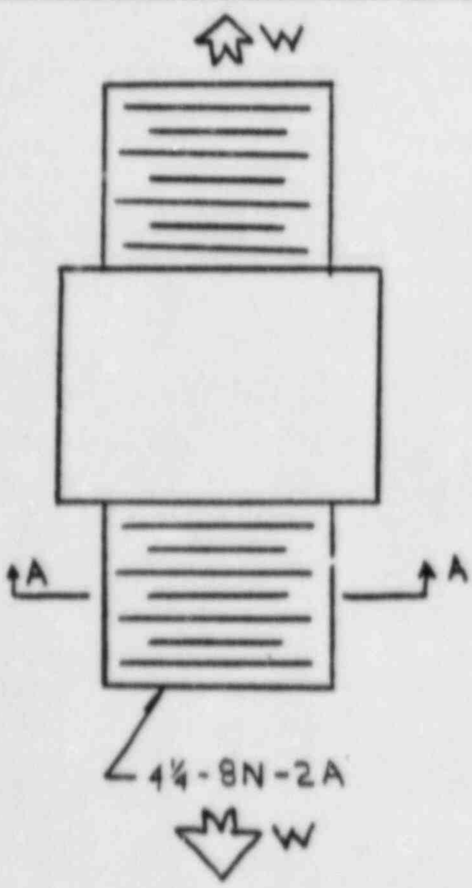
LOAD CELL (5)

MAT'L: 17-4 ph s/s
COND H 1100°



W = 329000 #

TENSION @ A-A

$f_t = P/A_t$

$P = W$

FROM MARK'S HANDBOOK FOR ME'S
8th Ed, P 8-13

STRESS AREA = 13.3683 = A_t

$f_t = W / 13.3683$

$f_t = W(0.07480)$

f_t = 23,936 PSI

THREAD SHEAR

THE THREAD SHEARING STRESS IS THE SAME AS FOR THE ADAPTORS

$f_v = W(0.04290)$

f_v = 13,728 PSI

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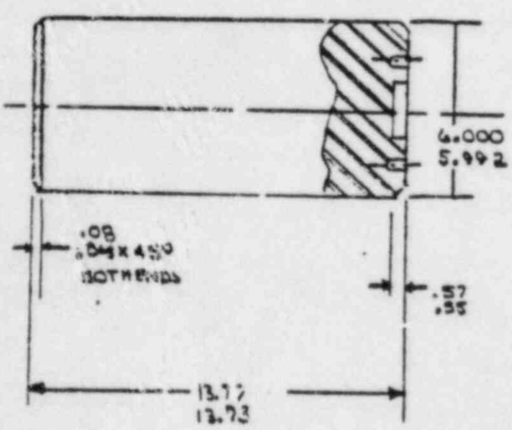
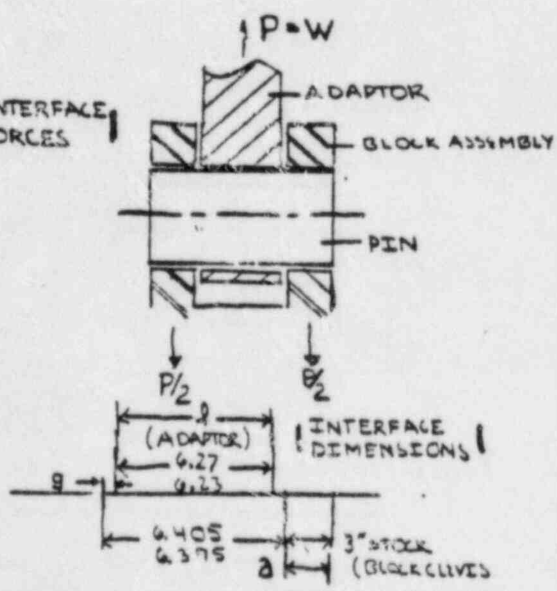
REMOVABLE PIN (7)

EST WT: 111.0#

MAT'L ASTM A434 CLASS BD
AISI 4340





W = 284,500#

SHEAR STRESS

$f_v = (P/2)/A_v$

$A_v = \pi d^2/4$

$= \pi(5.992)^2/4$

$= 28.199\ in^2$

$(P/2) = W/2$

$f_v = W/(2 * 28.199)$

$= W(.017731)$

$\underline{f_v = 5044\ PSI}$

BEARING STRESS

- PIN TO BLOCK ASSEMBLY

$f_c = (P/2)/A_c$

$A = dt = 3(5.992)$

$= 17.98\ in^2$

$P = W$

$f_c = W/(2 * 17.98)$

$f_c = W(.027815)$

$f_c = \underline{7913}\ PSI$

- PIN TO ADAPTOR

$f_c = P/A_c$

$P = W$

$A_c = dt = 5.992(6.23) = 37.33\ in^2$

$f_c = W(.026788)$

$\therefore f_c = \underline{7621}\ PSI$

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REMOVABLE PIN (7)

BENDING STRESS*

$P = W$

$a = 3.$ in

$l = 6.23$ in

$g = (6.405 - 6.23)/2 = .0875$ in

$d = 5.992$ in

$$f_b = \left(\frac{P}{2}\right)\left(\frac{a}{2} + g + \frac{l}{4}\right)\frac{32}{\pi d^3}$$

$$= W*(1/2)*(3/2 + .0875 + 6.23/4) * 32/\pi/d^3$$

$f_b = W(.07445)$ PSI

$\underline{f_b = 21,181}$ PSI

---

* THE FORMULA FOR PIN BENDING STRESS, USED ON THIS AND ALL SUBSEQUENT PINS, IS DERIVED ON THE FOLLOWING PAGE:

– PAGE 7 –

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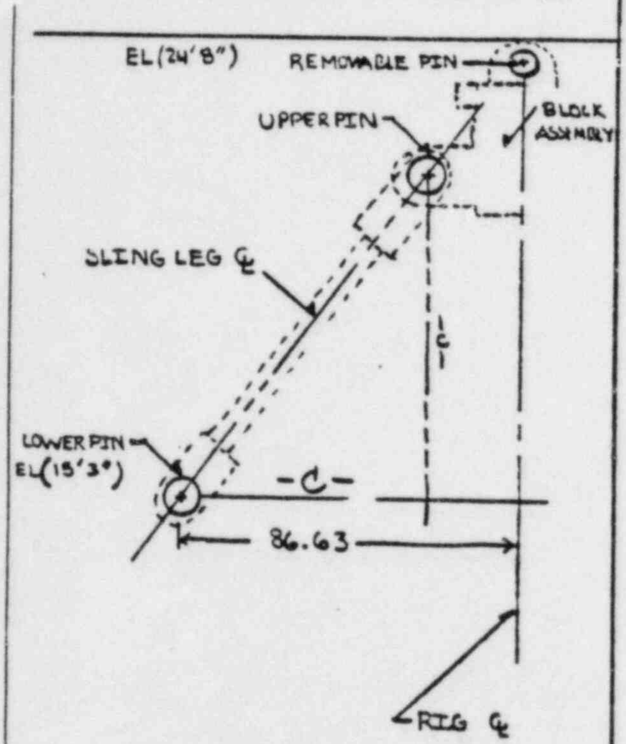
CALCULATION OF TENSION IN SLING LEG



A = RIG ℄ TO LOWER PIN ℄ = 86.63

B = RIG ℄ TO UPPER PIN ℄ = 14.00 ~~.09~~

C = (A−B) · 72.63

a = DIFFERENCE IN ELEVATION ABOVE HEAD OF REMOVABLE PIN AND LOWER PIN CENTERLINES

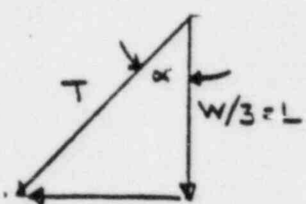
= 24'8" − 15'3" = 9'5" = 113"

b = DIFFERENCE IN ELEVATION OF REMOVABLE PIN AND UPPER PIN (FROM BLOCK ASS'Y)

= 7.0 + 19.50 − 1.0 − 8.5 = 17.0"

$c = a - b = 96''$

$\sqrt{72.63^2 + 96^2} = 120.38$ (CALC)



$W = 284{,}500$ K/lb

W = WEIGHT OF LOWER INTERNALS + RIG WT.

T = TENSION IN SLING LEG

K = OUTWARD FORCE EXERTED BY SPREADER

L = DOWNWARD FORCE EXERTED BY A LEG = W/3

$\tan\alpha = C/c = 72.63/96$

$\alpha = 37.11^\circ$

$T\cos\alpha = L = W/3$

$T = (.4180)W$

$T = 118{,}916$ lb

$T\sin\alpha = K$

$= .418\ W \sin\alpha$

$\therefore\ K = (.252)W$

$K = 71{,}751$ lb

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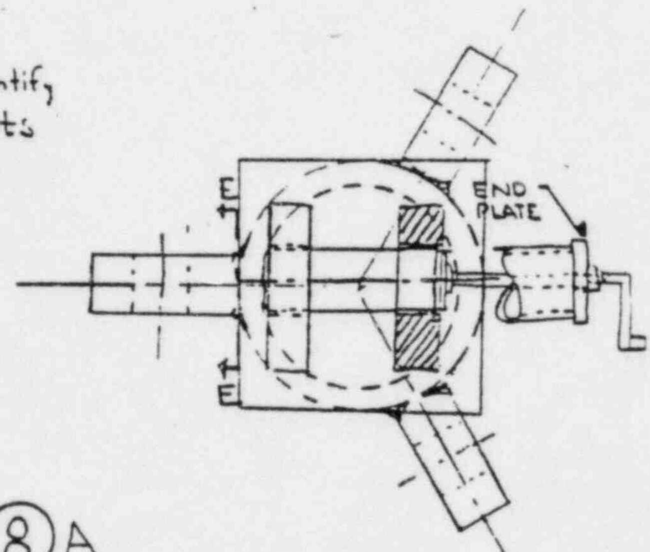
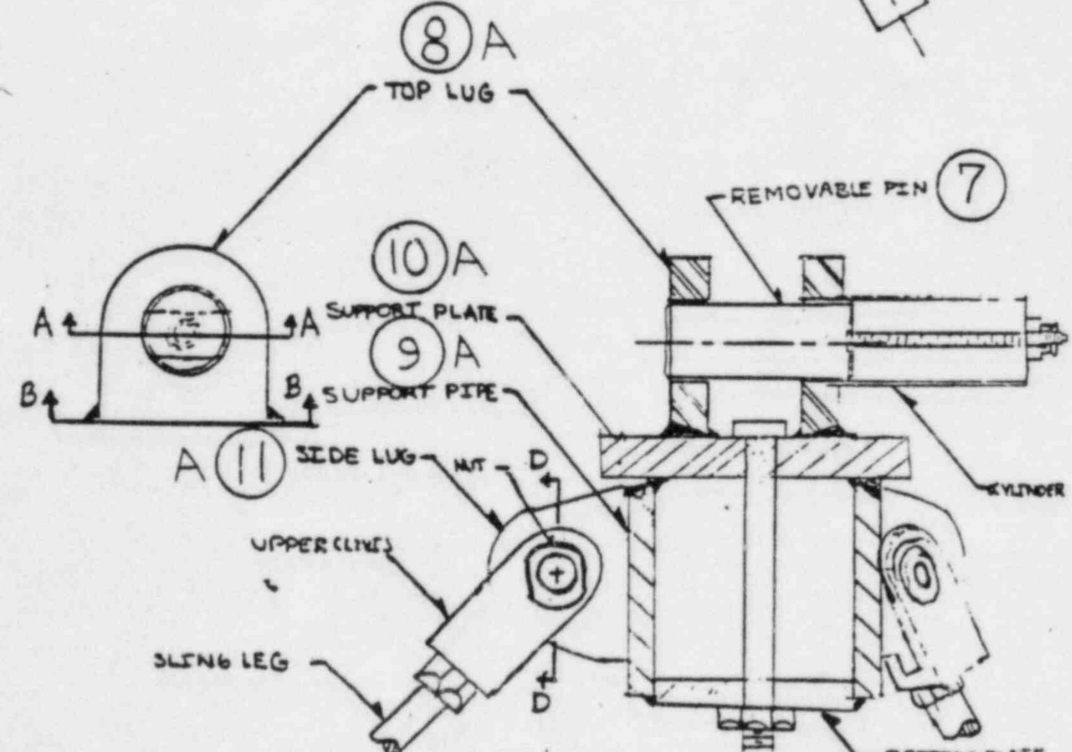
• BLOCK ASSEMBLY • PSE

Reference this page to identify the location of section cuts





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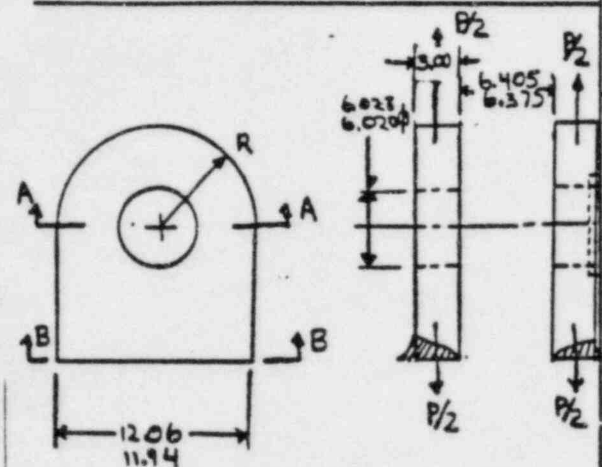
TOP LUG ⑧A



MAT'L

ASTM A 515
GR 70
QUENCHED & TEMPERED

$W = 284{,}500^{\#}$

TENSION @ A-A

$f_t = (P/2)/A_t$

$P = W$

$A_t = 3(11.94 - 6.028)$

$= 17.736 \text{ in}^2$

$f_t = W(0.02819)$

$\underline{f_t = 8020 \text{ PSI}}$

BEARING @ A-A

THE BEARING STRESS IS THE SAME AS THE OUTER BEARING STRESS OF THE REMOVABLE PIN. ⑦

$f_c = W(.027815)$

$\underline{f_c = 7913 \text{ PSI}}$

TENSION @ WELD @ B-B

$f_t = (P/2)/A_t = W/2A_t$

$A_t = 11.94(3.00) = 35.82 \text{ in}^2$

$f_t = W(0.01396)$

$\underline{f_t = 3972 \text{ PSI}}$

SHEAR FOR TEAR-OUT

$f_v = (P/2)/2A_v = W/4A_v$

$2A_v = 3(11.94 - 6.028) = 17.736 \text{ in}^2$

$f_v = W(0.02819)$

$\underline{f_v = 8020 \text{ PSI}}$

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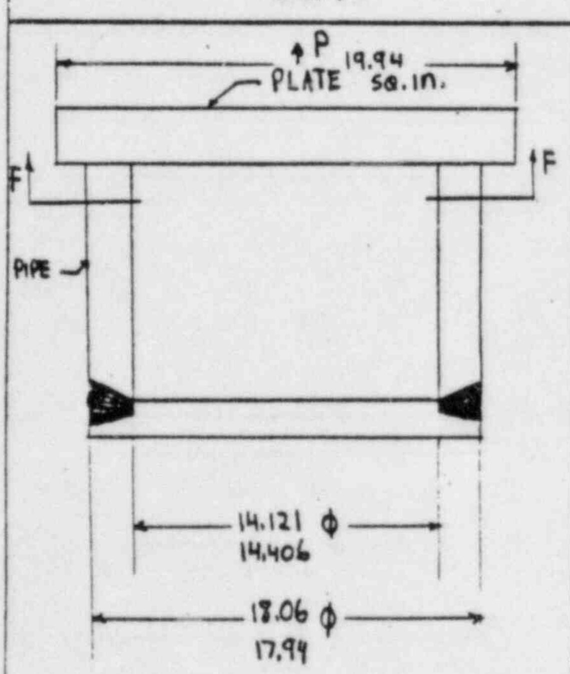
SUPPORT PLATE & (10)A
SUPPORT PIPE (9)A

