WCAP 10669

WESTINGHOUSE CLASS 3

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

NORTHEAST UTILITY SERVICE COMPANY
MILLSTONE NUCLEAR POWER STATION, UNIT NO. 3

SEPTEMBER, 1984

H. H. SANDNER, P. E.

Approved: J. R. Marshall, P.E. Manager
Component Handling Equipment

WESTINGHOUSE ELECTRIC CORPORATION
Nuclear Energy Systems
P.O. Box 355
Pittsburgh, PA 15230

ABSTRACT

An evaluation of the Millstone Nuclear Power Station, Unit No. 3 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.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

ATTACHMENTS

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 Northeast Utility Service Company, Millstone Nuclear Power Station, Unit No. 3.

B. Stress Report - Reactor Vessel Head Lift Rig, Reactor Vessel Internals Lift Rig, Load Cell and Load Cell Linkage for Northeast Utility Service Company, Millstone Nuclear Power Station, Unit No. 3.

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. Westinghouse Drawing 1212E27 - 4-Loop Lifting Rig - Head, General Assembly

4. Westinghouse Drawing 1464E23 - 4-Loop Reactor Plant Internals Lifting Rig General Assembly

5. Manual of Steel Construction, Seventh Edition, American Institute of Steel Construction.

6. Westinghouse Drawing 1216E70 - Head and Internals Lifting Rig Load Cell Linkage 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 <u>special lifting devices</u> 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. The Millstone Nuclear Power Station, Unit No. 3 lifting devices which can be categorized as <u>special lifting devices</u> 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 and 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 designed and built for the Millstone Nuclear Power Station, Unit No. 3 circa 1979-80. These devices were designed to the requirements that the resulting stress in the load carrying members when subjected to the total combined lifting weight should not exceed the allowable stresses specified in the AISC[5] code. Also, a 125 percent load test was required on both devices followed by appropriate non-destructive testing. 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 and operating instructions, where applicable.

SECTION 2
COMPONENT DESCRIPTION

2.1 REACTOR VESSEL HEAD LIFT RIG

The reactor vessel head lift rig[3] (Figure 2-1) is a three-legged carbon steel structure, approximately 48 feet high and 16 feet in diameter, weighing approximately 16,000 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 legs, clevis, and pins which are a part of the support for the seismic platform meet the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NF Class I Supports. The tripod assembly is attached to the three vertical legs and is used when installing and removing the reactor vessel head. During plant operation, 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 internals lifting rig[4] (Figure 2-2) is a three-legged carbon and stainless steel structure, approximately 30 feet high and 14 feet in diameter weighing approximately 21,000 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 reactor vessel internals lift rig attaches to the internals package by means of three rotolock studs which engage three rotolock inserts located in the internals flange. These rotolock studs are manually operated from the 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.

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. The unit is a load sensing clevis type, rated at 350,000 pounds.

This load cell is a part of the load cell linkage which is an assembly of pins, plates, and bolts that connect the polar crane main hook to the lifting blocks of both the reactor vessel head and the internal lift rigs.