MAT'L

SUPPORT PIPE
ASTM A106

SUPPORT PLATE
ASTM A515
GR. 70



$W = 284{,}500\#$

TENSION IN PLATE

$f_t = P/A_t = W/A_t$

$A_t = 19.94^2$

$f_t = (.002515)w$

$f_t = 716$ PSI

TENSION IN PIPE

$f_t = P/A_t = W/A_t$

$A_t = \pi/4(d_o^2 - d_i^2)$

$= \pi/4(17.94^2 - 14.421^2)$

$= 89.44 \text{ in}^2$

$f_t = W(0.011181)$

$f_t = 3181$ PSI

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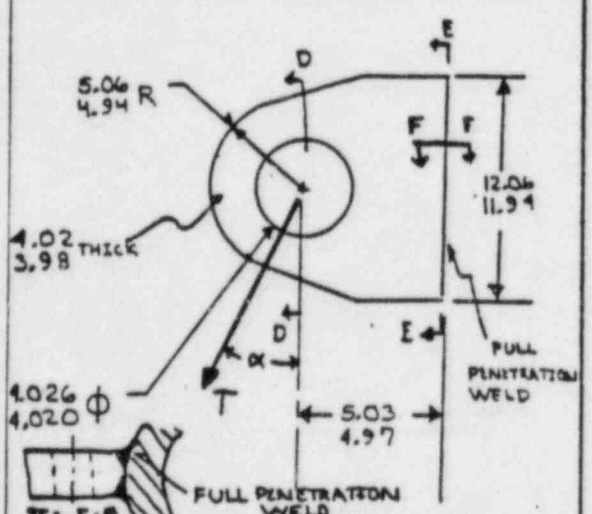
SIDE LUG (11) A

MAT'L
ASTM A515 GR70
QUENCHED &
TEMPERED



W = 284,500#

TENSION @ HOLE

THE AREA WILL CONSERVATIVELY BE TAKEN AS THE MINIMUM OBTAINED FOR HORIZONTAL FORCES

$f_t = T/A_t = .418W/A_t$

$A_{t_{min}} = [4.94(2) - 4.026] * 3.98$

$= 23.31 \text{ in}^2$

$f_t = W(0.017932)$

$f_t = 5102$ PSI

COMBINED STRESS @ WELD

TENSION: $f_t = T \sin\alpha / A_t$

$= .418W \sin 37.11° / 11.94(3.98)$

$= W(0.005307)$

SHEAR: $f_v = T\cos\alpha / A_v$

$= .418W \cos 37.11° / 11.94(3.98)$

BENDING: $f_b = Mc/I$

$= [T\cos\alpha \; 5.03][11.94/2] / [3.98 \cdot 11.94^3/12]$

WHERE $I = bh^3/12$

$f_b = (.418W)(4.015)(5.970)/564.57$

$f_b = W(0.017731)$

$f_v = (0.007014)W$

$f_t + f_b = W(.005307 + .017731)$

$= W(.023039)$

$f_{t\,comb} = 6554$ psi

$f_v = W(.007014)$

$f_v = 1995$ psi

BEARING

BEARING IS THE SAME AS THE CLEVIS PINS

INNER BEARING = .02630W = 7481 PSI

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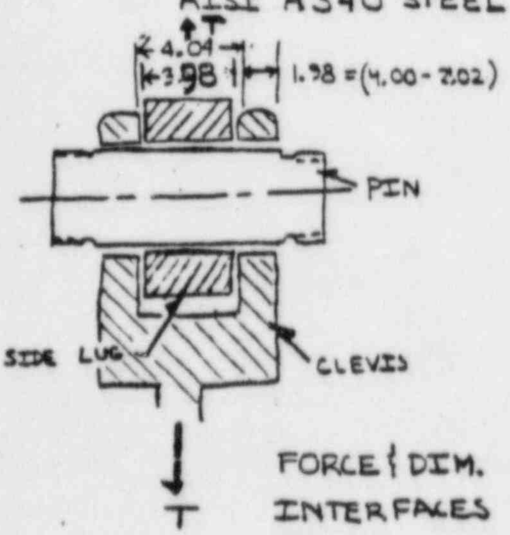
CLEVIS PIN (12)A

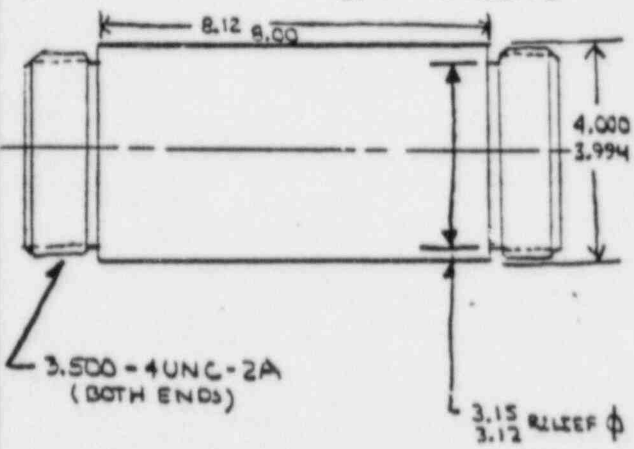
EST WT: 40#

MAT'L: ASTM A434 CLASS BD

AISI A340 STEEL



FORCE & DIM. INTERFACES



W = 284,500#

SHEAR STRESS

$f_v = P/2A_v$

$P = T = .418W$

$A_v = \pi d^2/4$

$= \pi(3.994)^2/4$

$= 12.53 \text{ in}^2$

$f_v = .418W/(2 * 12.53)$

$f_v = (.01668)W$

$f_v = 4745$ PSI.

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CLEVIS PIN (12)A

BEARING STRESS

I PIN TO CLEVIS

$f_c = (P/2)/A_v$

$(P/2) = T/2 = (.418W/2)$

$A_v = dt = 3.994(1.98)$

$= 7.91\ in^2$

$f_c = .418W/(2 * 7.91)$

$f_c = W(.02642)$

$f_c = 7517$ PSI

I PIN TO SIDE LUG

$f_c = P/A_v$

$P = T = .418W$

$A_v = dt = 3.994(3.98)$

$= 15.896\ in^2$

$f_c = .418W/15.896$

$f_c = W(.02630)$

$f_c = 7481$ PSI

BENDING STRESS

$P = T = .418W$

$a = 1.98$

$l = 3.98$

$g = (4.04 - 3.98)/2 = 0.03$

$d = 3.994$

$f_b = (P/2)(a/2 + g + l/4)\frac{32}{\pi d^3}$

$f_b = .418W/2(1.98/2 + .03 + 3.98/4)$

$* 32/(\pi * 3.994^3)$

$f_b = W(0.06733)$

$f_b = 19,155$ PSI

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• BLOCK ASSEMBLY • PNJ

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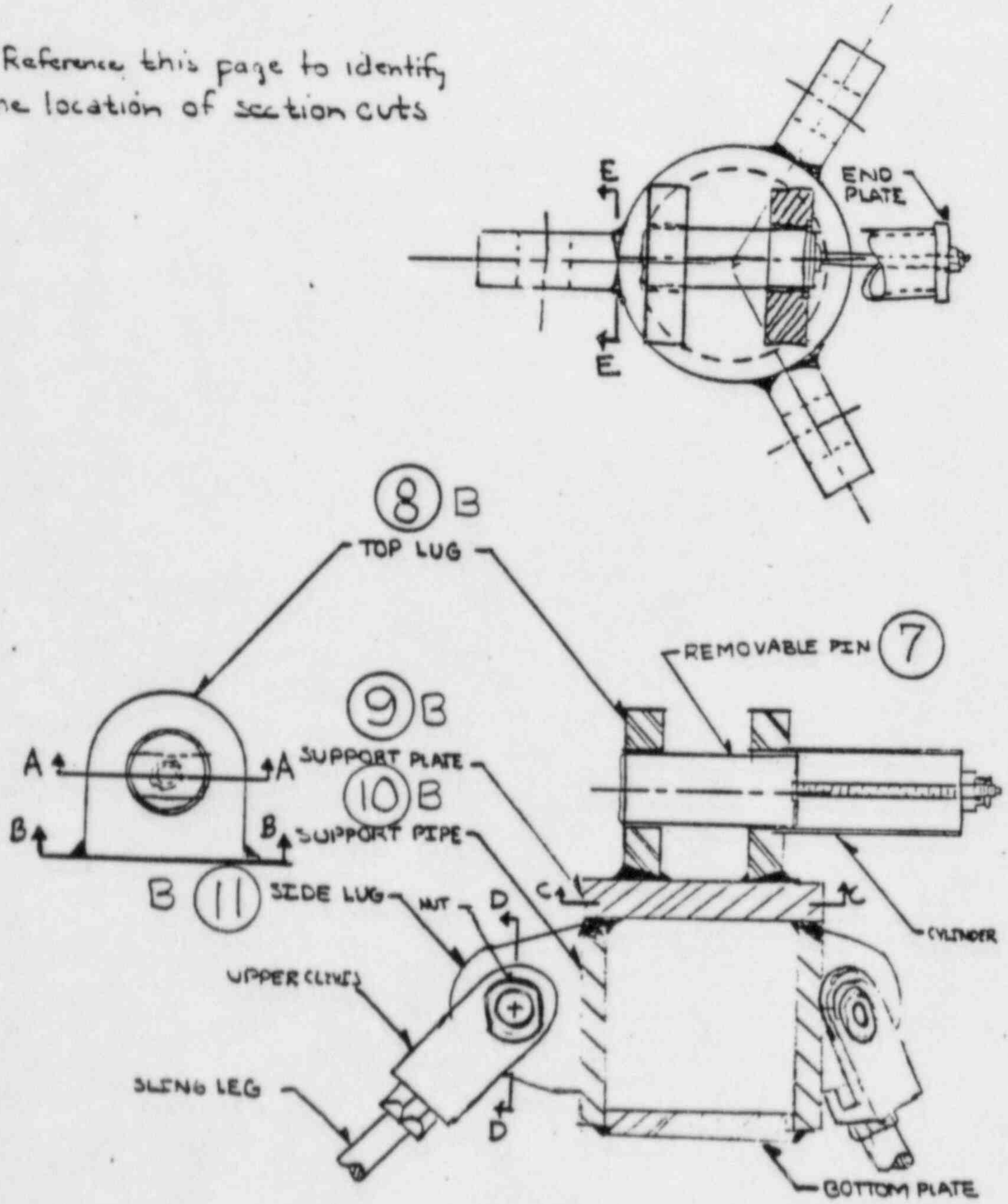

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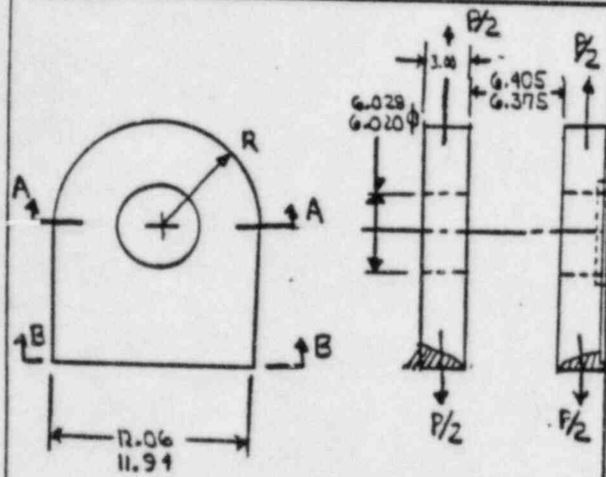
TOP LUG (8) B



MAT'L

ASTM A533 GR.B
CLASS 1
QUENCHED & TEMPERED

$W = 284,500\#$

TENSION @ A-A

$f_t = (P/2)/A_t$

$P = W$

$A_t = 3(11.94 - 6.028)$

$= 17.736 \text{ in}^2$

$f_t = W(0.02819)$

$f_t = 8020$ PSI

BEARING @ A-A

THE BEARING STRESS IS THE SAME AS THE OUTER BEARING STRESS OF THE REMOVABLE PIN. (7)

$f_c = W(.027815)$

$f_c = 7913$ PSI

TENSION @ WELD @ B-B

$f_t = (P/2)/A_t = W/2A_t$

$A_t = 11.94(3.00) = 35.82 \text{ in}^2$

$f_t = W(0.01396)$

$f_t = 3972$ PSI

SHEAR FOR TEAR-OUT

$f_v = (P/2)/2A_v = W/4A_v$

$2A_v = 3(11.94 - 6.028) = 17.736 \text{ in}^2$

$f_t = W(0.02819)$

$f_t = 8020$ PSI

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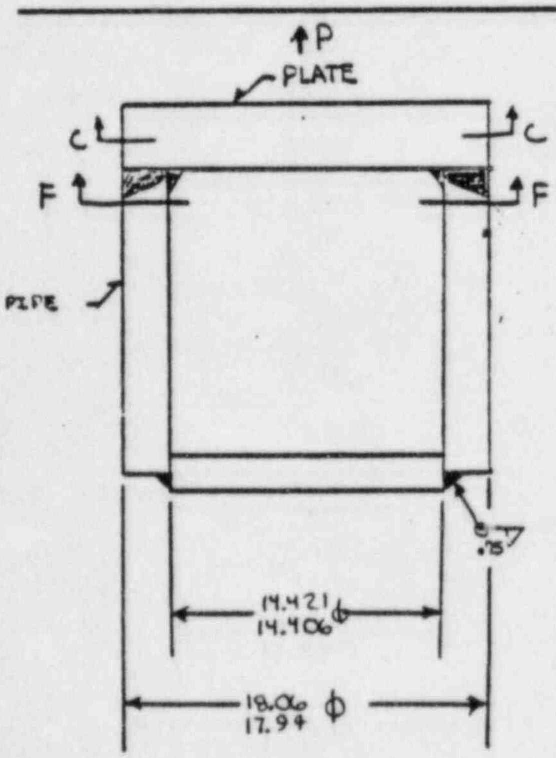
SUPPORT PLATE & (9)B
SUPPORT PIPE (10)B

MAT'L
SUPPORT PIPE
ASTM A106 GRB
SMLS. STEEL
SUPPORT PLATE
ASTM A533 GR. B
CLASS 1
QUENCHED & TEMPERED



W = 284,500#

TENSION IN PLATE

$f_t = P/A_t = W/A_t$

$A_t = \pi\, 17.94^2/4 = \pi d^2/4$

$= 252.8\ in^2$

$f_t = W(0.003956)$

$f_t = 1125$ PSI

TENSION IN PIPE

$f_t = P/A_t = W/A_t$

$A_t = \pi/4(d_o^2 - d_i^2)$

$= \pi/4(17.94^2 - 14.421^2)$

$= 89.44\ in^2$

$f_t = W(0.011181)$

$f_t = 3181$ PSI

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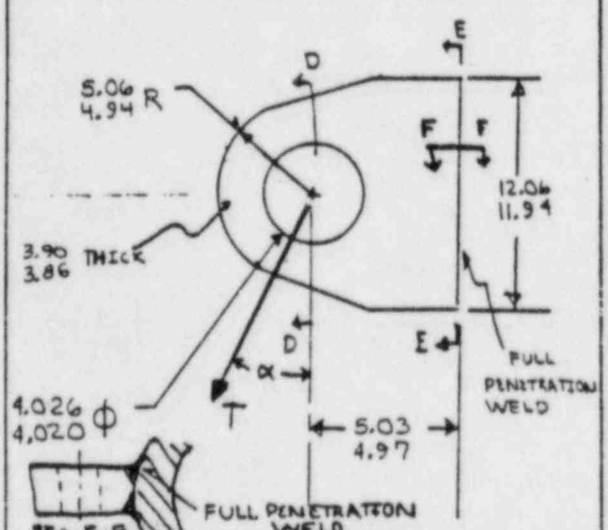
SIDE LUG (11) B

MAT'L
ASTM A588 GR.A
CLASS 1
QUENCHED @ 1650°F
TEMPERED @ 1200°F
TENSILE STRENGTH - 80,000 TO 92,000 PSI.



W = 284,500#

TENSION @ HOLE

THE AREA WILL CONSERVATIVELY BE TAKEN AS THE MINIMUM OBTAINED FOR HORIZONTAL FORCES

$f_t = T/A_t = .418W/A_t$

$A_{t_{min}} = [4.94(2) - 4.026] \cdot 3.86$

$= 22.60 \text{ in}^2$

$f_t = W(.018498)$

$f_t = 5263$ PSI

COMBINED STRESS @ WELD

TENSION: $f_t = T \sin\alpha / A_t$

$= .418W \sin 37.11° / [11.94 \cdot 3.86]$

$= W(.005472)$

SHEAR: $f_v = T\cos\alpha / A_v$

$= .418W \cos 37.11° / [11.94 \cdot 3.86]$

BENDING: $f_b = Mc/I$

$= [T\cos\alpha \; 5.03][11.94/2] / [3.86 \cdot 11.94^3/12]$

WHERE $I = bh^3/12$

$f_b = (.418W)(4.011)(5.970)/547.61$

$f_b = W(.018280)$

$f_t + f_b = W(.005472 + .018284)$

$= W(.02375)$

$f_{t\,comb} = 6758$ psi

$f_v = W(.007233)$

$f_v = 2058$ psi

BEARING

BEARING IS THE SAME AS THE CLEVIS PINS

INNER BEARING = $W(.02711) = 7714$ PSI

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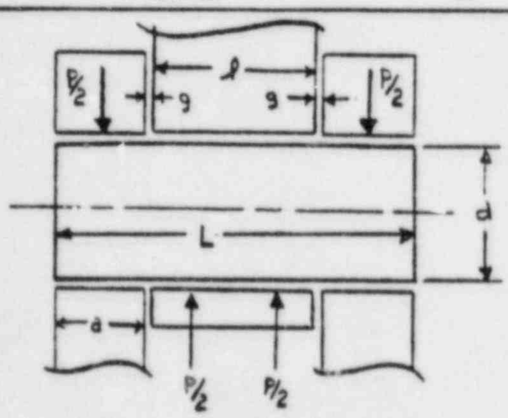
CLEVIS PIN (12) B

MAT'L: ASTM A434 CLASS BD
AISI 4340 STEEL



P = force acting on assembly, lb.
d = diameter of pin, in.
ℓ = length of bearing surface of center body, in
a = length of bearing surface one side of outer body, in
g = gap between bearing surfaces, in.
L = total active length of pin, in
 = ℓ + 2(a + g)

$P = T = .418W$ lb.
$d = 3.994$ in
$\ell = 3.86$ in
$a = 1.98$ in
$g = 0.09$ in $= (4.04 - 3.86)/2$

SHEAR STRESS

$f_v = P/2A_v$
$P = T = .418W$
$A_v = \pi d^2/4$
$A_v = \pi(3.994)^2/4$
$A_v = 12.529$ in²

$f_v = (.418W)/(2 \cdot 12.529)$
$= W(.016682)$
$f_v = 4746$ PSI

BEARING STRESS

$f_c = P/A_v$
$P = T = .418W$

INNER

$A_v = d\ell = (3.994)(3.86)$
$= (15.417)$ in²
$f_c = (.418W)/(15.417)$
$= W(.02711)$
$f_c = 7714$ PSI

OUTER

$A_v = 2ad = 2(1.98)(3.994)$
$= (15.816)$ in²
$f_c = (.418W)/(15.816)$
$= W(.02643)$
$f_c = 7519$ PSI

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BENDING STRESS*

$f_b = (P/2)(a/2 + g + \ell/4)\frac{32}{\pi d^3}$

$f_b = (.418W)/2 * (1.98/2 + .09 + 3.86/4) * 32/(\pi(3.994)^3)$

$= W(.06833)$

$f_b = 19,440$ PSI.

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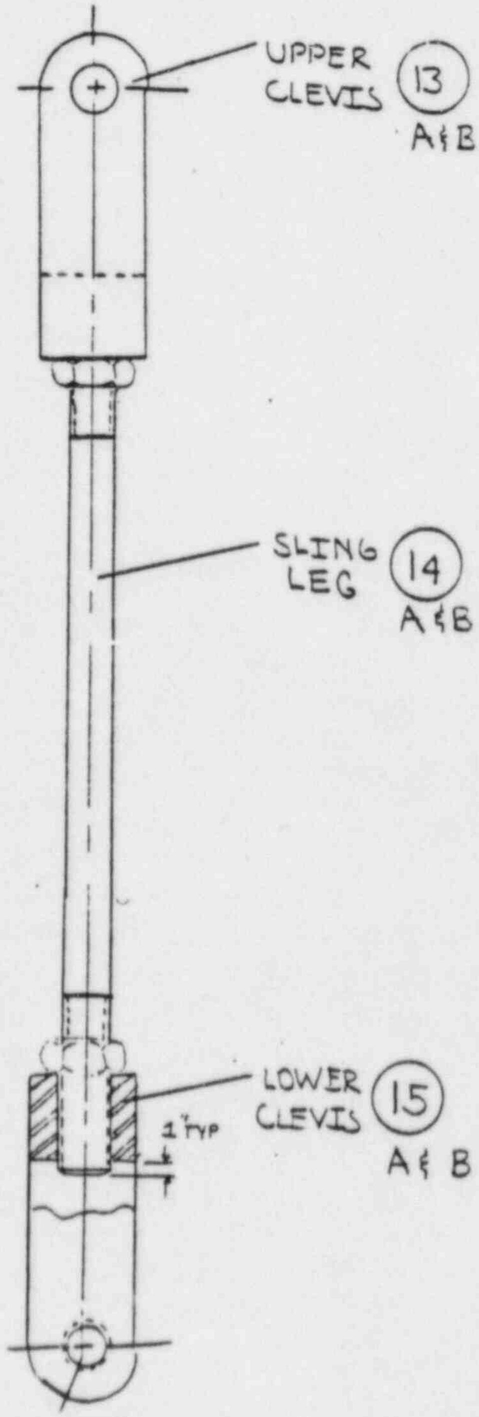
- SLING LEG ASSEMBLY -



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UPPER CLEVIS (13) A & B

PSE

MAT'L: SA-508 CL. 2

QUENCHED AND TEMPERED

YIELD 50,000 PSI

TENSILE 80,000 PSI

PNJ

MAT'L: ASTM A668 AISI 4340 STEEL CLASS M

W = 284,500 #

TENSION @ A-A

$f_t = P / A_t$

$A_t = (7.94 - 4.023)(1.98)$

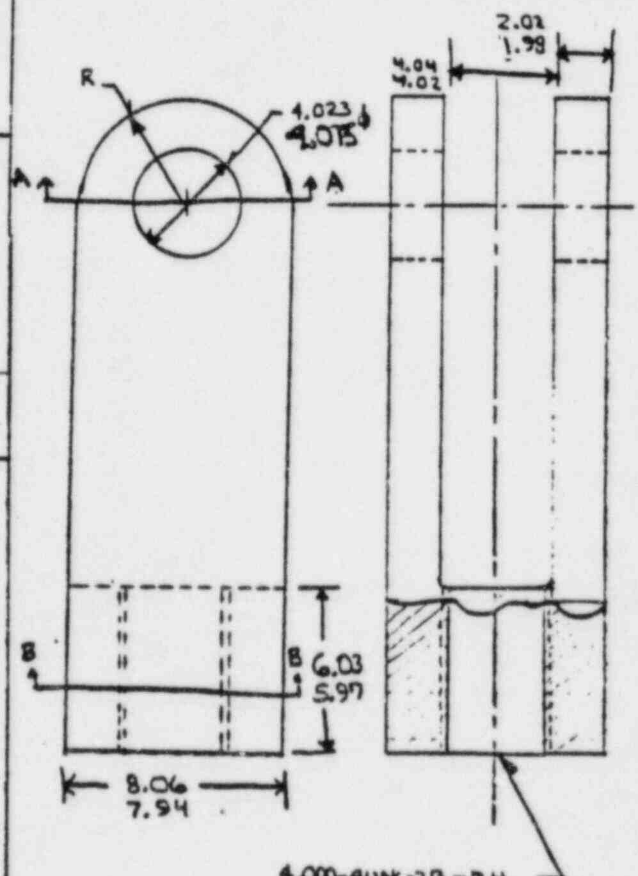
$= 7.756 \text{ in}^2$

$P = T/2 = .418 W/2$

$f_t = .418W / 7.756 / 2$

$f_t = W(0.02695)$

$f_t = 7666$ PSI



BEARING @ A-A

BEARING STRESS @ A-A WAS PREVIOUSLY CALCULATED DURING CLEVIS PIN ANALYSIS.

$f_c = W(.02642)$

$f_c = 7517$ PSI.

THREAD SHEAR

(SEE SLING LEG ANALYSIS THAT FOLLOWS)

$f_v = W(0.011058)$

$f_v = 3288$ PSI

TEAR-OUT SHEAR

$f_v = (P/2)/2A_v = (.418W/2)/(2 \cdot [(7.94 - 4.023)/2] \cdot 1.98) = W(.02695)$

$f_v = 7666$ PSI

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SLING LEG (14) A&B

PSE
MAT'L: AISI-1117
HOT ROLLED
OR 1018 COLD ROLLED

PNJ
MAT'L ASTM A434 CL BC
AISI 4340 TURNED & GROUND
OR
ASTM A598
NORMALIZED, TURNED GROUND

W = 284,500#
THREAD SHEAR @ A-A

$f_v = P/A_v$

$A_v = \pi D_{pitch} \times l/2$

FROM MARK'S HANDBOOK FOR M.E.'S
8th ED. P 8-10

$D_{pitch} = 3.838$ in

FROM CLEVIS DWG (ASSY SHOWS THREADS EXTEND 1" (TYP) PAST CLEVIS THREADING)

$l = 6.0$ in

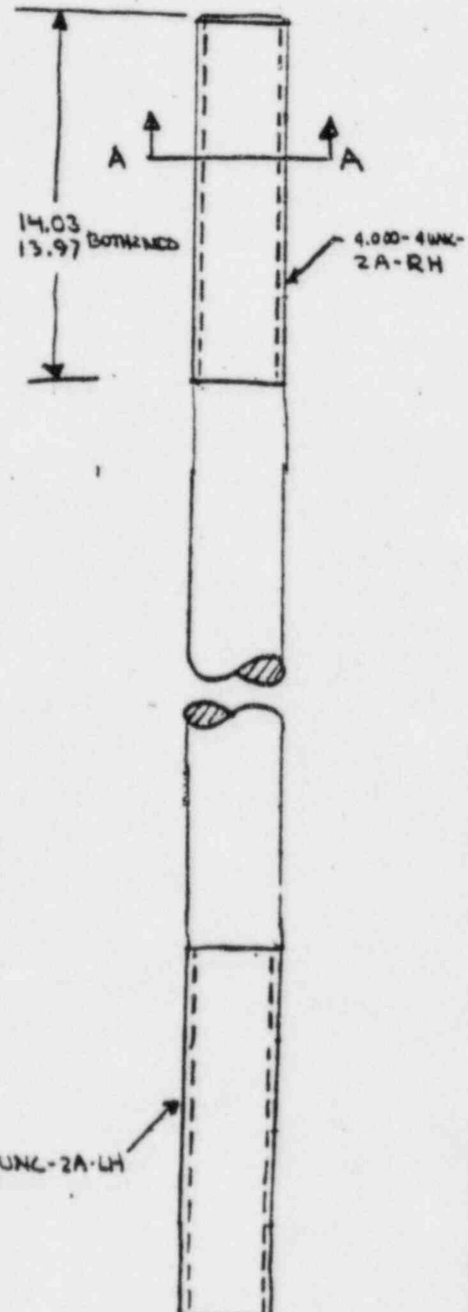
$A_v = \pi(3.838)6.0/2 = 36.17 in^2$

$P = T = .418W$

$f_v = .418W/36.17$

$f_v = W(0.011557)$

$f_v = 3288$ PSI



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SLING LEG (14) A & B

(PSE)

TENSILE STRESS

$f_t = P/A_t$

@ A-A FROM MARK'S HANDBOOK FOR MECHANICAL ENGINEER'S p8-10 8th Ed; A_t = STRESS AREA = 11.0805 in

THEREFORE

$f_{tmax} = P/11.0805$

$P = T = .418W$

$f_{tmax} = .418W/11.0805$

$f_{tmax} = W(0.03772)$

$f_{tmax} = 10{,}732$ PSI.

SLING LEG (14) B

(PNJ)

PNJ HAS A THREAD RELIEF

$f_t = P/A_t$

$P = T = .418W$

$A_t = \pi/4\,(3.617)^2 = 10.275$

$f_t = .418W/10.275$

$= W(.04068)$

$f_t = 11{,}574$ PSI

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LOWER CLEVIS (15) A & B

LOWER CLEVIS' DIMENSIONS ARE THE SAME AS THE UPPER CLEVIS' EXCEPT THAT THE UPPER HOLE THROUGH BOTH LUGS IS THREADED WITH 4.000 - 4UNC-2B-RH AND THE THREAD WHICH ATTACHES TO THE SLING LEG IS LH.

$W = 284{,}500\#$

THREAD SHEAR

FROM THE SLING LEG CALCULATIONS

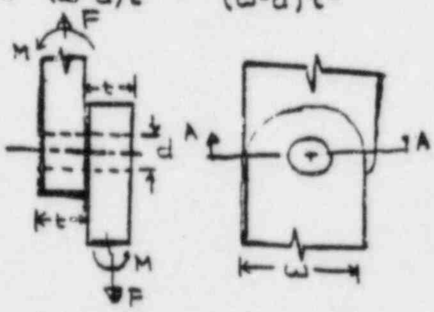
$$f_v = W(0.011557)$$

$$f_v = 3288 \text{ PSI}$$

TENSION

AT SECTION A-A (SEE UPPER CLEVIS SKETCH) THE FIBER TENSILE STRESS IS FOUND TO BE (FROM SEC 9.5.2 OF TECHNOLOGY INCORPORATED'S STRESS ANALYSIS MANUAL)

$$f_{t_{max}} = \frac{F}{(w-d)t} + \frac{6M\frac{1}{t}}{(w-d)t^2}$$



$$F = T/2 = \left(\frac{.419}{2}\right)W$$

$$M = F(1.99)/2 = 0.2080W$$

$$f_{t_{max}} = W\left[\frac{.209 + 6(.208)/1.99}{(7.94-4.023)\,1.99}\right]$$

$$= W(0.10727)$$

N.B. THE THREADED BOLT REDUCES THE ASSUMED MOMENT.

$$f_{t_{max}} = 30{,}518 \text{ PSI}$$

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Check of extreme fiber stress to AISC Criteria

From MANUAL OF STEEL CONSTRUCTION, AISC Ed 7., CHAPTER 5

SECTION 1.6.2
AXIAL TENSION & BENDING
- FORMULA (1.6-1b) APPLIES

f_b = computed bending tensile stress

f_a = computed axial stress

F_y = yield stress = 50,000 psi

F_a = axial stress permitted if axial force alone existed
= .60 F_y per sec 1.5.1.1

F_b = bending stress permitted if bending moment alone existed
= .75 F_y per sec 1.5.1.4.3

FORMULA (1.6-1b)

$$\frac{f_a}{0.60F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} \leq 1.0$$

FROM THE PREVIOUS CALCULATIONS

$f_{by} = 0$

$$f_{bx} = \frac{6M}{(w-d)t^2}$$

$$= \frac{6(.2080)W}{(7.94-4.023)1.99^2} = .08046W$$

= 22,891 psi

$$f_a = \frac{F}{(w-d)t} = \frac{.418W/2}{(7.94-4.023)1.99} = .02681W$$

= 7,628 psi

$$\frac{f_a}{.6F_y} + \frac{f_{bx}}{F_{bx}} + \frac{f_{by}}{F_{by}} =$$

$$\frac{7,628}{50,000(.60)} + 0 + \frac{22,891}{50,000(.75)}$$ (A)

$= .865 \leq 1.0$

∴ STRESSES ARE BELOW AISC ALLOWABLES

$$\frac{7,628}{110,000(.60)} + 0 + \frac{22,891}{110,000(.75)}$$ (B)

$= .393 \leq 1.0$

∴ STRESSES ARE BELOW AISC ALLOWABLES

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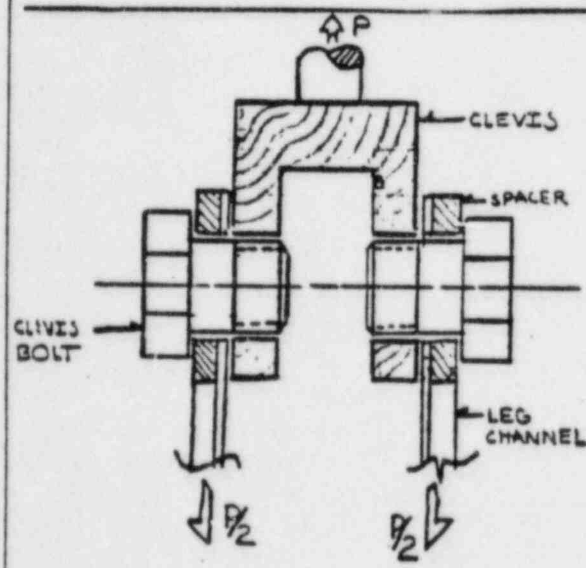
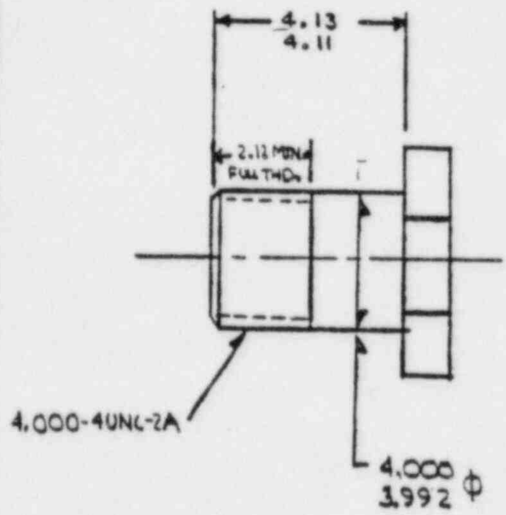
CLEVIS BOLT (16)





MAT'L:

ASTM A434
CLASS BD
AISI 4340 STEEL

SHEAR

$f_v = P/2A_v = T/2A_v$

$A_v = \pi/4 \; D_{minor}^2$

WHERE D_{MINOR} = ROOT DIAMETER OF THREAD

FOR A 4.000-4UN-2A THD

$D_{MINOR} = 3.6933$ in

$T = .418W$

$f_v = .418W/(2 * \pi/4 * 3.6933^2)$

$= W(0.01951)$ PSI

f_v 5551 PSI

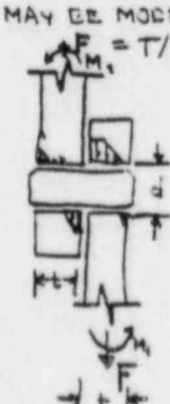
BEARING STRESS

FROM CHAPTER 9, SEC 5 OF TECHNOLOGY INCORPORATED'S STRESS ANALYSIS MANUAL:

1) THE AMOUNT OF BENDING IS SIGNIFICANTLY REDUCED BY BOLT CLAMPING OF SINGLE SHEAR JOINTS.