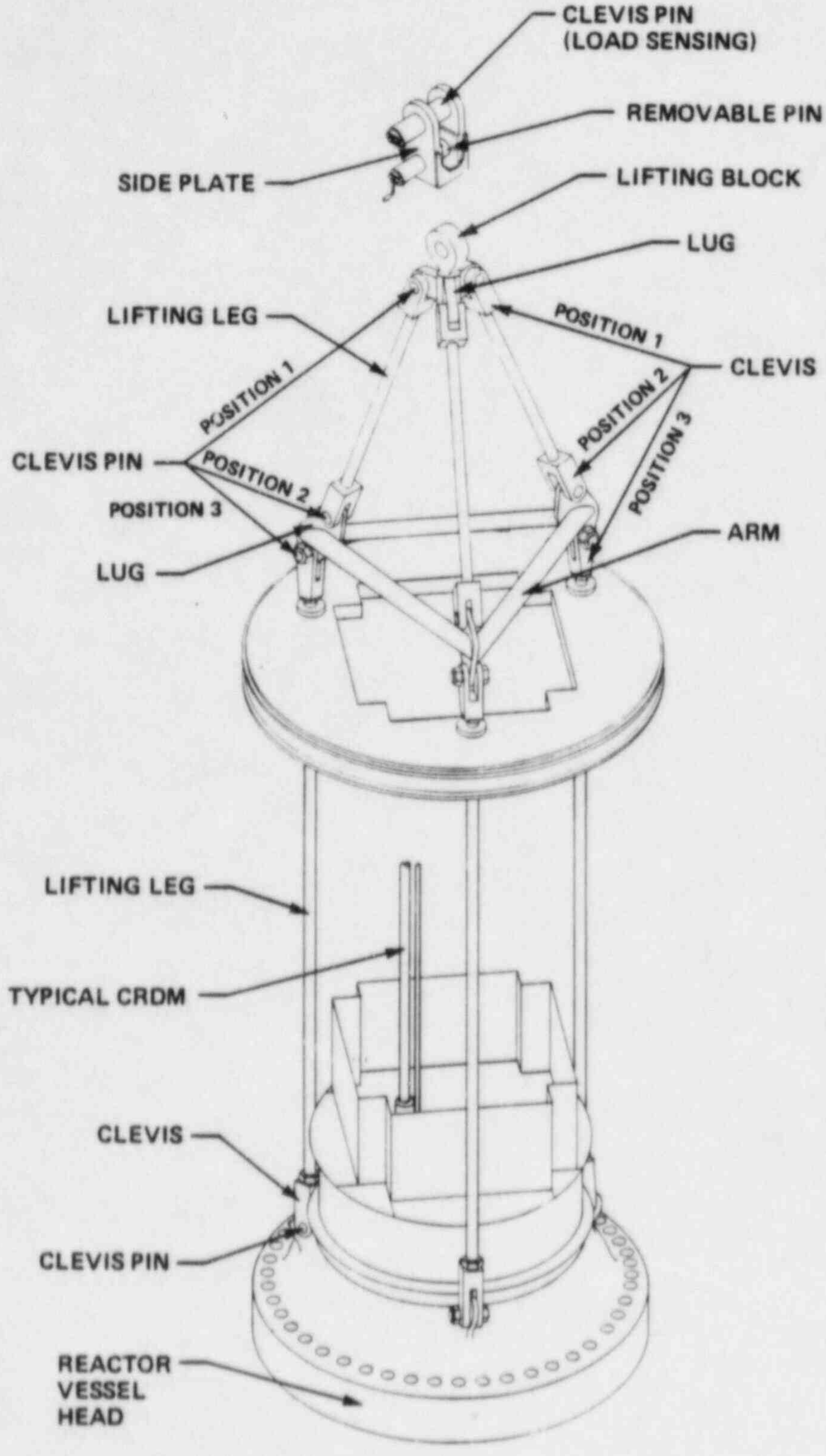


Figure 2-1. Reactor Vessel Head Lift Rig

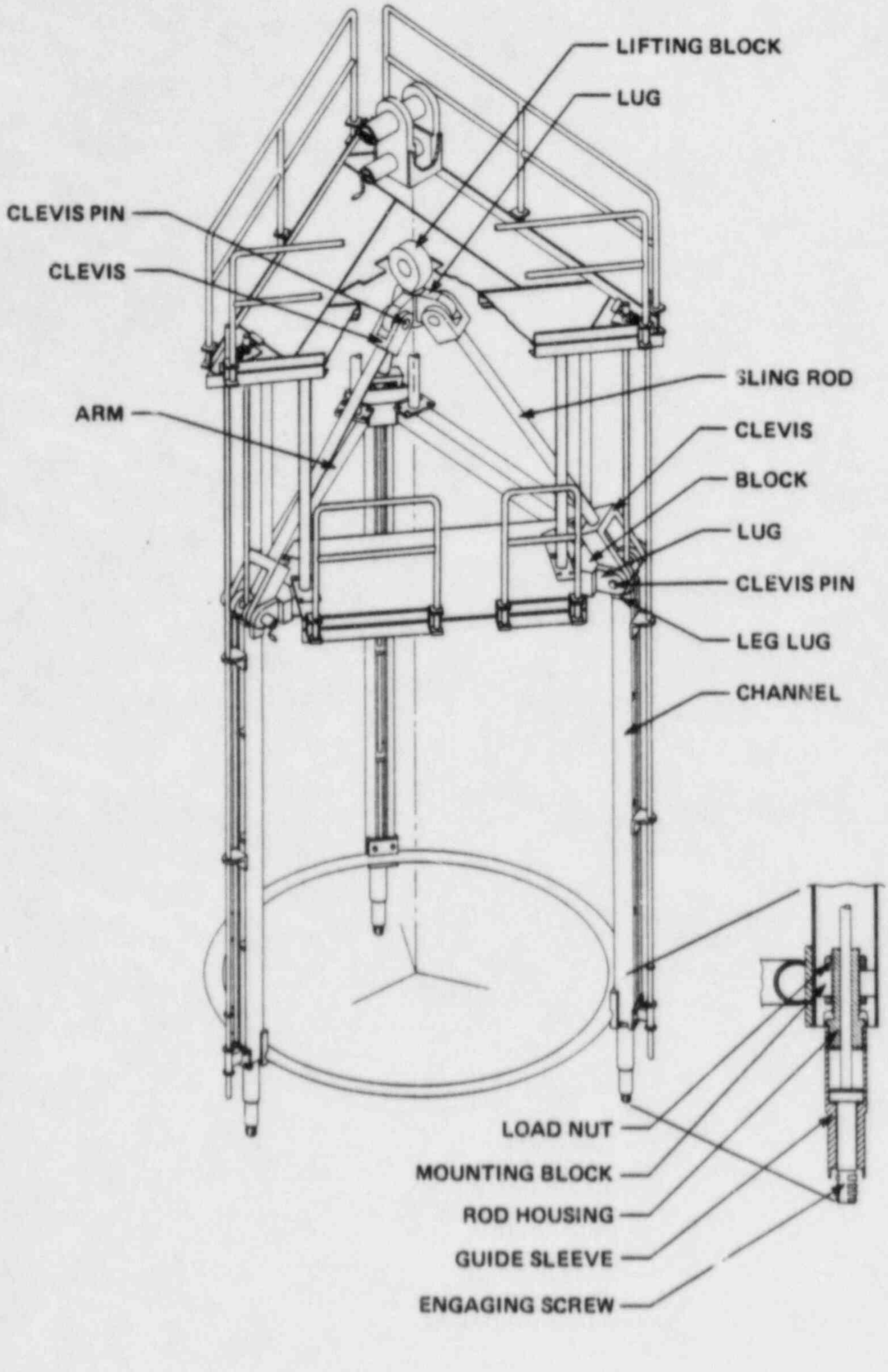


Figure 2-2. Reactor Vessel Internals Lift Rig

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 preparation of a stress report in accordance with Section 3.2 and 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 with the exception of the tensile stresses in the rod housing (item 15) and the guide sleeve (item 16) 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. In addition, all of the tensile and shear stresses meet the requirements of the AISC[5] code.

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.

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 most 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 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 approximately 50 percent and considered well within the ANSI N14.6 criteria for stress design factors.

6.2 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 5, 6, and 7.

6.3 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 that the 125 percent of maximum load test that was performed be accepted in lieu of the 150 percent load test.

6.4 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 (maximum of 6 inches) and hold for 10 minutes. Visually inspect the sling block lugs to the lifting block 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 (a maximum of 6 inches) and hold for 10 minutes. Visually inspect the sling block lugs to the lifting block 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 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 16 feet diameter by 50 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.

6.5 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.

WESTINGHOUSE CLASS 3

Although information contained in this report is nonproprietary, no distribution shall be made outside Westinghouse or its licensees without the customer's approval.

ATTACHMENT A
to
WCAP-10669

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 the Load Cell Linkage

for

Northeast Utility Service Company
Millstone Nuclear Power Station, Unit No. 3

September 1984

H. H. Sandner, P.E.

Approved [signature]

J. R. Marshall, P.E., Manager
Component Handling Equipment

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 Millstone Nuclear Power Station, Unit No. 3 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 Millstone Nuclear Power Station, Unit No. 3 lifting devices has been prepared.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

REFERENCES

1. Westinghouse Drawing 1212E27 - 4-Loop Lifting Rig - Head, General Assembly.

2. Westinghouse Drawing 1464E23 - 4-Loop Reactor Plant Internals Lifting Rig General Assembly.

3. Manual of Steel Construction, Seventh Edition, American Institute of Steel Construction.

4. Westinghouse Drawing 1216E70 - Head and Internals Lifting Rig Load Cell Linkage 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 and 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, and the load cell linkage. This comparison is listed in Table 2-1.

2.1 BACKGROUND

The reactor vessel head and internals lifting rigs were designed and built for the Millstone Nuclear Power Station, Unit No. 3, circa 1979-80. These devices were designed to the requirement that the resulting stress in the load carrying members, when subjected to the total combined lifting weight, should not exceed the allowable stresses specified in the AISC[3] code. Also, a 125 percent load test was required on both devices, followed by appropriate non-destructive testing. Westinghouse also required non-destructive tests and inspections on critical load path parts and welds both as raw material and as finished items. These requirements of design, manufacturing and quality assurance were identified on detailed manufacturing drawing and purchasing documents.

Westinghouse also issued field assembly and operating instructions, where applicable.