2) ASSUMING AN UNTHREADED JOINT THE BEARING STRESS DISTRIBUTION MAY BE MODELED BY

$F_{M_1} = T/2$



AND $f_{c\,max} = \dfrac{F}{dt} + \dfrac{6M}{dt^2}$

W = 284,500#

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CLEVIS BOLT (16)

Assuming even distribution of the moment between the lugs, and assuming yielding is not occurring (checked by $f_{c\,max}$ being $< F_{YIELD}$)

$d = 4.015$

$t = 1.99$

$M = (F)(1.99)/2 = (P/2)(1.99)/2$

$= T(.4975) = W(.2080)$

$F = T(.500) = .209\ W$

$f_{c\,MAX} = .209\ W/(4.015 * 1.99) + 6(W(.208)/4.015 * 1.99^2)$

$= W(0.10465)$

$f_{c\,max} = 29773$ PSI

THIS IS BELOW YIELDING, ASSUMPTION ∴ HOLDS

BENDING STRESS

FROM SEC 9.5.5 THE BENDING STRESS FORMULA FOR THE PIN OF A SINGLE SHEAR JOINT IS

$$f_{b\,max} = \frac{10.19\,Ft}{d_{pin}^3} \frac{\left(\sqrt{\left(\frac{2M}{Ft}\right)^2+1} - 1\right)}{2M/Pt}$$

WITH $M/Pt = 0.5$

WHEN NOT ALLOWING A PLASTIC ANALYSIS

$M = .208W$

$F = .209W$

$$f_{b\,max} = W(.209)\frac{(10.19)(1.99)}{(3.992)^3}\left[\left[\left(\frac{2(.208)}{.209(1.99)}\right)^2+1\right]^{1/2} - 1\right]$$

$= W(0.06662)(\sqrt{1.4144} - 1)$

$= W(0.02760)$

$f_b = 7854$ PSI.

THE BEARING STRESS CALCULATION DONE ON THE PRIOR PAGE, IS DONE ONLY TO DETERMINE THE STRESS FIELD, THE ONLY CRITERIA BEING THAT IT BE BELOW YIELD. THE APPROPRIATE CALCULATION FOR ACTUAL BEARING IS THE SAME AS FOR THE SPACER-CHANNEL (21)(20) AND IS

$f_c = W(.05235)$

$f_c = 14,894$ PSI.

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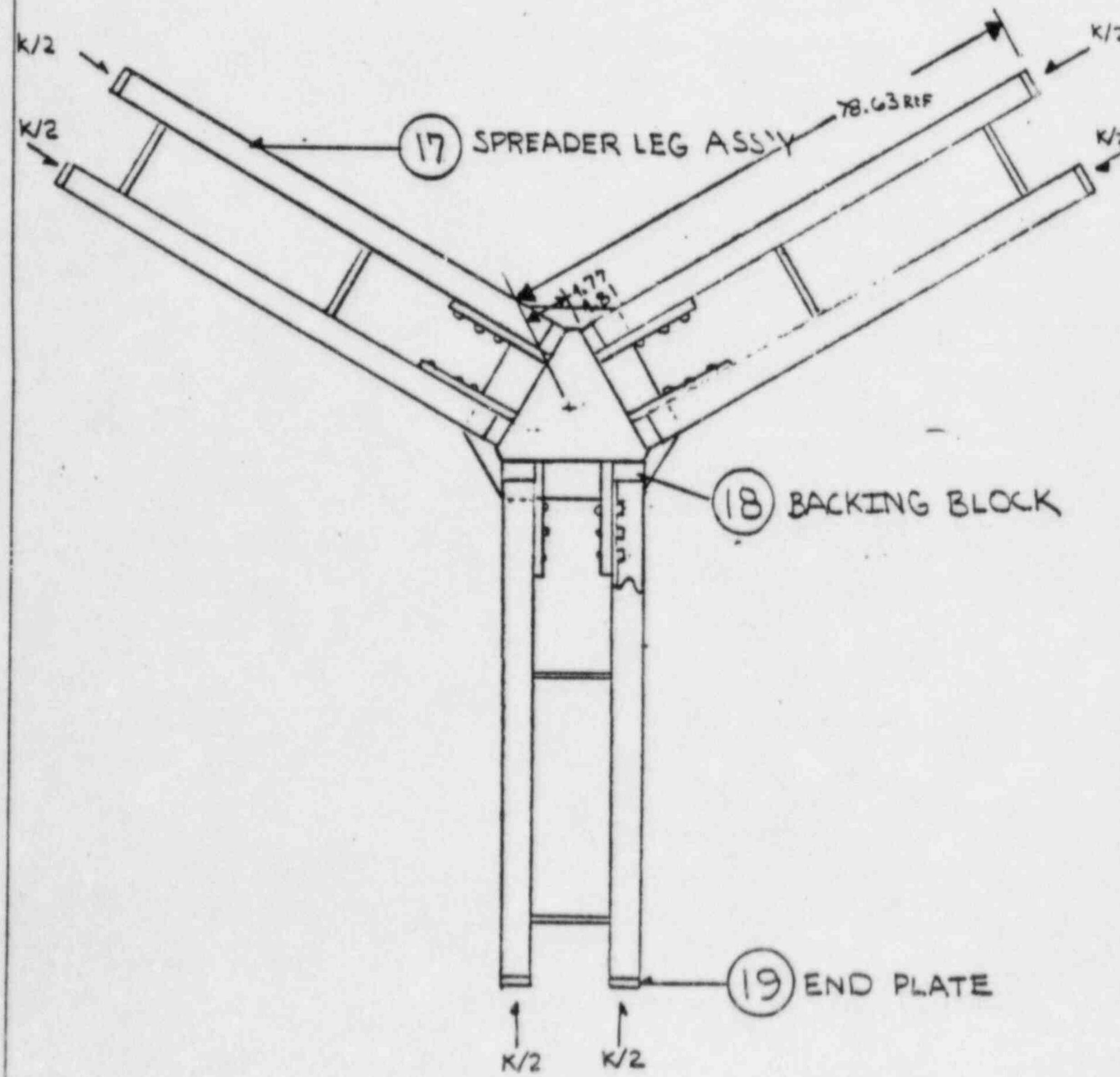
• SPREADER ASSEMBLY •



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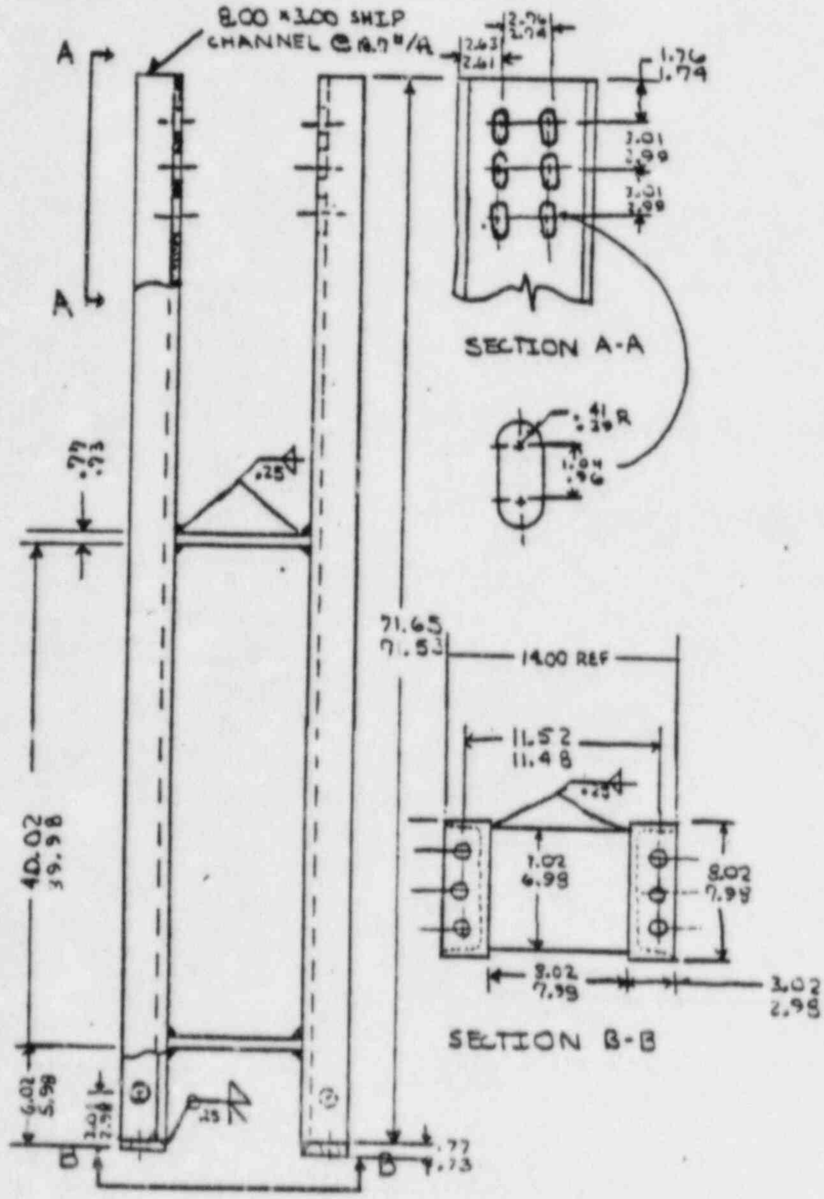
SPREADER
LEG ASSEMBLY (17)

MAT'L: ASTM - A36



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SPREADER LEG ASSEMBLY (17)

$W = 284{,}500\#$

THE NOMINAL COMPRESSIVE STRESS IN THE SPREADER IS

$f_t = K/2A_t$

WHERE K = INWARD FORCE ON SPREADER LEG = $(.252)W$

A_t = AREA OF ONE CHANNEL OF A LEG

FOR 8x3 @ 18.7#/ft SHIP CHANNEL

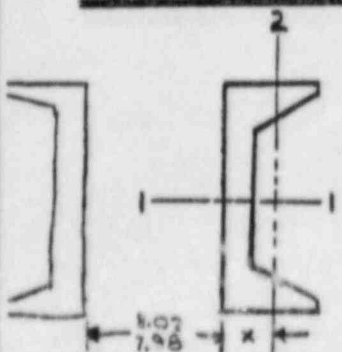
$A_t = 5.49\ in^2$

(FROM MARKS HANDBOOK FOR MECH. ENGRS P 12-33, 8th ED.

$f_t = .252W/2/5.49$

$f_t = W(0.02295)$

$f_t = 6530$ PSI.



$I_{1-1} = 43.7\ in^4$

$r_{1-1} = 2.82\ in$

$S_{1-1} = 10.9\ in^3$

$r_{2-2} = 0.60\ in$

$X = 0.57\ in$

COMPRESSION IN LEG

FROM THE AISC STEEL CONSTRUCTION MANUAL 7th ed, p 5-16 Sec 1.5.1.3

F_a = AXIAL STRESS PERMITTED IN THE ABSENCE OF BENDING

K_e = EFFECTIVE LENGTH FACTOR

l = SPAN LENGTH

r = RADIUS OF GYRATION

E = MODULUS OF ELASTICITY = 29,000 KIPS/IN² FOR STEEL

F_y = MINIMUM YIELD STRESS

C_c = COLUMN SLENDERNESS RATIO DIVIDING ELASTIC AND INELASTIC BUCKLING

$C_c = (2\pi^2 E/F_y)^{1/2}$

$= (2\pi^2\ 29{,}000{,}000/36{,}000)^{1/2}$

$= 126.10$

If $K_e l/r < C_c$

ON THE GROSS SECTION OF AXIALLY LOADED MEMBERS

$F_a = [1 - \frac{1}{2}A^2]F_y/(\frac{5}{3} + \frac{3}{8}A - \frac{1}{8}A^3)$

when $A = (Kl/r)/C_c$

If $K_e l/r > C_c$

$F_a = 12\pi^2 E/(23 \cdot (K_e l/r)^2)$

let $K_e = 2.1$

FROM THE SPREADER ASSEMBLY SKETCH

$l = 78.63 - 4.77 = 73.86$

$r_1 = 2(2.82) = 5.64$

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SPREADER LEG ASSEMBLY (17)

COMPRESSION IN LEG (CONT)

$I = r^2 A_t$

$I = I_{CG} + d^2 A_t$

d = distance between axis passing through centroids and desired axis

I_{CG} = moment of inertia through centroidal axis

FOR A CHANNEL $I_{CG} = r_{2-2}^2 A_t$

$= (0.60)^2 5.49 = 1.9764 \text{ in}^4$

$d = 7.98/2 + .57 = 4.56 \text{ in}$

$A_t = 5.49 \text{ in}^2$

$I_1 = 1.9764 + (4.56)^2 5.49$

$= 116.13 \text{ in}^4$

for two channels

$I_2 = 232.27$

$r_1 = \sqrt{232.27/(2 \times 5.49)}$

$= 4.60 \text{ in.}$

$K_e l/r_1 = 2.1(73.86)/5.64$

$= 27.49$

$K_e l/r_2 = 2.1(73.86)/4.60$

$= 33.70$

FOR BOTH AXES $Kl/r < C_c$

SO

$F_a = [1 - \frac{1}{2}A^2] F_y / (\frac{5}{3} + \frac{3}{8}A - \frac{1}{8}A^3)$

$A_1 = 27.49/126.10 = 0.2180$

$A_2 = 33.70/126.10 = 0.2672$

$F_{a_1} = 20,116 \text{ psi}$

$F_{a_2} = 19,674 \text{ psi}$

THEN ASSUME THE COLUMNS ACT TOGETHER. THE LONGEST UNBRACED LENGTH ABOUT AXIS 2-2 IS 40.02

$K_e = 0.65$* (PAGE 5-138 OF AISC HANDBOOK)

$l = 40.02$

$r = 0.60$

$K_e l/r = 43.36 < C_c = 126.10$

$(K_e l/r)/C_c = 43.36/126.10$

$= .3439$

$F_{a_3} = 18,917 \text{ psi}$

* K_e IS TAKEN AS 2.1 FOR THE FULL LENGTH AS THE ENDS ARE BOLTED AND (CONSERVATIVELY) MAY DEFLECT SLIGHTLY IF LOOSE. THE CASE OF THE UNBRACED LENGTH HAS K = .65 AS IT IS WELDED TO THE PLATE AND SO WOULD DEFORM IN THE MODE

K = .5 theoretical
.65 recommended

MAXIMUM BEARING STRESS SAME AS FOR THE BACKING BLOCKS (18)

$f_c = W(.04124) = 11,734 \text{ psi}$

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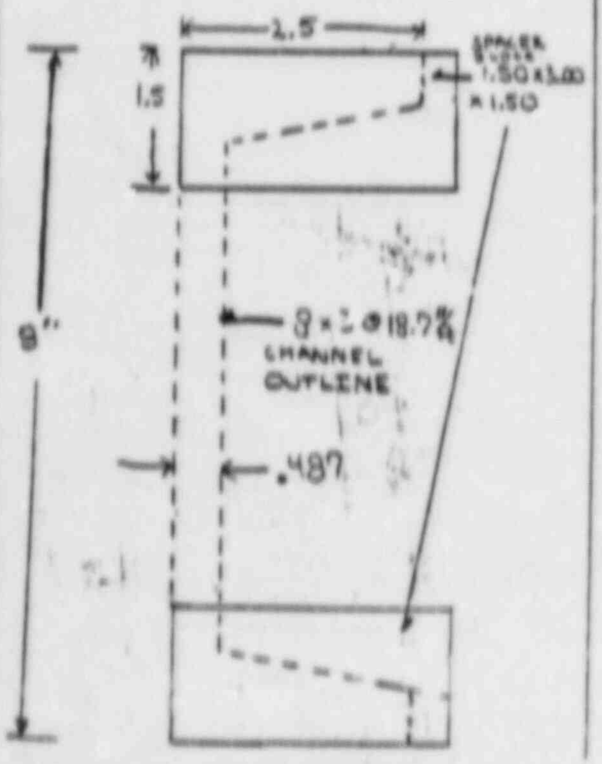
(18)

BACKING BLOCK

MAT'L:
ASTM A 276 TYPE 304
C.F. COND A.