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 48 feet high and 16 feet in diameter, weighing approximately 15,000 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 legs, clevis, and pins which are a part of the support for the seismic platform meet the requirements of the ASME Boiler and Pressure Vessel Code, Section III, subsection NF Class I supports. 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 30 feet high and 14 feet in diameter weighing approximately 21,000 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 reactor vessel internals lift rig attaches to the internals package by means of three rotolock studs which engage three rotolock inserts located in the internals flange. These rotolock studs are manually operated from the internals 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.

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. The unit is a load sensing device type, rated at 350,000 pounds.

This load cell is a part of the load cell linkage which is an assembly of pins, plates, and bolts that connect the polar crane main hook to the lifting blocks of both the reactor vessel head and internals lift rigs.

TABLE 2-1

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 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 design specification was written concerning these specific requirements. However, assembly and detailed manufacturing drawings and purchasing documents contain the following requirements: (1) Material specification for all 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

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 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. C. Repair procedures were not identified. D. No limitations were identified as to the use of these devices under adverse environments. E. The Internals Lift Rig and Load Cell linkage have nameplates attached which include pertinent information. F. Critical item lists have been prepared for each device that identify load carrying members and welds of these special lifting devices.

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
3.2 3.2.1 to 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. These devices were originally designed to the requirement that the resulting stress in the load carrying members, when subjected to the total combined lifting weight, should not exceed the allowable stresses specified in the AISC code. A stress report 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, load cell). Although the fracture toughness was not determined, the material was selected based on it's fracture toughness characteristics. However, the stress design factors of ANSI N14.6 Section 3.2.1 of 3 and 5 were used in previous analyses and the resulting stresses were acceptable. 3. Where necessary, the weight of pins was considered for handling. 4. For the Head Lifting Rig, the material for the clevis pin, the lifting leg, and the clevis meets the Charpy V-notch requirements per ASME Boiler and Pressure Vessel Code, Section III subsection NF 2300.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
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. 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 and position indication is provided from the operating platform.
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.
3.5 3.5.1 to 3.5.10	Coatings - 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 when applicable. These specifications require 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 ensuring non-contamination of stainless steel items.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND MILLSTONE NO. 3 SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
3.6 3.6.1 to 3.6.3	Lubricants - These sections contain requirements for special lubricants to minimize contamination and degradation of the lubricant and contacted surfaces or water pools	On the head lifting rig, threaded connections and 63 finishes are coated with Fel/pro N-1000 as indicated on the drawings. On the internals lift device, threaded connections are coated with neolube. On the load cell linkage, silicone grease is used where applicable as indicated on the drawings.
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 specifically required. All the manufacturers welding procedures and non-destructive testing procedures were reviewed by Westinghouse prior to use. All critical load carrying members require certificates 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.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device 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 some in-process and final inspections similar to those identified in these sections, and issued a Quality Release. (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.
5 5.1 5.1.1 to 5.1.8	Acceptance Testing Maintenance, and Assurance of Continued Compliance Owner's Responsibilities - 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 the Reactor Vessel Head and Internals Lift Rigs were proof tested upon completion with a load of approximately 1.25 times the design weight. Upon the completion of the test, all parts, particularly welds, were visually inspected for cracks or obvious deformation. Critical welds were magnetic partical inspected. In addition, the Westinghouse Quality Release verifies 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 include a visual check of critical welds and parts during lifting to comply with this requirement for functional testing.

TABLE 2-1 (cont)

COMPARISON OF REQUIREMENTS OF THE ANSI N14.6 AND

MILLSTONE NO. 3 SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
	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.
	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. The rigs are identified as indicated in Section E., page 2-5.
	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 REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 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	Acceptance Testing and Testing to Verify Continuing Compliance - These paragraphs require the rigs to be initially tested at 150 percent maximum load followed by non-destructive testing of critical load bearing parts and welds and also annual 150 percent load tests or annual non-destructive tests and examinations; qualification of replacement parts.	The head and internals lifting rigs were load tested as indicated in Section 5. The requirement for 150 percent load testing, or dimensional checking and non-destructive testing is not practical due to the space limitations and cleanliness requirements in containment. In lieu of these requirements, written procedures should be developed requiring the special lifting devices to be attached to their respective loads, lifted a maximum of six inches, and held for ten minutes prior to use at each refueling. A visual inspection of critical welds and parts should follow. Further note that with the use of the load cell for the head and internals, lifting and lowering is monitored at all times. Replacement parts should be in accordance with the original or equivalent requirements.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 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 procedures should contain, as much as possible, requirements that were used in the original fabrication. The critical items list will contain the original type of 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. If pins, bolts or other fasteners need repairs, they should be replaced, in lieu of repair in accordance with the original or equivalent requirements for material and non-destructive testing.

TABLE 2-1 (cont)

COMPARISON OF THE REQUIREMENTS OF ANSI N14.6 AND

MILLSTONE NO. 3 SPECIAL LIFT DEVICES

ANSI N14.6 Section	Description of ANSI N14.6 Requirement	Actual Special Lift Device Requirements
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 ASTM specifications, 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 can be 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. These devices, for the most part, were manufactured under Westinghouse surveillance with identified hold points, procedure review and personnel qualification which adequately meet these related ANSI requirements. A 125 percent load test was performed on both the head and internals lift rigs followed by the appropriate non-destructive testing.

It is anticipated that 100 percent load test, performed on each device, at each refueling, followed by a visual check of critical welds would be sufficient to demonstrate compliance. This may require modification of the Millstone Nuclear Power Station, Unit No. 3 operating and maintenance procedures.

Upon completion of the field assembly of the internals lift rig, prior to using, the assembly procedure calls for a visual inspection of all bolted joints on the rig and a visual inspection for cracks or distortions, particularly in the area of the welds. Upon completion of the field assembly of the reactor vessel head lfiting rig, the assembly procedure calls for a 100 percent load test (lifting of the assembled head), with a visual inspection for any signs of distortion.

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 and the load cell and load cell linkage. 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 all 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 almost 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 all welds. Westinghouse required a certificate, or letter 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 for the internals and head lifting rigs.