THE BOLT HOLES ARE SLOTTED SO THAT THE BACKING BLOCKS RESIST THE INWARD FORCE $\bar{R}$.



BEARING

$A_{CHANNEL} = 5.49 in^2$

$A_{CONTACT} = A_{CHANNEL} - [8 - 2(1.5)](.487)$
$= 3.055 in^2$

$P = K/2 = .252W/2$
$= .126W$

$f_c = P/A_{CONTACT}$
$= .126W/3.055$
$= W(.04124)$

$f_c = 11,734$ psi

COMPRESSION IN BLOCK

$f_t = P/A_t$
$P = K/2 = .252W/2$
$= .1260W$
$A_t = 1.5 \times 3.0 = 4.5$

$f_t = .126W/4.5$
$= W(.028)$
$f_t = 7966$ psi

$W = 284,500\#$

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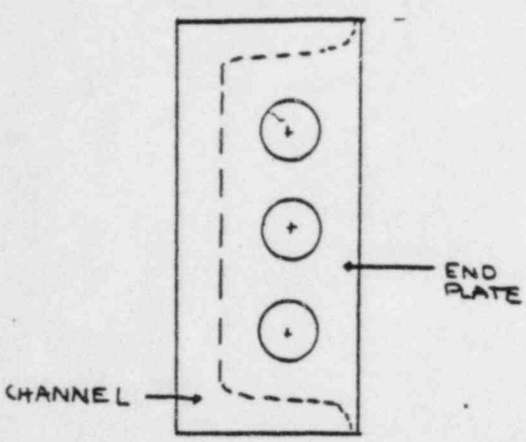
END PLATE (19)

ASTM - A36



BEARING

OF CHANNEL ONTO END PLATE (NEGLECTING WELD AREA)

$f_c = P/A_c$

$A_c = A_{CHANNEL} = 5.49\ in^2$

$P = K/2 = .252\,W/2$

$f_c = .252 * W/2/5.49$

$= W(.02295)$

$f_c = 6529\ psi$

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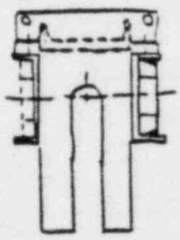
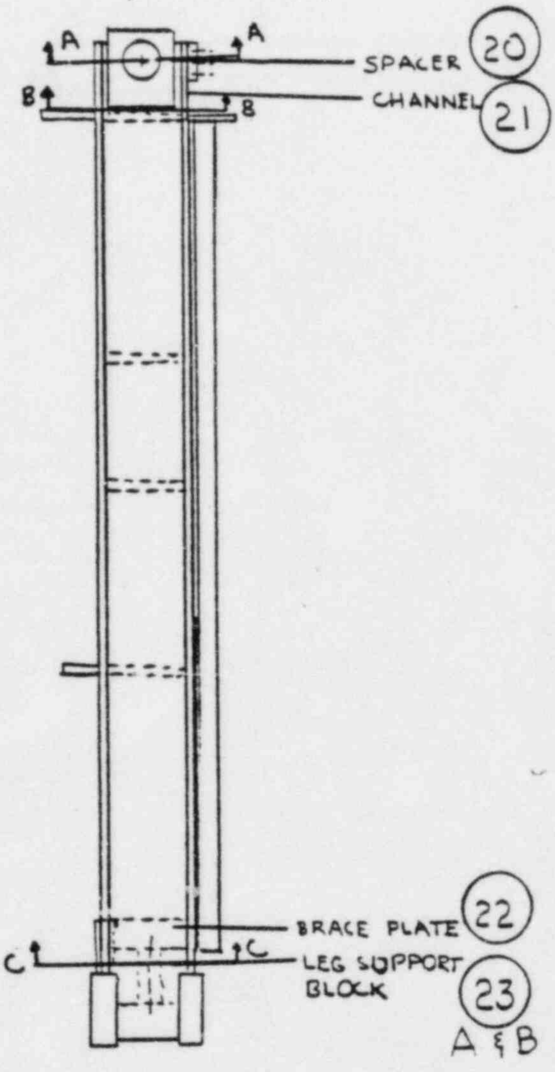
LEG ASSEMBLY



TOP VIEW



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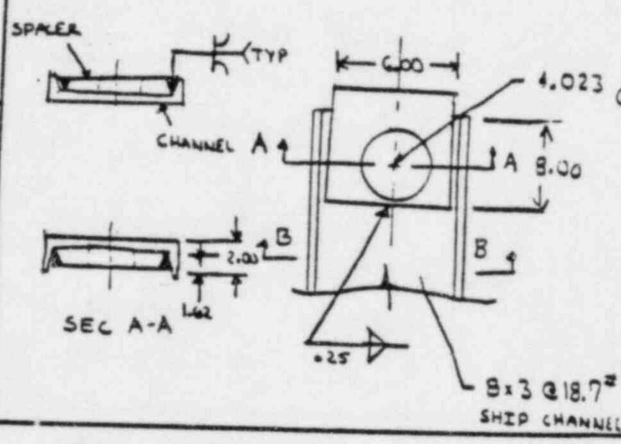
SPACER & CHANNEL (20/21)

$W = 284{,}500$#



MAT'L
SPACER - ASTM A588
GRADES A OR B
CHANNEL - ASTM-36

$W = 284{,}500$#

BEARING STRESS

THE FIRST BEARING CALCULATION FOR THE CLEVIS BOLT IS A LOCAL FIBER STRESS BEARING WHICH IS CALCULATED MERELY TO PRODUCE A STARTING POINT FOR DETERMINING THE STRESS DISTRIBUTIONS IN THE CLEVIS LUG AND SPACER-CHANNEL WELDMENT. TRADITIONALLY, BEARING OF PIN JOINTS IS DONE IGNORING SUCH LOCAL CONCENTRATIONS AND SO THE APPROPRIATE CALCULATION FOR WHICH REFERENCE ALLOWABLES ARE OBTAINABLE IS

$f_c = P/A_t$

$P = T = .4180W$

$A_t = d_m t = 3.992(2.00)$

$f_c = .4180W/3.992/2.00$

$= W(.05235)$

$f_c = 14{,}894$ PSI

THE SHEAR IN THE [weld symbol] WELD AND [.25 fillet weld symbol] FILLET WELD WOULD BE

$f_v = P/A_v$

$P = (W/3)$

$A_v = 8.00(1.62)(2)(2) + .707(6)(2)(.25)$

$= 53.96\ in^2$

$f_v = W(0.006177)$

$f_v = 1757$ PSI

IF AS A WORST CASE IT IS ALLOWED THAT ALL FORCES ACT ON THE SPACER

TENSION @ B-B

$f_t = P/A_t$

$P = W/3$

$A_t = 2A_{CHANNEL} = 2(5.49) = 10.98\ in^2$

$f_t = W(0.030358)$

$f_t = 8640$ PSI

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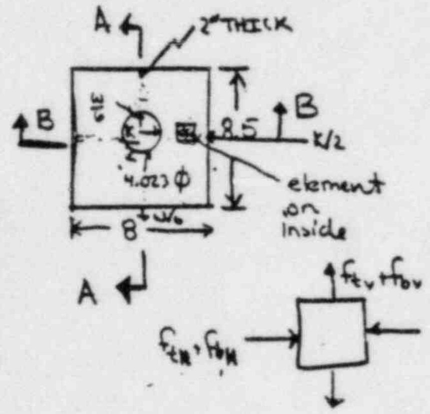
CHECK OF MAXIMUM STRESS TO AISC CRITERIA

W = 284,500 #
T = .418 W
K = .252 W

THE TENSILE STRESS WILL BE DETERMINED BY SPLITTING THE FORCE T AND THE MOMENTS IT PRODUCES INTO COMPONENTS AND APPROXIMATING THE SPACER-CHANNEL WELDMENT BY THE FOLLOWING:



At the stressed element shown four forces act

$f_{t\,vertical} = \frac{W}{6} / (8-4.023)/2 = \underline{5,961 \text{ psi}}$

$f_{t\,horizontal} = \frac{K}{2} / (8.5 * 2) = \underline{2109 \text{ psi}}$

$f_{bv} = M_v c / I$
$= [(\frac{W}{3})/2][1] / (\frac{[8-4.023]2^3}{12})$
$= \underline{17,886 \text{ psi}}$

$f_{bH} = M_H c / I$
$= [\frac{W(.252)}{2}][1] / [\frac{8.5 \; 2^3}{12}]$
$= \underline{6326 \text{ psi}}$

combining by the square-root-of-the sum-of-the squares

$f_t = \sqrt{f_{tH}^2 + f_{tv}^2} = 6,325 \text{ psi}$

$f_b = \sqrt{f_{bH}^2 + f_{bv}^2} = 18,972 \text{ psi}$

THE METHOD FOLLOWED IS SIMILAR TO THAT DONE FOR THE CLEVIS, AND TAKES NO CREDIT FOR THE JOINT BEING BOLTED

USING THE WEAKEST YIELD (THE CHANNEL, $F_y = 36$ KSI), AND SO CONSERVATIVELY NEGLECTING THE HIGHER STRENGTH PROVIDED BY THE SPACER ($F_y = 50$ KSI)

formula (1.6-1b) of chapter 5 see (1.6-1b) of AISC becomes $\frac{f_t}{.6(36,000)} + \frac{f_b}{.75(36,000)} \leq 1$

$= .995$

$f_{t\,max} = f_b + f_t = 25,297 \text{ psi}$

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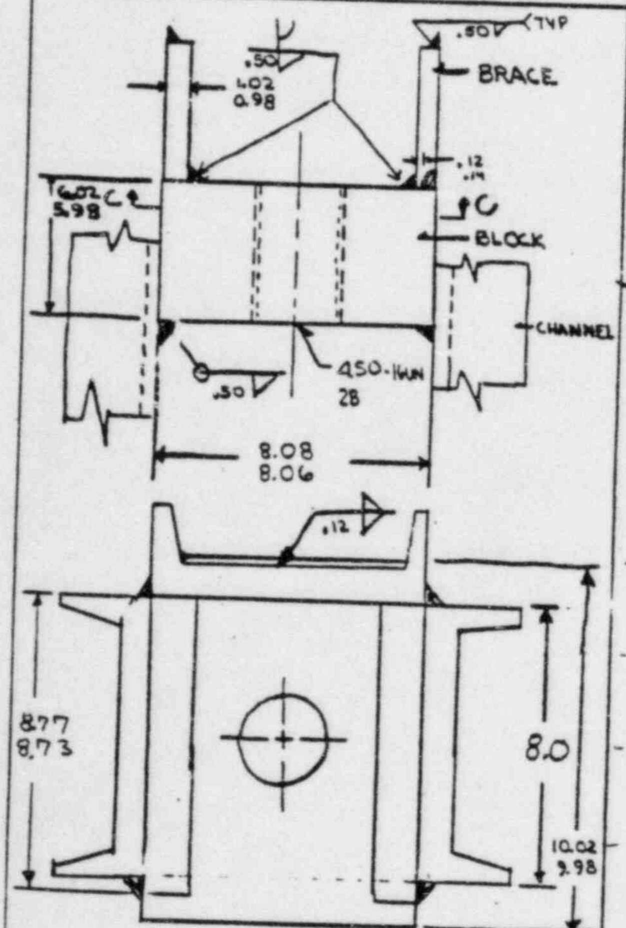
LEG SUPPORT BLOCK (23) A AND BRACE PLATE (22)

MAT'L
LEG SUPPORT BLOCK: AISI 8620
BRACE PLATE: ASTM A-36



THREAD SHEAR (A)

$W = 284{,}500\#$

THE THREAD SHEAR IS THE SAME AS THAT FOR THE ADAPTOR

$f_v = W(0.019879)$

$f_v = 5656$ PSI

WELD SHEAR

THE SMALL WELD (.12) BRACING THE BACK CHANNEL STIFFENER HAS NEGLIGIBLE EFFECT ON THE WELD DISTRIBUTION, THE [weld symbol] WELD GIVES MORE THAN FULL STRENGTH TO THE BLOCK-PLATE CONNECTION. SO THE SHEAR STRESS IN THE FILLET WELDS IS

$f_v = P/A_w$

$P = W/3$

$A_w = (.707)(.50)[8.0\times 4) + 4(6)]$

$= .707\, t_{THROAT}\, l_{WELD}$

$= 19.796\ in^2$

$f_v = W(0.016838)$

$f_v = 4{,}791$ PSI

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LEG SUPPORT BLOCK (23) B

THE PNJ LEG SUPPORT BRACKET IS THE SAME AS THE PSE UNIT (FOR ANALYSIS) EXCEPT THAT THE 4.50-16UN-2B THREADED HOLE IS REPLACED BY A SMOOTH-BORED HOLE WHOSE DIAMETER IS

$\phi = \begin{matrix}4.81\\4.75\end{matrix}$

BEARING OF NUT (ITEM 28) ON LEG SUPPORT BLOCK

$$f = F/A_c$$

$$F = W/3$$

$$A_c = \left\{[6.49 - 2(.21)]^2 \ 4.81^2\right\} \frac{\pi}{4}$$

$$= 10.767 \text{ in}^2$$

$$f_c = W/3/10.767$$

$$= W(.030959)$$

$$\underline{\underline{f_c = 8,808 \text{ PSI}}}$$

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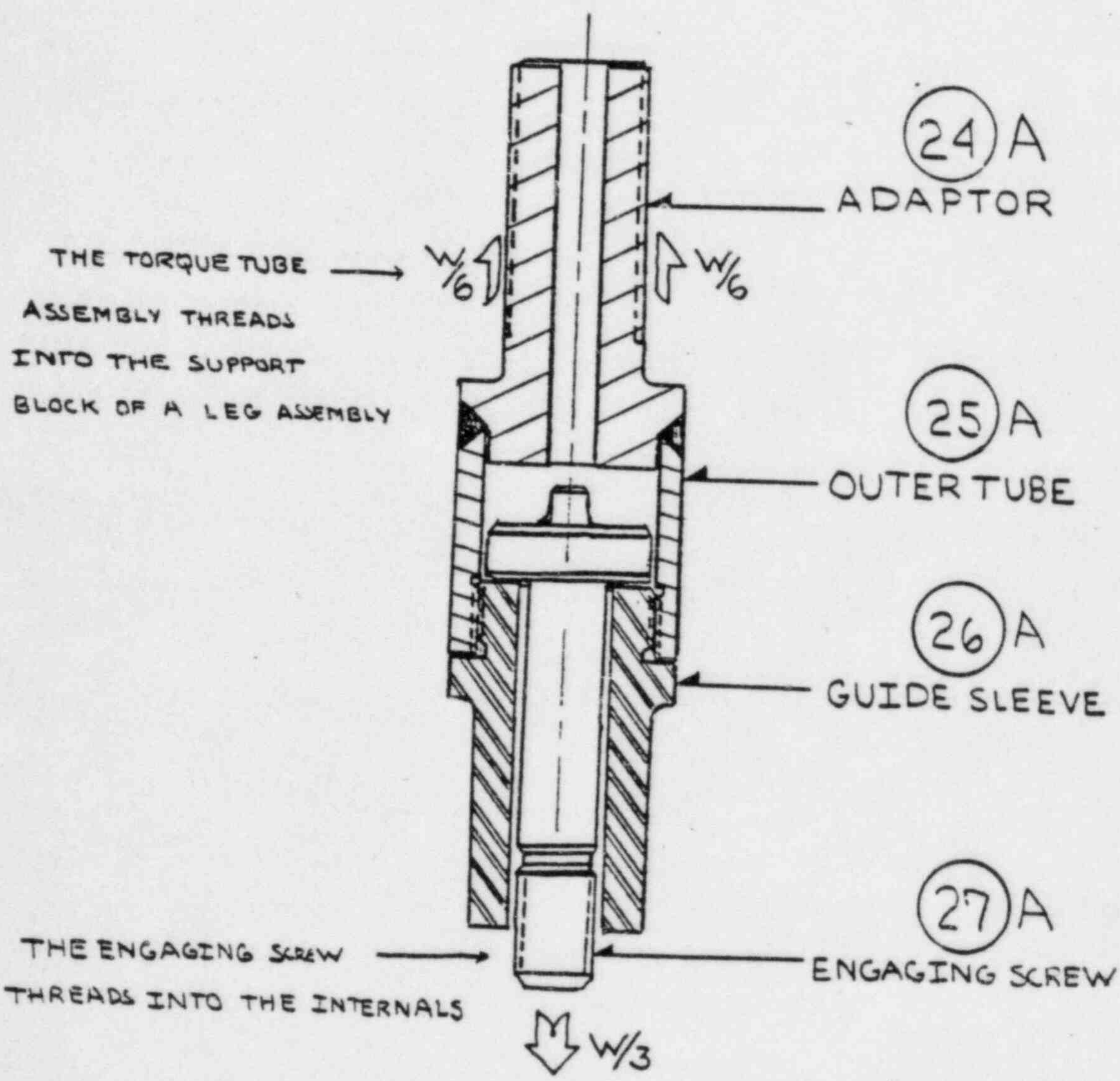
TORQUE TUBE ASSEMBLY PSE



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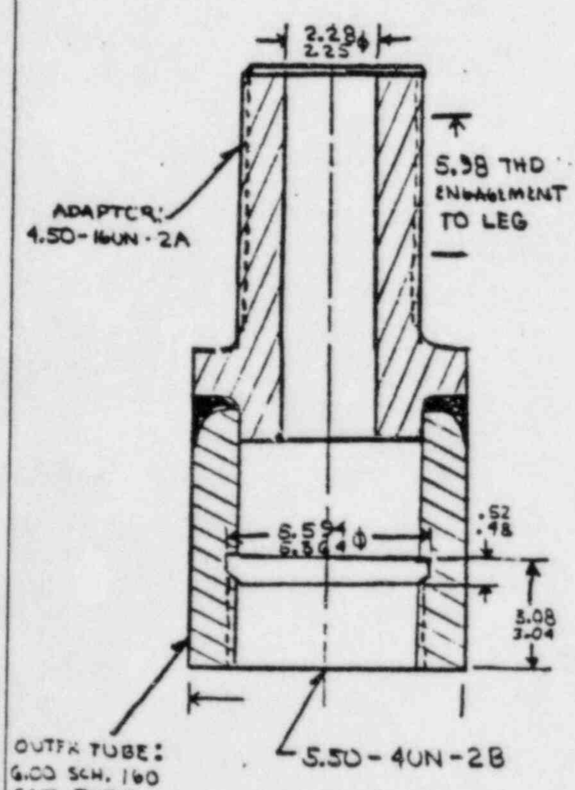
ADAPTOR & OUTER TUBE (24/25) A

MAT'L:

ADAPTOR - ASTM A-276 TYPE 304 HOT ROLLED & PICKLED COND A.

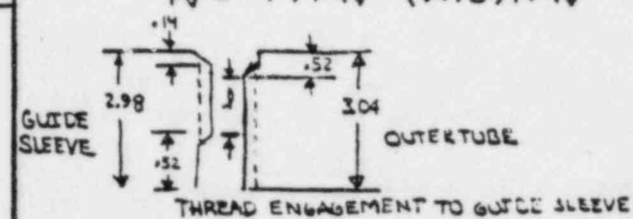
OUTER TUBE - ASTM A-312 TYPE 304 SMLS. CF. & HT. TR.



W = 284,500#

5.5-4 THREAD SHEAR @ 5.5-4UN

$f_v = P/A_v = (W/3)/A_v$



$l = (3.04 - .52) - .52 = l = 2.00$

$A_v = \pi D_{pitch}\, l/2$

$D_{pitch} = D_3 - .64952/n$

$= 5.5 - .64952/4 = 5.33762$

$A_v = \pi(5.33762)(2.00)/2 = 16.769$

$f_v = W(.019879)$

$f_v = 5656.$ PSI

THREAD SHEAR @ 4½-16 THD

$f_v = P/A_v = (W/3)/A_v$

$A_v = \pi D_{pitch}\, l/2$

$l = 5.98$ in

$D_{pitch} = 4.4594$ (MARKS, 8th Ed)

$A_v = \pi(4.4594)\,5.98/2 = 41.889$ in²

$f_v = W/(3 * 41.889)$

$f_v = W(0.007958)$

$f_v = 2264$ PSI

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ADAPTOR & OUTER TUBE (24/25) A

TENSION @ THREAD RELIEF

FROM MARK'S HANDBOOK, P 8-158, 8th ed
6.00 SCH 160 SST PIPE HAS AN O.D. OF 6.625 in.

$f_t = P/A_t = (W/3)/A_t$

$A_t = \pi/4\,(d_o^2 - d_i^2)$

$= \pi/4\,(6.625^2 - 5.594^2)$

$= 9.894\ in^2$

$f_t = W(0.03369)$

$f_t = 9585$ PSI

TENSION @ 4½ THREAD

FROM MARK'S HANDBOOK, 8th ed
THE STRESS AREA OF A 4½-16UN-2A THREAD IS $A_s = 15.4662\ in^2$

$f_t = P/A_t = (W/3)/A_t$

$A_t = A_s - \pi/4\, d_i^2$

$= 15.4662 - (\pi/4)(2.28)^2$

$= 11.383\ in^2$

$f_t = W(0.02928)$

$f_t = 8330$ PSI

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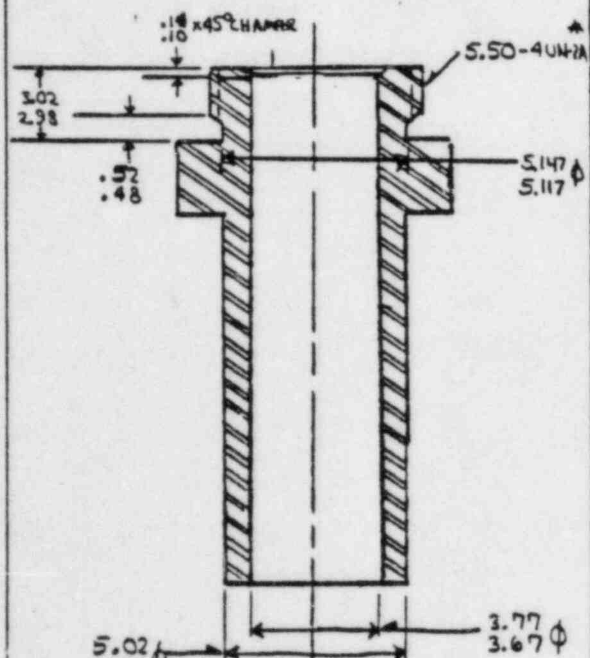
GUIDE SLEEVE (26)A

MAT'L: ASTM A 276
TYPE 304
HOT ROLLED & PICKLED
COND. A.



FOR A 5½-4UN-2A THREAD
$D_{pitch} = 5.500 - 0.64952/4$
$= D_s - 0.64952/n$
where D_s = major diameter and n = number of threads per inch

$W = 284{,}500\#$

BEARING STRESS

THE BEARING STRESS BETWEEN THE GUIDE SLEEVE AND ENGAGING SCREW IS CALCULATED IN THE ENGAGING SCREW SECTION.

$f_c = W(0.05961)$

$f_c = 16{,}958$ PSI

COMPRESSION AT THE RELIEF
- AN UPPER LIMIT ANALYSIS -

$f_t = (-1)\, P/A_t = (W/3)/A_t$

$A_t = \pi/4\,(d_o^2 - d_i^2) = \pi/4\,(5.117^2 - 3.77^2)$

$f_t = -W/(3 * 9.402)$

$f_t = -W(0.03545)$

$f_t = -10{,}086$ PSI

THREAD SHEAR

$f_v = P/A_v = (W/3)/A_v$

$A_v = D_{pitch}\,\pi\,\ell/2$

FROM ADAPTOR/OUTER TUBE $\ell = 2.00$

$A_v = 5.3376\pi(2.00)/2 = 16.769$

$f_v = W/(3 * 16.769)$

$f_v = W(0.019879)$

$f_v = 5656$ PSI

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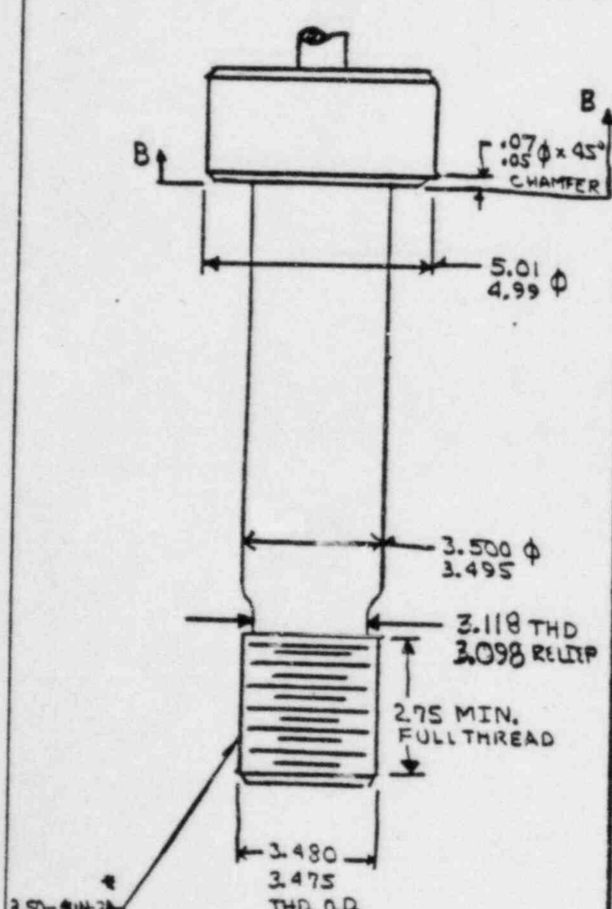
ENGAGING SCREW (27)A

MAT'L:
ASTM A-276
TYPE 304
COND. A.



* FROM MARK'S HANDBOOK FOR M.E.'S, 8th Ed
Sec 8: $D_{pitch} = 3.3373$ in.

$W = 284{,}500$ #

BEARING @ B-B

$f_c = P/A_c$

$P = (W/3)$

$A_c = (d_o^2 - d_i^2)\,\pi/4$

$= (\pi/4)\left((4.99 - 2(.07))^2 - (3.77 + 2(.14))^2\right)$

$= 5.592\ in^2$

$f_c = W/(3 * 5.592)$

$f_c = W(0.05961)$

$f_c = 16{,}959$ PSI

TENSILE @ THREAD RELIEF

$f_t = P/A_t$

$P = W/3$

$A_t = \pi/4\, d^2 = 3.098^2(\pi/4) = 7.5379\ in^2$

$f_t = W/(3 * 7.5379) = W(0.04422)$

$f_t = 12{,}581$ PSI

THREAD SHEAR

$f_v = P/A_v = (W/3)/A_v$

$A_v = D_{pitch}\,\pi\, l/2 = 3.3373\,\pi\, 2.75/2$

$f_v = W(0.02312)$

$f_v = 6577$ PSI

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ENGAGING SCREW (27) B

THE PNJ ENGAGING SCREW IS THE SAME AS THE PSE ENGAGING SCREW EXCEPT THAT THE BEARING STRESS IS AS SHOWN AND THE MATERIAL IS DIFFERENT

BEARING ON GUIDE SLEEVE

THE BEARING IS THE SAME AS CALCULATED FOR THE GUIDE SLEEVE ITEM 30-B

$f_c = W(.04348)$

$f_c = 12,370$ PSI

MAT'L ASTM A-564
GRADE 630
COND 1100

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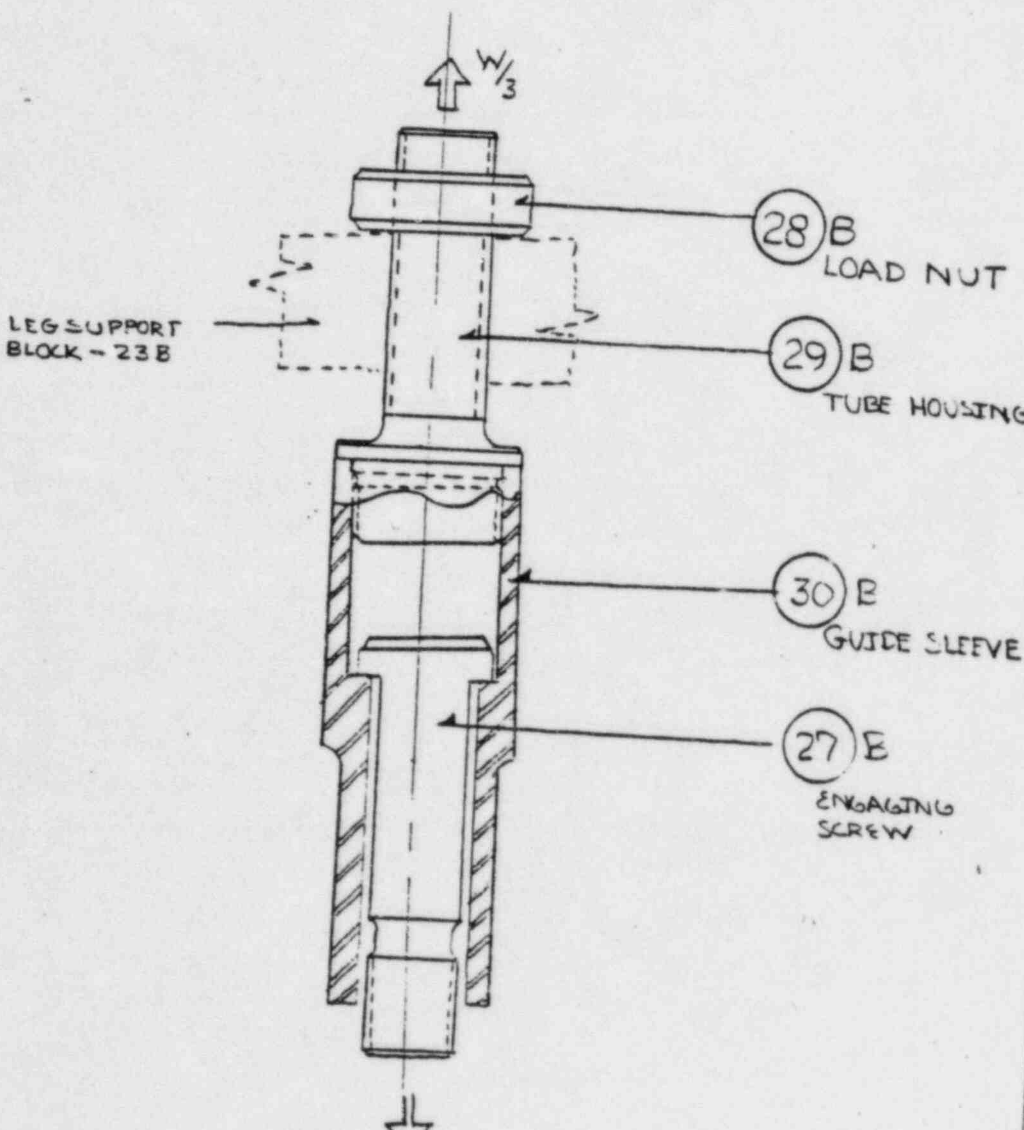
S.O. PTNP-188	CALC NO.	FILE NO.	GROUP CHE

TORQUE TUBE ASSEMBLY - PNJ



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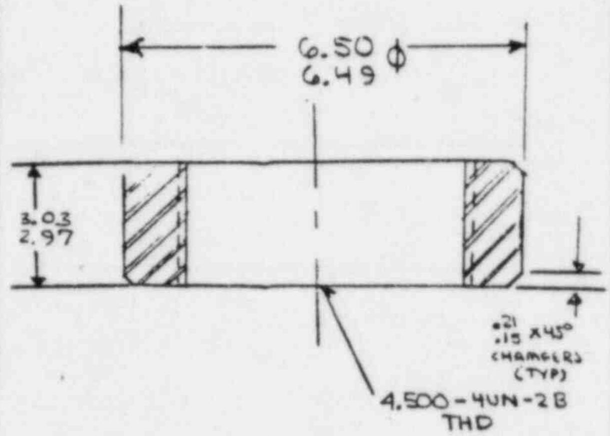
LOAD NUT (28)B