TABLE A-1

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

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item[a]	Description	Material	Non-destructive Testing	
			Material	Finished
1	Lifting Block	ASTM A350 GR. LF	Ultrasonic	Magnetic Particle
2,7	Lug	ASTM A516 Grade 70	Ultrasonic Magnetic Particle	Magnetic Particle (item 2 only)
3,6	Clevis Pin	ASTM A434 AISI 4340 Steel Class BD	Ultrasonic	Magnetic Particle
4,10	Clevis	ASTM A668 Forging and Class L AISI 4340	Ultrasonic	Magnetic Particle
5,9	Lifting Leg	ASTM A434 Class BC AISI 4340	Ultrasonic	Magnetic Particle
11	Clevis Pin (load sensing)	ASTM A564 Type XM12	Ultrasonic	Magnetic Particle
12	Side Plates	ASTM 533 Type B Class 1	Ultrasonic	--
13	Removable Pin	ASTM A564 Type 630	Ultrasonic	Liquid Penetrant

[a] See figure A-1

TABLE A-2

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

CRITICAL ITEMS LIST OF WELDS

PER ANSI N14.6-1978

Item	Description	Non-destructive Testing	
		Root Pass	Final
1,2	Lugs to Lifting Block (Full Penetration)	Magnetic Particle	Magnetic Particle Radiograph
7,8	Spreader Arm Lug to Spreader Arm (fillet)	Magnetic Particle	Magnetic Particle

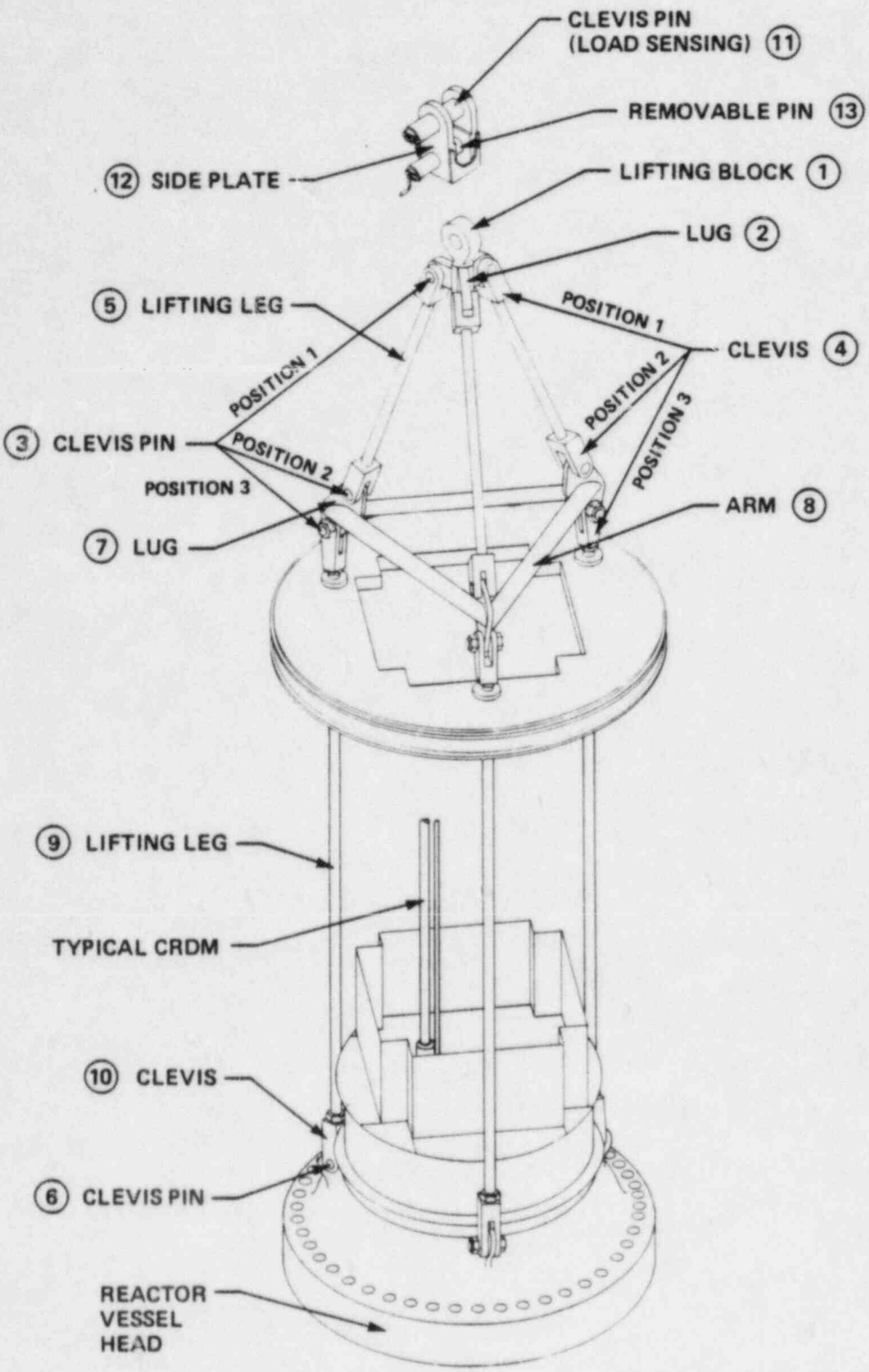


Figure A-1. Reactor Vessel Head Lift Rig

TABLE A-3

REACTOR VESSEL INTERNALS LIFT RIG

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item[a]	Description	Material	Non-destructive Testing	
			Material	Finished
1	Lifting Block	ASTM A350 Grade LF 2	Ultrasonic	Magnetic Partical
2	Lifting Block Lug	ASTM A516 Grade 70	Ultrasonic Magnetic Particle	Magnetic Partical
3,7	Clevis Pin	ASTM A564, Grade 70 Precipitation Hardening SST Age treated @ 1150° F/4hrs. Air cooled RC 28-31	Ultrasonic	Liquid Penetrant
4,6	Clevis	ASTM A471 Class 3 Steel Forging	Ultrasonic	Magnetic Particle
5	Sling Rod	ASTM A434 Class BC AISI 4340 or (ASTM A588)	Ultrasonic	Magnetic Particle
8,11	Spread Lug Leg Lug	ASTM A516 GR 70 STL Plate Normalized	Ultrasonic Particle Magnetic	
12	Leg Channels	ASTM A36 CS, HR	Visual	
13	Mounting Block	ASTM A350 LFI Forging Steel	Ultrasonic Magnetic Particle	

(a)See figure A-2

TABLE A-3 (cont)

REACTOR VESSEL INTERNALS LIFT RIG

CRITICAL ITEMS LIST OF PARTS

PER ANSI N14.6-1978

Item[a]	Description	Material	Non-destructive Testing	
			Material	Finished
14,15	Load Nuts Rod Housing	ASTM A276, Type 304 SST, Hot Rolled, Condition A	Ultrasonic	
16	Guide Sleeve	ASTM A276, Type 304 SST, Hot Rolled, Annealed & Pickled, Condition A	Ultrasonic	Liquid Penetrant
17	Rotolock Stud	ASTM A564, Type 630, 17-4 pH Steel 1100°F for 4 hours	Ultrasonic	Liquid Penetrant