MAT'L:

ASTM A-276 TYPE 304
HOT ROLLED & PICKLED
COND. A

BEARING

THE BEARING STRESS HAS BEEN CALCULATED IN THE LEG SUPPORT BLOCK CALCS FOR ITEM 23 B

$f_c = W(.030959)$

$f_c = 8{,}809$ PSI

THREAD SHEAR

$f_v = P/A_v$

$P = W/3$

$A_v = D_p \ell \pi/2$

$\ell = 2.97$ in

$D_p = D_s - .64952/n$

$= 4.50 - .64952/4$

$= 4.3376$ in

$A_v = 4.3376(2.97)\pi/2$

$= 20.24$ in^2

$f_v = W/3/20.24$

$= W(.016472)$

$f_v = 4686$ PSI

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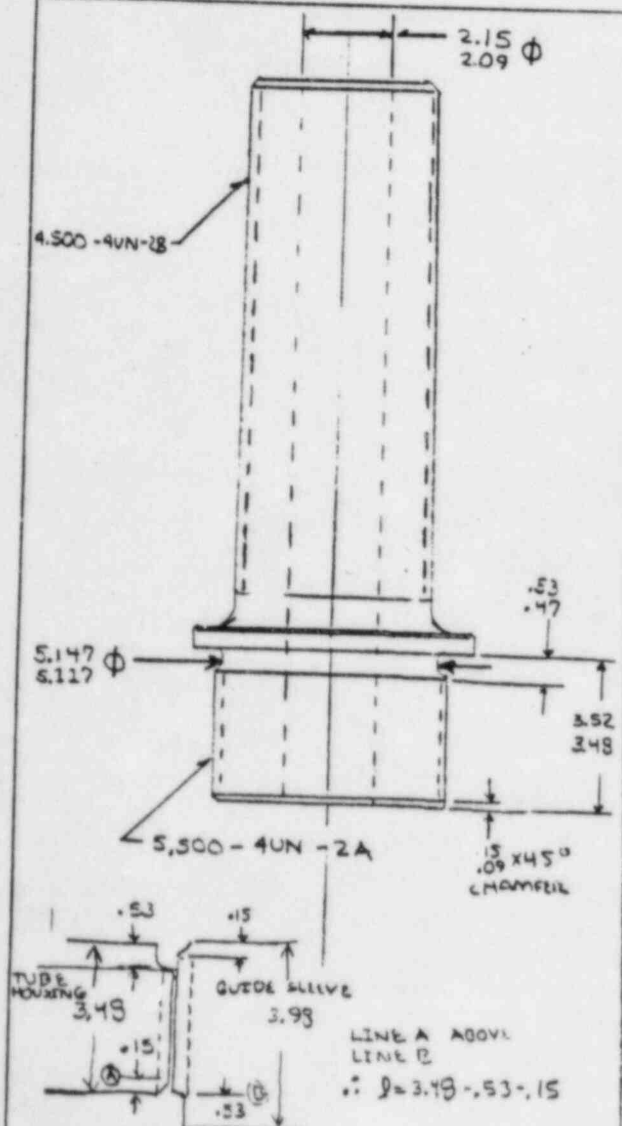
S.O. PTNP-188	CALC. NO.	FILE NO.	GROUP CHE

TUBE HOUSING (29) B

MAT'L:

ASTM A-276 TYPE 304
HOT ROLLED & PICKLED
COND. A.



THREAD SHEAR ON LOAD NUT
CALCULATED AT LOAD NUT
ITEM 28-B

$f_v = W(.016472)$

$f_v = 4686$ PSI

TENSION AT MINIMUM SECTION

$f_t = P/A_t$

$P = W/3$

$A_t = A_T - \frac{\pi}{4}(2.15)^2$

$A_T = \frac{\pi}{4}(D_s - .9743/n)^2$

$= \frac{\pi}{4}(4.5 - .9743/4)^2$

$= 14.229 \text{ in}^2$

$A_t = 14.229 - \frac{\pi}{4}(2.15)^2$

$= 10.599 \text{ in}^2$

$f_t = W/3/(10.599)$

$= W(.031450)$

$f_t = 8948$ PSI

THREAD SHEAR ON GUIDE SLEEVE

$f_v = P/A_v = (W/3)/A_v$

$A_v = \pi D_p \ell/2$

$D_p = D_s - .64952/n =$

$= 5.500 - .64952/4 = 5.3376 \text{ in}$

$\ell = 3.48 - .53 - .15 = 2.800 \text{ in}$

$A_v = \pi(5.3376)(2.80)/2 = 23.476 \text{ in}^2$

$f_v = W/3/23.476$

$= W(.014199)$

$f_v = 4040$ PSI

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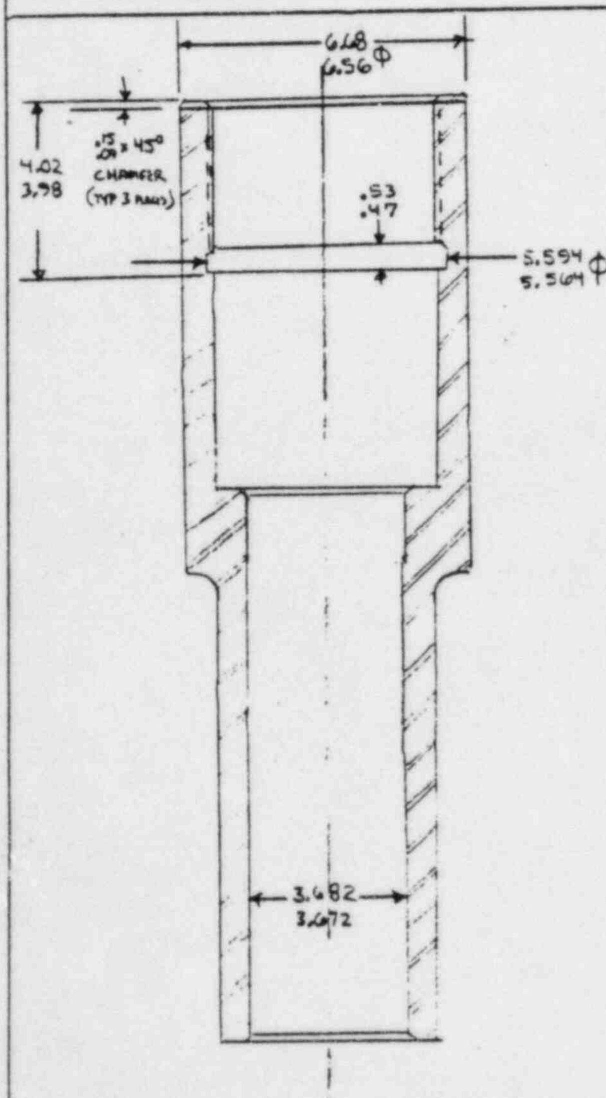
S.O. PTNP-188	CALC. NO.	FILE NO.	GROUP CHE

GUIDE SLEEVE (30)B

MAT'L: ASTM A-276 TYPE 304
HOT ROLLED & PICKLED
COND A



THREAD SHEAR ON TUBE HOUSING

CALCULATED AT TUBE HOUSING CALCS, ITEM 29-B

$f_v = W(.014199)$

$f_v = 4040$ PSI

TENSION AT THREAD RELIEF

$f_t = P/A_t$

$P = W/3$

$A_t = \frac{\pi}{4}(d_o^2 - d_i^2)$

$= \frac{\pi}{4}(6.56^2 - 5.594^2)$

$= 9.221 \text{ in}^2$

$f_t = W/3/9.221$

$= W(.03615)$

$f_t = 10,284$ PSI

BEARING ON ENGAGING SCREW

$f_c = P/A_c$

$P = W/3$

$A_c = \frac{\pi}{4}(d_o^2 - d_i^2)$

$d_o = 4.99 - 2(.07) = 4.85$

$d_i = 3.682 + 2(.15) = 3.982$

$A_c = 7.67 \text{ in}^2$

$f_c = W/3/7.67$

$= W(.04348)$

$f_c = 12,370$ PSI

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S.O. PTNP-198	CALC. NO.	FILE NO.	GROUP CHE	

ROTO-LOCK BACKFIT

THESE ITEMS SEE ONLY THE LOAD FROM THE INTERNALS. THE LOWER INTERNALS WEIGH $W_L = 260,000$ LB. THE UPPER INTERNALS WEIGH $W_U = 120,000$ LB. ALL PARTS EXCEPT THE INSERTS ARE USED TO LIFT BOTH THE UPPER AND LOWER INTERNALS SO $W = 260,000$ LB FOR THESE ITEMS. WHEN ANALYZING THE ENGAGEMENT OF THE STUDS TO THE INSERTS IT WILL BE CONSERVATIVELY ASSUMED THAT 9 OUT OF 12 LANDS ARE ACTIVE WHEN LIFTING THE LOWERS, AND 6 OUT OF 9 LANDS WILL BE ASSUMED ACTIVE WHEN ANALYZING THE LIFT OF THE UPPERS.

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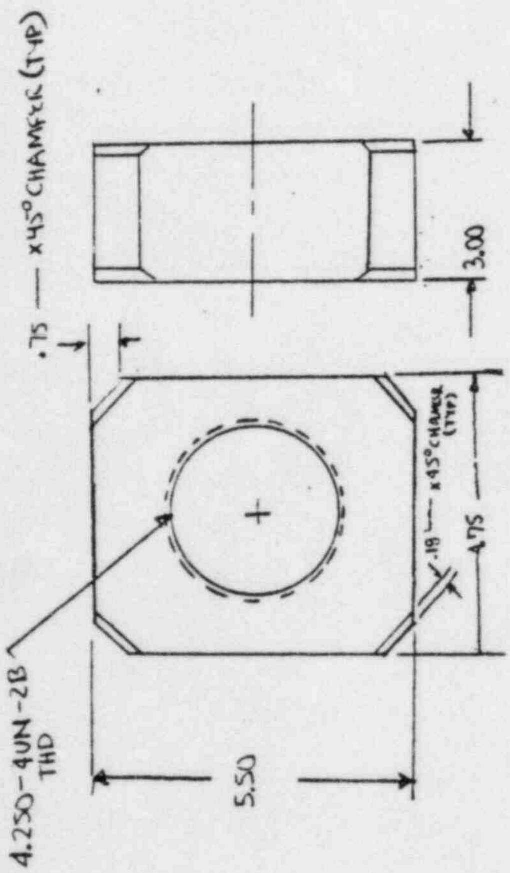
ROTO-LOCK BACKFIT
LOAD NUT (31)
A

MATL:
ASTM A276
TYPE 304
HOT ROLLED
COND. A



THREAD SHEAR

$f_v = F/A_v = (W/3)/A_v$

$A_v \cong D_p \, l \, \pi/2$

$D_p = D_s - .64952/n$

$= 4.250 - .64952/4$

$= 4.0876$

$l = 3.00$

$A_v = 4.0876(3.00)\pi/2$

$= 19.262 \text{ in}^2$

$f_v = W/3/19.262$

$= W(.017305)$

$f_v = 4499$ PSI

BEARING

$f_c = F/A_c$

$F = W/3$

$A_c = 5.50(4.75) - 2(.75 + .18\sqrt{2})^2 - \pi/4(4.250)^2$

9.9205 in^2

$f_c = W/3/9.9205$

$= W(.03360)$

$f_c = 8736$ PSI

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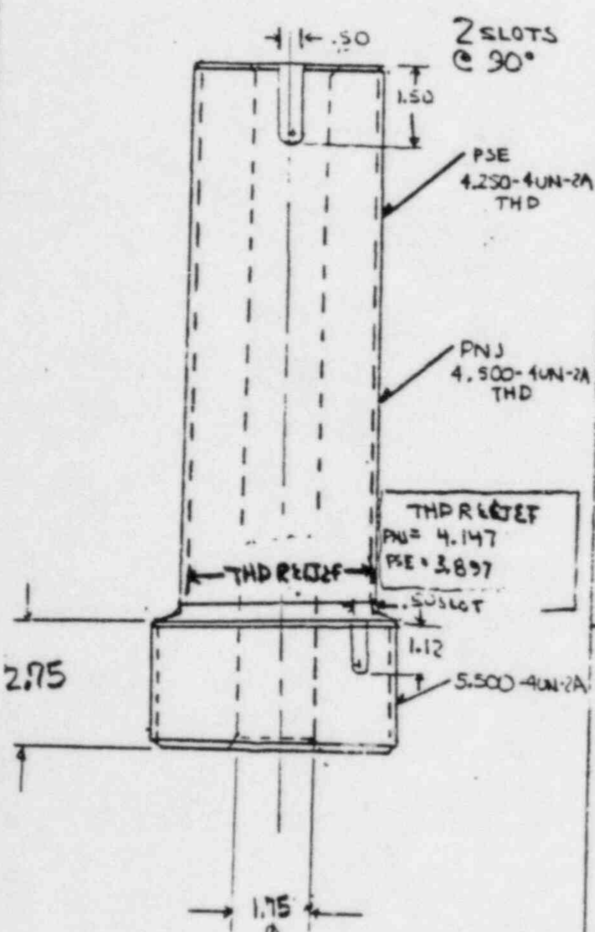
ROTO-LOCK BACKFIT ADAPTOR (32) A & B

MAT'L:
ASTM A 276
TYPE 304
HOT ROLLED
COND A.



UPPER THD. SHEAR

FOR PSE IT IS THE SAME AS FOR THE ROTO-LOCK BACKFIT LOADNUT

$f_v = 4499$ PSI (PSE)

FOR PNJ $f_v = P/A_v = W/3/A_v$

$A_v = D_p \ell \pi/2$

$D_p = D_t - .64952/n = 4.500 - .64952/4 = 4.338$

$f_v = W/3/(4.338 * 3.00 * \pi/2) = W(.01631)$

$f_v = 4240$ PSI (PNJ)

TENSION @ MINIMUM AREA

$f_t = P/A_t = W/3/A_t$

$A_t = \pi/4 (d_o^2 - d_i^2)$

PSE $d_o = 3.897$

PNJ $d_o = 4.147$

$d_i = 1.75$

$A_{t\,PSE} = 9.5222 \text{ in}^2$

$A_{t\,PNJ} = 11.102 \text{ in}^2$

$f_{t\,PSE} = W/3/9.5222 = W(.035006)$

$f_t = 9{,}102$ PSI (PSE)

$f_{t\,PNJ} = W/3/11.102 = W(.03003)$

$f_t = 7{,}807$ PSI (PNJ)

LOWER THREAD SHEAR

THE LOWER THREAD SHEAR IS THE SAME AS FOR THE GUIDE SLEEVE.

$f_v = 4475$ PSI

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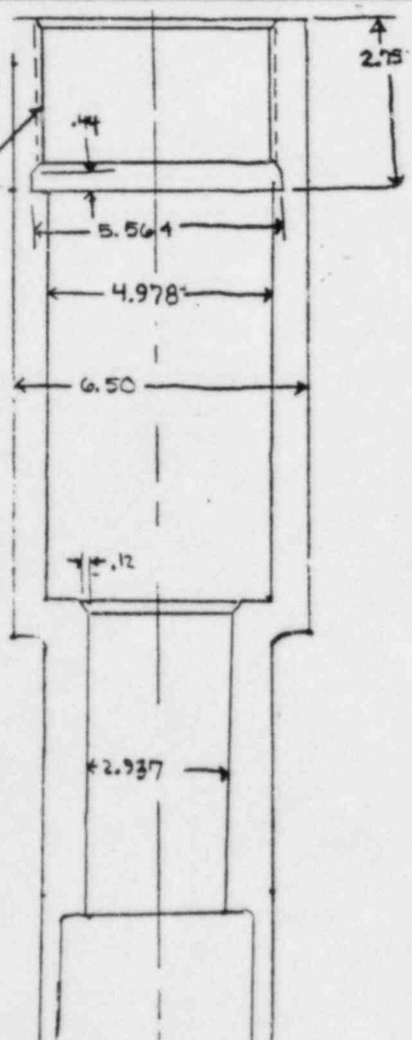
ROTOLOCK BACKFIT (33)
GUIDE SLEEVE

MAT'L:
ASTM A276
TYPE 304
HOT ROLLED, ANNEALED & PICKLED
COND A.



TENSION @ THD RELIEF

$f_t = P/A_t = (W/3)/A_t$

$A_t = \pi/4\,(d_o^2 - d_i^2)$

$= \pi/4\,(6.50^2 - 5.564^2)$

$= 8.869\ in^2$

$f_t = W/3 / 8.869\,in^2$

$= W(.037586)$

$f_t = 9,772$ PSI

THREAD SHEAR

$f_v = P/A_v = W/3/A_v$

$A_v = \pi D_p \ell / 2$

$D_p = D_s - .64952/n$

$= 5.5 - .64952/4$

$= 5.3376\ in$

$\ell = 2.75 - .44 = 2.31$

$A_v = \pi(5.3376)(2.31)/2$

$= 19.368\ in^2$

$f_v = W/3/19.368 = W(.01721)$

$f_v = 4475$ PSI

BEARING ON STUD

THE BEARING ON THE STUD IS THE SAME AS THE BEARING OF THE STUD ON THE GUIDE SLEEVE.

$f_c = 9889$ PSI

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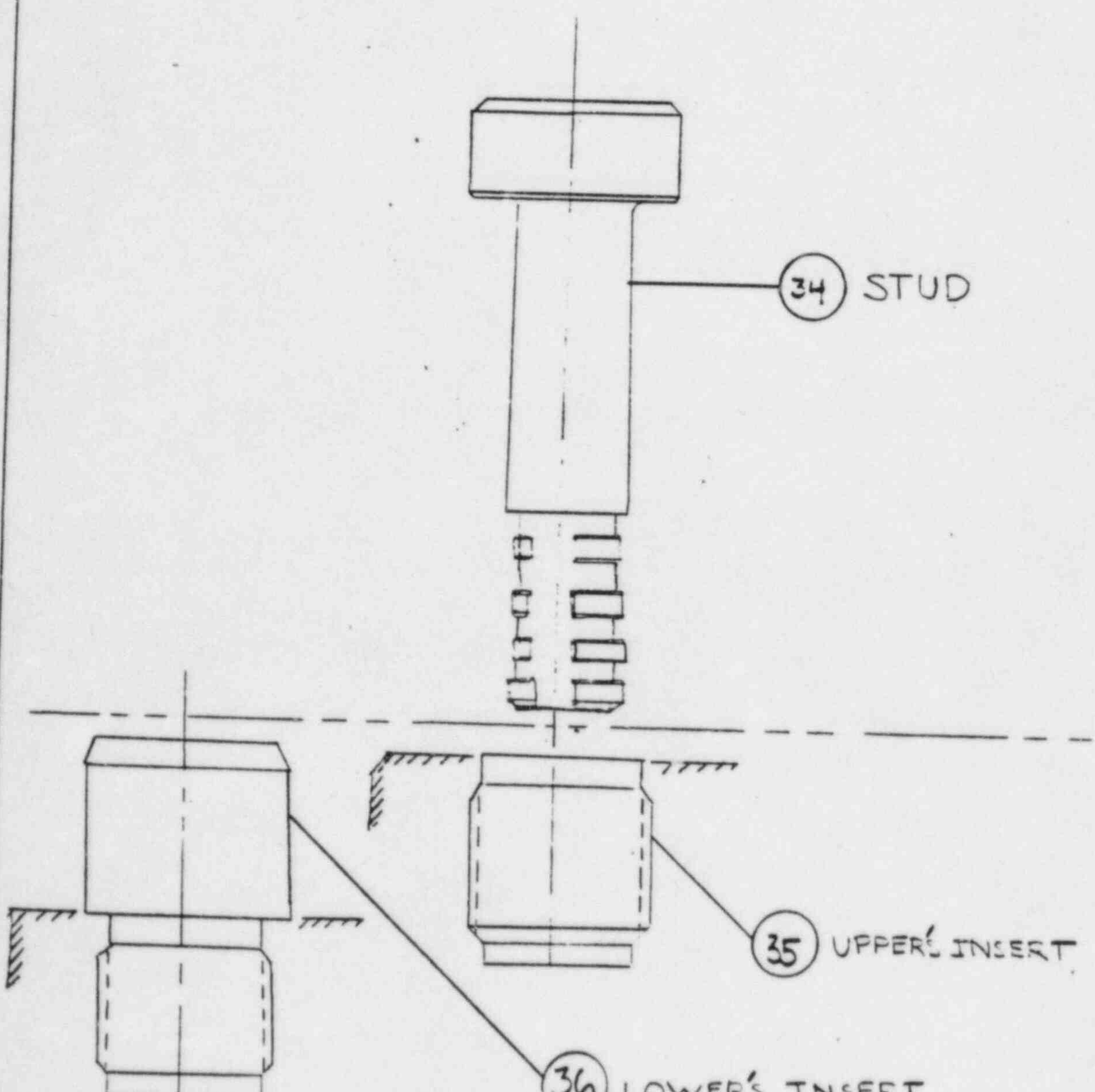
ROTO-LOCK BACK FIT



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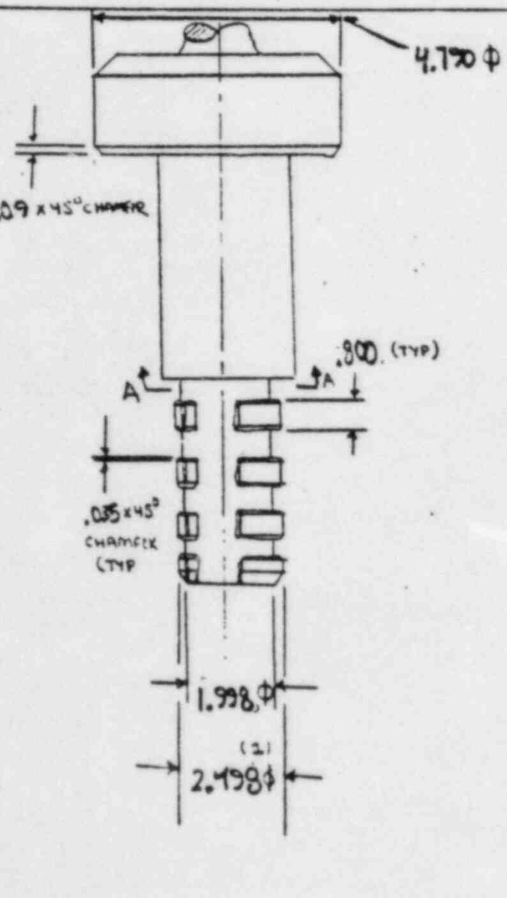
STUD (34)

MAT'L:
ASTM A564, TYPE 630, 17-4
PRECIPITATION HARDENING SS.
AGE TREATED @ 1100°F FOR 4 HRS &
AIR COOLED. T_{min} = 140,000 PSI



(1) DIAMETER OF CIRCLE ENCLOSING OUTER SURFACE OF LANDS. LANDS HAVE 3 TEETH PER LEVEL EQUALLY SPACED ABOUT ..., EACH TOOTH IS 54 DEGREES WIDE.

TENSION AT SEC A-A (MIN. DIA)

$f_t = P/A_t$

$P = (W/3) = 260{,}000/3$

$A_t = \pi/4\, d^2 = \pi/4 (1.998)^2 = 3.135 in^2$

$f_t = W/3/3.135$

$= W(.10632)$

$\underline{f_t = 27{,}642 \text{ PSI}}$

SHEAR OF STUD LANDS

$f_v = P/A_v = (W/3)/A_v$

$A_v = L_c d$

L_c = LENGTH OF LANDS

d = DEPTH OF LANDS

.800 in

$L_c = \frac{54}{360} \pi (2.998) \times N$

N = NUMBER OF LANDS, LETTING THE LARGER BOTTOM LAND BE EQUIVALENT TO THE TYPICAL UPPER LANDS.

$\left(\frac{W}{N}\right)_{max} = \frac{260{,}000}{9} = 28{,}889$

$L_c = 8.474 in$

$A_v = 8.474 (.800) = 6.779 in^2$

$f_v = (260{,}000/3)/6.779$

$= W(.04917)$

$\underline{f_v = 12{,}784 \text{ PSI}}$

BEARING ON GUIDE SLEEVE

$f_c = P/A_c = (W/3)/A_c$

$W_{max} = 260{,}000$ lb

$A_c = \pi/4 \left([4.790 - 2(.09)]^2 - (2.937 + 2(.12))^2 \right)$

$= 8.764 in^2$

$f_c = 260{,}000/3/8.764$

$f_c = \underline{9889 \text{ PSI}}$

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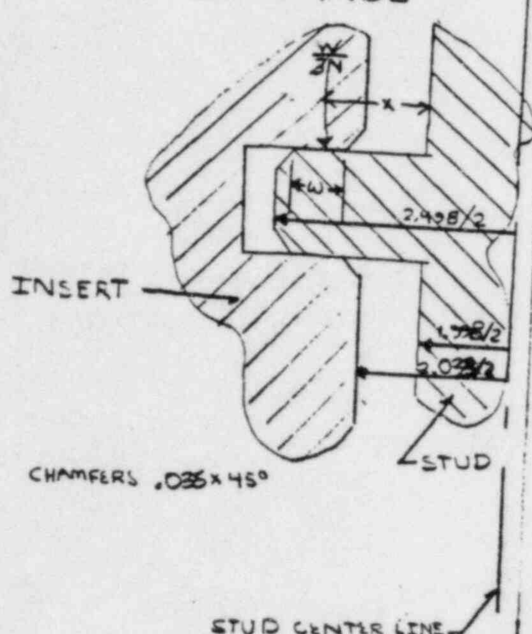
BENDING IN LANDS



w = width of bearing surface
$= 2.498/2 - .035 - [2.033/2 + .035]$
$= 0.160$ in

$X = 2.498/2 - .035 - .160/2 - 1.998/2$
$= .135$ in
= moment arm of force

$f_b = M/Z$

$Z_{LAND} = L_c d^2/6$
$= (\frac{54}{360}) \pi (1.998)(.800^2)/6$
$= .10043 \text{ in}^3$

M = bending moment
$= Px = (\frac{W}{3N})(.135)$

$N = 9$

$M \sim (W/3/9) * .135 = .00500 W$

$f_b = .005 W / .10043$
$= W(.04979)$

f_b 12,944 PSI

BEARING ON LAND SURFACES

$A_1 \simeq [2.498 - 2(.035)]^2 \pi/4$

$A_2 = [2.033 + 2(.035)]^2 \pi/4$

$A_c = A_1 - A_2 = 1.1566 \text{ in}^2$

$A_c' \approx N \frac{54}{360} A_c - 2N(w * .04)$

$N = 9$

$A_c' = 1.446 \text{ in}^2$

$f_c = P/A_c'$
$= (W/3)/A_c'$
$= W(.2305)$

f_c 59,929 PSI

NOTE:
The stresses in shear, bending, and land bearing are dependent on $\frac{W}{N}$. $\frac{W}{N}$ is maximum when lifting the lowers, so the higher stresses occur when lifting the lowers. Therefore, for the stud stresses
W = 260,000 lb
N = 9 out of 12 assumed active

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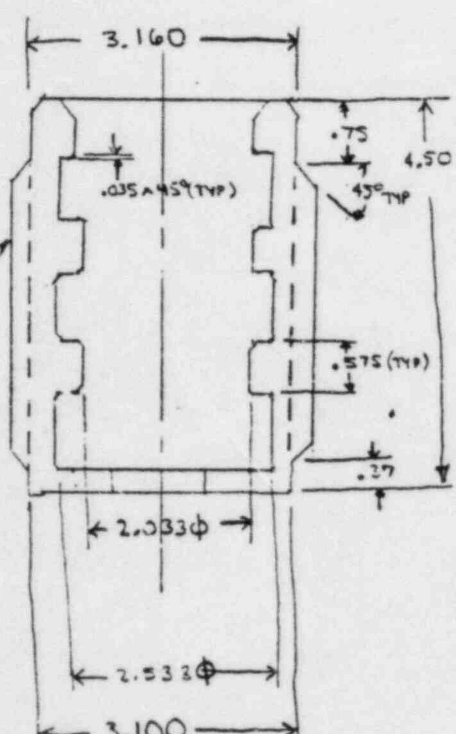
UPPER'S INSERT (35)

MAT'L:
ASTM A637 GRADE 688 TYPE 2
HUNTINGTON ALLOYS X-750 HOT FINISHED ROUND 115,000 PSI MINIMUM YIELD STRENGTH



THE BEARING STRESS IS THE SAME AS FOR THE STUD EXCEPT W = 120,000 PSI AND N=6

$f_c = W(.2305)\frac{9}{6}$

$f_c = 41,490$ PSI

THREAD SHEAR

$f_v = P/A_v = W/3/A_v$

$A_v = [D_3 - .64952/n]\, l\pi/2$

$= (3.50 - .64952/4)(4.50 - .75 - .37) * \pi/2$

$= 17.720 \text{ in}^2$

$f_v = W/3/17.720 = W(.01881)$

$f_v = 2257$ PSI

BENDING IN LANDS

FROM STUD CALCS:

$w = .160$ = width of bearing surface

x = moment arm of force

$= 2.533/2 - .035 - .160/2 - 2.033/2$

$= .135$ in

$f_b = M/Z$

$Z_{LAND} = L_c d^2/6 = \frac{54}{360}\pi(2.533)(.575)^2/6$

$= .065775 \text{ in}^3$

M = bending moment

$= (\frac{W}{3N})(.135)$

$N = 6$

$M = W(.0075)$

$f_b = .0075W/.065775$

$= W(.11403)$

$f_b = 13,683$ PSI

SHEAR OF LANDS

$f_v = P/A_v = W/3/A_v$

$A_v = \frac{54}{360} N\pi(2.533) = 7.1619 \text{ in}^2$

$f_v = W/3/7.1619 = W(.04654)$

$f_v = 5585$ PSI

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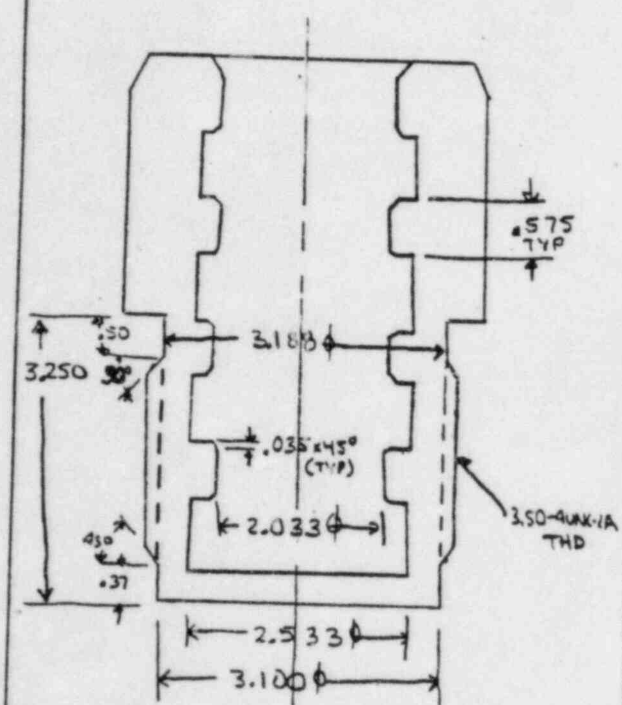
LOWER'S INSERT (36)

MAT'L:
ASTM A 637 GRADE 688 TYPE 2
HUNTINGTON ALLOYS X-750 HOT FINISHED ROUND. 115,000 PSI MINIMUM YIELD STRENGTH



THE BEARING STRESS IS THE SAME AS FOR THE STUD

$f_c = \omega(.2305)$

$f_c = 59,929$ PSI

THREAD SHEAR

$f_v = P/A_v = \omega/3/A_v$

$A_v = (D_s - .64952/n)\, l\pi/2$

$= (3.50 - .64952/4)(3.250 - .50 - .37)\pi/2$

$= 12.478\ in^2$

$f_v = \omega/3/12.478 = \omega(.02671)$

$f_v = 6946$ PSI

BENDING IN LANDS

THE BENDING IN THE LANDS IS THE SAME AS FOR THE UPPER INSERTS EXCEPT $\omega = 260,000$ LB. & N = 9

$f_b = \omega(.11403)\frac{6}{9}$

$f_b = 19,765$ PSI

SHEAR OF LANDS

THE SHEAR IN THE LANDS IS THE SAME AS FOR THE UPPER INSERT EXCEPT THAT $\omega = 260,000$ and N = 9

$f_v = \omega(.04654)\frac{6}{9}$

$f_v = 8067$ PSI

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