(a) See figure A-2

TABLE A-4

REACTOR VESSEL INTERNALS LIFT RIG

CRITICAL ITEMS LIST OF WELDS

PER ANSI N14.6-1978

Item	Description	Non-destructive Testing	
		Root Pass	Final
1,2	Lugs to Lifting Block (Full Penetration)	Magnetic Particle	Magnetic Particle Radiograph
8,9	Lug to Spreader Block (Full Penetration)	Magnetic Particle	Magnetic Particle
11,12	Leg Lug to Channel Leg (fillet)	Magnetic Particle	Magnetic Particle
12,13	Mounting Block to Channel Leg (fillet)	Magnetic Particle	Magnetic Particle

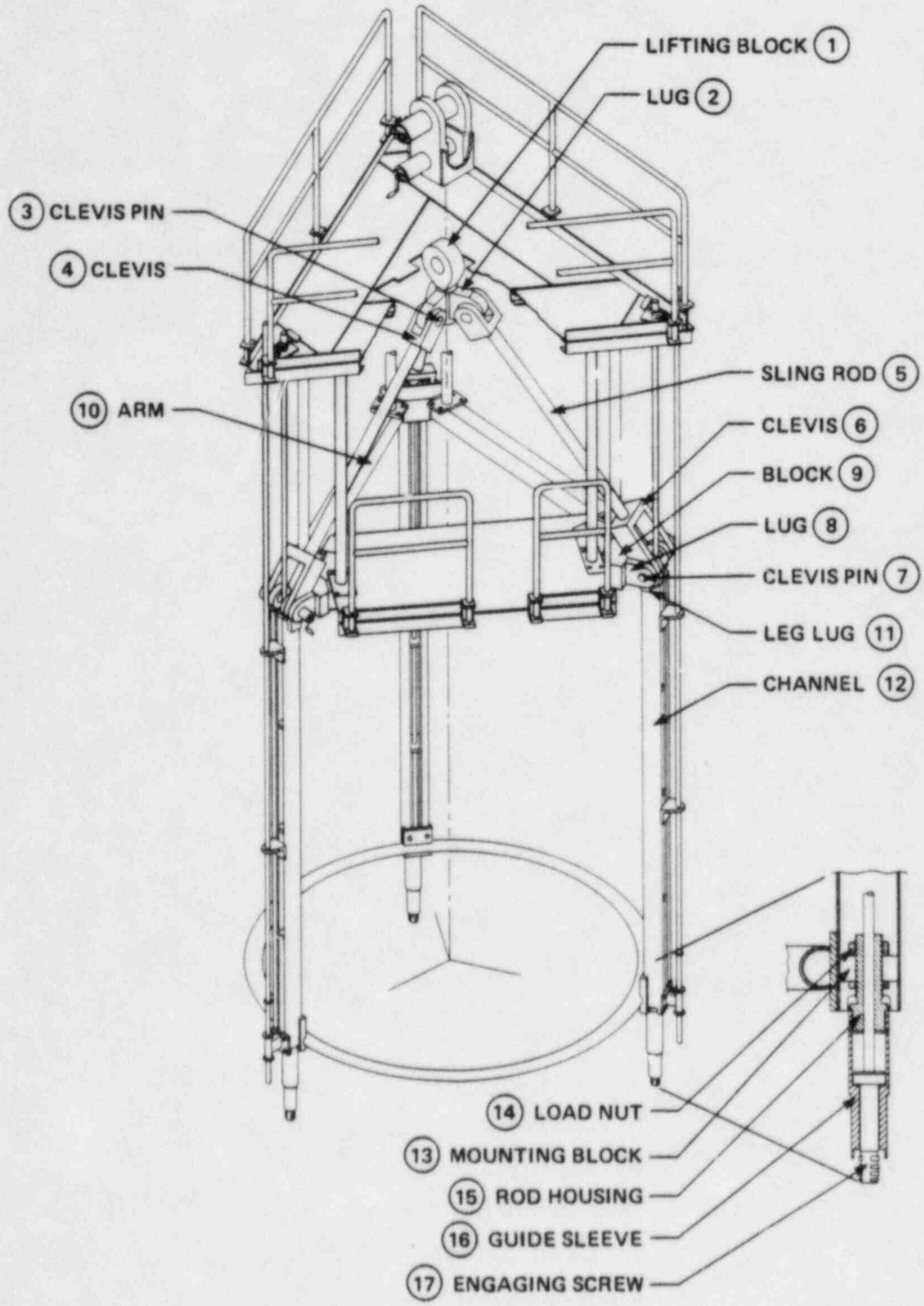


Figure A-2. Reactor Vessel Internals Lift Rig

APPENDIX B

TABULATION OF ANSI N14.6-1978 REQUIREMENTS INCOMPATIBLE WITH THE MILLSTONE NUCLEAR POWER STATION, UNIT NO. 3 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 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 all the material used in these special lifting devices. However, the material selection was based on its fracture toughness characteristics.

4a. Requirement:

Para. 5.1 lists <u>Owner Responsibilities</u> 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.

4b. Remarks:

There wasn't any design specification for these rigs. A 125 percent load test followed by the appropriate nondestructive testing was performed. In addition, the Westinghouse Quality Release, may be considered an acceptable alternate to verify that the criteria for the letters of compliance for materials and specifications required by Westinghouse drawings and purchasing document were satisfied.

5a. Requirement:

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

5b. 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.

6a. 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.

6b. 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.

7a. 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.

7b. Remarks:

Both the reactor vessel head and internals lifting rigs and load cell were proof tested upon completion with a load of approximately 1.25 times the design weight. Upon completion of the test, all parts, particularly welds, were visually inspected for cracks or obvious deformation and critical welds were magnetic partical inspected. In addition the Westinghouse Quality Release verified that the criteria for letters of compliance for materials and specifications required by the Westinghouse drawings and purchasing documents were satisfied.

8a. Requirement:

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

8b. 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.

9a. 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.

9b. 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. Crane capacity could also be limiting. It is suggested that written procedures be developed requiring the special lifting devices to be attached to their respective loads, lifted a maximum of six inches, and held for ten minutes prior to use at each refueling. A visual inspection of critical welds and parts should follow. Further note that with the use of the load cell for the head and internals lift rig, all lifting and lowering is monitored at all times.

2. SUMMARY

The ANSI requirements for periodic checking and functional load testing appear to be 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

Although information contained in this report
is nonproprietary, no distribution shall
be made outside Westinghouse or its
licensees without the customer's approval

ATTACHMENT B to
WCAP-10669

STRESS REPORT
REACTOR VESSEL HEAD LIFT RIG,
REACTOR VESSEL INTERNALS LIFT RIG
AND THE LOAD CELL LINKAGE

FOR

NORTHEAST UTILITY SERVICE COMPANY

MILLSTONE NUCLEAR POWER STATION, UNIT NO. 3

September 1984

H. H. Sandner, P.E.

Approved: ______________________
J. R. Marshall, P.E., Manager
Component Handling Equipment

8079B:1b-083184

ABSTRACT

A stress analysis of the Millstone Nuclear Power Station, Unit No. 3 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

Acknowledgment is hereby made to the following individuals who contributed to the structural analysis presented in this report.

F. C. Peduzzi

J. W. Richard

R. M. Blaushild

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

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. Westinghouse Drawing 1212E27 - 4-Loop Lifting Rig - Head, General Assembly.

4. Westinghouse Drawing 1464E23-4-Loop Reactor Plant Internals Lifting Rig General Assembly.

5. Manual of Steel Construction, Seventh Edition, American Institute of Steel Construction.

6. Westinghouse Drawing - 1216E70 - Head and Internals Lifting Rig Load Cell Linkage 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 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.

This report contains the stress analysis performed on the Millstone Nuclear Power Station, Unit No. 3 reactor vessel head lift rig, reactor vessel internals lift rig and the 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 lifting rig and load cell and load cell linkage, were designed and built for the Millstone Nuclear Power Station, Unit No. 3, circa 1979-1980. These devices were designed to the requirements that the resulting stress in the load carrying members when subjected to the total combined lifting weight should not exceed the allowable stresses specified in the AISC[5] code. Also a 125 percent load test was required on both devices, followed by appropriate non-destructive testing. These items were not classified as nuclear safety components and thus 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 and operating instructions, where applicable.

SECTION 2
COMPONENT DESCRIPTION

2.1 REACTOR VESSEL HEAD LIFT RIG

The reactor vessel head lift rig[3] is a three-legged carbon steel structure, approximately 48 feet high and 16 feet in diameter, weighing approximately 15,000 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 leg, clevises, and pins which are a part of the support for the seismic platform, meet the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NF Class I supports. 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[4] is a three-legged carbon and stainless steel structure, approximately 30 feet high and 14 feet in diameter weighing approximately 21,000 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 reactor vessel internals lift rig attaches to the internals package by means of three rotolock studs which engage three rotolock inserts located in the internals flange. These rotolock studs are manually operated from the 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.

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. The unit shall be a load sensing clevis type rated at 350,000 pounds. This load cell is a part of the load cell linkage which is an assembly of pins, plates, and bolts that connect the polar crane main hook to the lifting blocks of both the reactor vessel head and internals lift rig.

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 static load should be increased by an amount based on the crane dynamics 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, we consider the dynamic factor for a typical containment crane to be not much larger than 1.0.

To provide flexibility on stress design factor, the summary table lists the stresses with stress design factors of 1, 3 and 5. Thus, any stress design factor may be easily applied to satisfy 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, Load Cell, and Lcad Cell Linkage

The design weight is 336,218 pounds which is the total weight of the assembled head and the lifting device.

3.2.2 Reactor Vessel Internals Lift Rig

The design weight for the lower internals including the internals lifting rig is 300,000 pounds.

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 and load cell linkage are listed in Tables 4-1 and 4-2.

TABLE 4-1

REACTOR VESSEL HEAD LIFT RIG AND LOAD CELL LINKAGE MATERIAL AND MATERIAL PROPERTIES

Item[a]	Descripcion	Material	Yield Strength S_y (ksi)	Ultimate Strength S_{ult} (ksi)
1	Lifting Block	ASTM A350	36	70
2,7	Lug	ASTM A516 Grade 70	38	70
3,6	Clevis Pin	ASTM A434 AISI 4340 Steel Class BD	110	140
4,10	Clevis	ASTM A668 Forging and Class L AISI 4340	85	110
5,9	Lifting Leg	ASTM A434 Class BC AISI 4340	85	110
8	Arm	ASTM A106	35	60
11	Clevis Pin (load sensing)	ASTM A564, Type XM12	105	135
12	Side Plates	ASTM A533, Type B Class 1	50	80
13	Removable Pin	ASTM A564, Type 630	105	135

(a) See figure 5-1.

TABLE 4-2

REACTOR VESSEL INTERNALS LIFT RIG MATERIAL AND MATERIAL PROPERTIES

Item[a]	Description	Material	Yield Strength S_y (ksi)	Ultimate Strength S_{ult} (ksi)
1	Lifting Block	ASTM A350, Grade LF 2	36	70
2	Lifting Block Lug	ASTM A516, Grade 70	38	70-90
3,7	Clevis Pin	ASTM A564, Grade 70 Precipitation Hardening SST, Age Treated 1150°F/ 4 hrs. Air Cooled RC 28-31	105	135
4,6	Clevis	ASTM A471, Class 3 Steel Forging	95	110
5	Sling Rod	ASTM A434, Class BC AISI 4340 or (ASTM A588)	85/(46)	110/(67)
8,11	Spreader Leg Lug	ASTM A516, GR 70 STL Plate Normalized	38	70-90
9,13	Spreader and Mounting Block	ASTM A350, LFI Forging Steel	30	60
10	Spreader Arm	ASTM A500, Grade B	46	58
12	Leg Channels	ASTM A36, CS, HR	36	58-80
14,15	Load Nuts Rod Housing	ASTM A276, Type 304, SST Hot Rolled, Cond. A	30	75
16	Guide Sleeve	ASTM A276, Type 304, SST, Hot Rolled, Annealed and pickled, Condition A	30	75
17	Rotolock Stud	ASTM A564, Type 630 17-4 PH Steel 1100°F for 4 hrs.	115	140

(a) See figure 5-2.

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, load cell and load cell linkage and the internals lift rig. All of the tensile and shear stresses with the exception of the tensile stresses in the rod housing (item 15) and the guide sleeve (item 16), 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 accompanying allowable stress limits of yield and ultimate strength, respectively. In addition, all of the tensile and shear stresses meet the requirement of not exceeding the allowables of the AISC[5] code.

5.1 DISCUSSION OF RESULTS

5.1.1 Application of ANSI N14.6 Criteria

Both the reactor vessel head and internals lift rig were originally designed to the requirement that all resulting stresses in the load carrying members, when subjected to the total combined lifting weight, should not exceed the allowable stresses specified in the AISC[5] code.

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. bending, bearing. This is an extremely conservative approach and in several instances the resulting stresses exceed the accompanying allowable stress limit.

5.2 CONCLUSIONS

a) 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 Section 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[5] code.

b) Bending Stresses - The removable pin and the load sensing clevis pin in the load cell linkage do not meet the Section 3.2.1.1 5W criteria. However, a very conservative approach was used to calculate the bending stress in pins, as shown in the reactor vessel head lifting rig calculations. In addition, this is a local fiber stress. Even if the fiber stresses reached anywhere near the yield stress, the rest of the pin cross-section could assume the additional load. The shear stress in the pin is extremely low and well within the Section 3.2.1.1 criteria. Again, Section 3.2.1.2 applies if necessary. The bending stress meets the AISC[5] code criteria.

c) Combined Stresses - The combined tensile stress from bending and tension, in the lower sling rod clevis (item 6), and the leg lug (item 11) of the internals lift rig exceed the Section 3.2.1.1 criteria. As indicated above, 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.

d) Tensile Stresses - The rod housing (item 15) and the guide sleeve (item 16) do not meet the 3W criteria of ANSI N14.6 when analyzed for tension at the thread relief. However these items do meet the AISC allowable tensile stress criteria of 0.6 times the yield strength and this is considered acceptable from a design standpoint.

TABLE 5-1

SUMMARY OF RESULTS

REACTOR VESSEL HEAD LIFT RIG AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value W[b]	3W	5W	Material Allowable (ksi) Sy[c]	S_{ult}[d]
1	Lifting Block	Tension @ 6.515" Dia. Hole	4.4	13.2	22.0	36	70
	ASTM A350	Bearing @ 6.515" Dia. Hole	6.9	20.7	34.5		
	Grade LF2	Shear @ 6.515" Dia. Hole	4.4	13.2	22.0		
		Tension @ Lug Supports Cross-Section	7.2	21.6	36.0		
2	Lug	Tension @ 4.015" Dia. Hole	4.8	14.4	24.0	38	70
	ASTM A516	Bearing @ 4.015" Dia. Hole	8.3	24.9	41.5		
	Grade 70	Shear @ 4.015" Dia. Hole	4.8	14.4	24.0		
		Tension @ Lug Root	7.7	23.1	38.5		
		Shear @ Lug Root	2.4	7.2	12.0		

(a) See figure 5-1 for location of item number 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 AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Calculated Stresses (ksi) Designation	Value $W^{(b)}$	3W	5W	Material Allowable (ksi) $S_y^{(c)}$	$S_{ult}^{(d)}$
3	Clevis Pin	Position 1				110	140
	ASTM A434	Shear	5.3	15.9	26.5		
	AISI 4340	Bearing	8.3	24.9	41.5		
	Steel Class BD	Bending	25.9	77.7	129.5		
		Position 2					
		Shear	5.3	15.9	26.5		
		Bearing	8.6	25.8	43.0		
		Bending	26.6	79.8	133.0		

(a) See figure 5-1 for location of item number 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 AND LOAD CELL LINKAGE

Item[(a)] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value W[(b)]	3W	5W	Material Allowable (ksi) Sy[(c)]	S_{ult}[(d)]
		Position 3					
		Shear	4.8	14.4	24.0		
		Bearing	7.7	23.1	38.5		
		Bending	24.0	72.0	120.0		
4	Clevis	Position 1					
	ASTM A668	Tension @ 4.005" Dia. Hole	5.3	15.9	26.5	85	110
	Forging &	Bearing @ 4.005" Dia. Hole	6.9	20.7	34.5		
	Class L	Tension @ Thread Relief	2.1	6.3	10.5		
	AISI 4340	Shear @ 4.005" Dia. Hole	5.3	15.9	26.5		
	Steel	Thread Shear	2.5	7.5	12.5		

(a) See figure 5-1 for location of item number 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 AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value W[b]	3W	5W	Material Allowable (ksi) Sy[c]	S_{ult}[d]
		Position 2					
		Tension @ 4.005" Dia. Hole	5.4	16.2	27.0	85	110
		Bearing @ 4.005" Dia. Hole	7.1	21.3	35.5		
		Tension @ Thread Relief	2.1	6.3	10.5		
		Shear @ 4.005" Dia. Hole	5.5	16.5	27.5		
		Thread Shear	2.5	7.5	12.5		

(a) See figure 5-1 for location of item number 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 AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value W[b]	3W	5W	Material Allowable (ksi) S_y[c]	S_{ult}[d]
		Position 3					
		Tension @ 4.005" Dia. Hole	4.9	14.7	24.5	85	110
		Bearing @ 4.005" Dia. Hole	6.4	19.2	32.0		
		Tension @ Thread Relief	1.9	5.7	9.5		
		Shear @ 4.005" Dia. Hole	4.9	14.7	24.5		
		Thread Shear	2.3	6.9	11.5		
5	Lifting Leg ASTM A434 Class BC AISI 4340 Steel	Tension @ Threads	7.5	22.5	37.5	85	110
		Thread Shear	2.5	7.5	12.5		

(a) See figure 5-1 for location of item number 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 AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value W[b]	3W	5W	Material Allowable (ksi) Sy[c]	S_{ult}[d]
6	Clevis Pin	Shear	4.4	13.2	22.0	110	140
	ASTM A434	Bearing	6.8	20.4	34.0		
	AISI 4340	Bending	22.3	66.9	111.5		
	Steel						
	Class BD						
7	Lug	Tension @ Upper Hole	4.9	14.7	24.5	38	70
	ASTM A516	Shear @ Upper Hole	4.9	14.7	24.5		
	Grade 70	Tension @ Lower Hole	4.0	12.0	20.0		
		Shear @ Lower Hole	4.4	13.2	22.0		
		Shear @ Weld	2.4	7.2	12.0		

(a) See figure 5-1 for location of item number 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 AND LOAD CELL LINKAGE

Item[(a)] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value $W^{(b)}$	3W	5W	Material Allowable (ksi) $Sy^{(c)}$	S_{ult}[(d)]
8	Arm ASTM A106 Grade B Seamless	Compressive Stress Shear @ Weld	2.6 2.4	7.8 7.2	13.0 12.0	35 18[(e)]	60
9	Lifting Leg ASTM A434 Class BC AISI 4340 Turned, Ground & Polished	Thread Shear Tension @ Thread	2.3 6.8	6.9 20.4	11.5 34.0	85	110

(a) See figure 5-1 for location of item number 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 and Pressur Vessel Code, Section III, Division 1 - Subsection NF 1980 Edition, Table NF-3292 1-1, page 43.

TABLE 5-1 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL HEAD LIFT RIG AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value W[b]	3W	5W	Material Allowable (ksi) Sy[c]	S_{ult}[d]
10	Clevis	Tension @ 3.947" Dia. Hole	4.2	12.6	21.0	85	110
	ASTM A668	Bearing @ 3.947" Dia. Hole	5.6	16.8	28.0		
	Forging	Shear @ 3.947" Dia. Hole	4.2	12.6	21.0		
	Grade L	Tension @ Thread Relief	1.6	4.8	8.0		
	AISI 4340	Thread Shear	2.0	6.0	10.0		
	Steel						
11	Clevis Pin	Bearing @ Midspan Section	7.8	23.4	39.0	105	131
	(Load Sensing)	Bearing @ End Sections	7.8	23.4	39.0		
	ASTM A564	Shear	4.7	14.1	23.5		
	Type XM12	Bending	26.6	79.8	133.0		

(a) See figure 5-1 for location of item number 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 AND LOAD CELL LINKAGE

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value			Material Allowable (ksi)	
			W[b]	3W	5W	Sy[c]	S_{ult}[d]
12	Side Plates	Tension @ 7.5 Dia. Hole	5.0	15.0	25.0	50	80
	ASTM A533	Bearing @ 7.5 Dia. Hole	7.8	23.4	39.0		
	Type B, Class 1	Bearing @ 6.520 Dia. Hole	7.2	21.6	36.0		
		Shear Tear-out @ 6.52 Dia. Hole	4.4	13.2	22.0		
		Shear Tear-out @ 7.5 Dia. Hole	5.0	15.0	25.0		
13	Removable Pin	Shear	5.6	16.8	28.0	105	135
	ASTM A564	Bearing @ Midspan	6.9	20.7	34.5		
	Type 630	Bearing Ends	7.2	21.6	36.0		
		Bending	28.3	84.9	141.5		

(a) See figure 5-1 for location of item number 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)

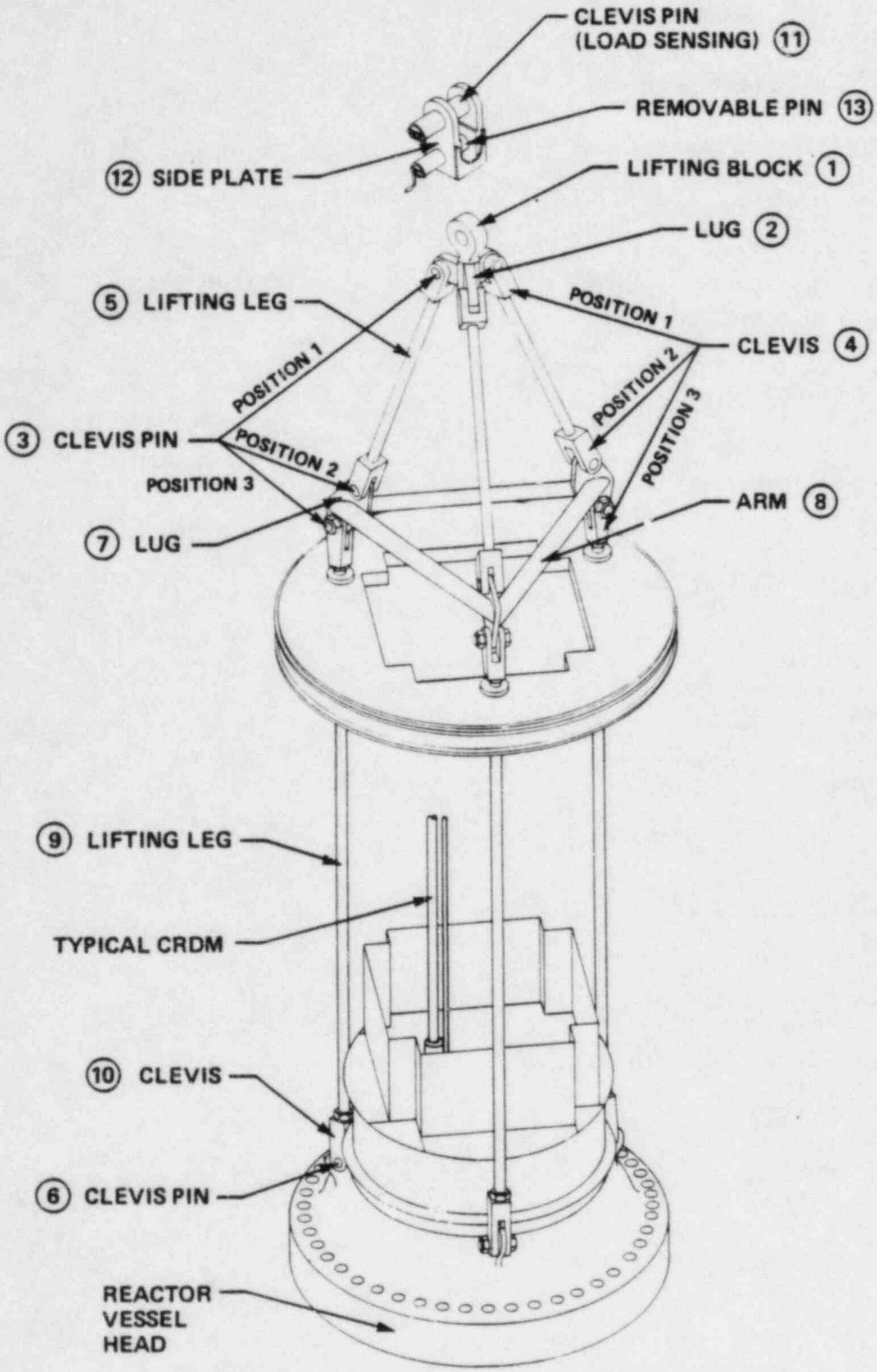


Figure 5-1. Reactor Vessel Head Lift Rig

TABLE 5-2

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG

Item[a] No.	Part Name And Material	Calculated Stresses (ksi)				Material Allowable (ksi)	
		Designation	Value				
			W[b]	3W	5W	Sy[c]	S_{ult}[d]
1	Lifting Block ASTM A350 Grade LF2	Tensile Stress @ 6.515 Dia. Hole	3.9	11.7	19.5	36	70
		Bearing Stress @ 6.515 Dia. Hole	5.7	17.1	28.5		
		Shear Tear-out @ 6.515 Dia. Hole	3.9	11.7	19.5		
		Tensile Stress @ Central Cylinder	6.0	18.0	30.0		

(a) See figure 5-2 for location of item number 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

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value			Material Allowable (ksi)	
			W[b]	3W	5W	Sy[c]	S_{ult}[d]
2	Lifting Block Lug ASTM A516 Grade 70	Tensile Stress @ 4.015 Dia. Hole	4.7	14.1	23.5	38	70
		Bearing Stress @ 4.015 Dia. Hole	7.8	23.4	39.0		
		Tension @ Lug Root	6.7	20.1	33.5		
		Shear Tear-out @ 4.015 Dia. Hole	4.7	14.1	23.5		
		Shear @ Lug Root	2.0	6.0	10.0		

(a) See figure 5-2 for location of item number 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

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value			Material Allowable (ksi)	
			W[b]	3W	5W	S_y[c]	S_{ult}[d]
3	Clevis Pin	Shear	5.0	15.0	25.0	105	135
	ASTM A564	Bearing on Lifting Block Lug	7.9	23.7	39.5		
	Type 630	Bending	23.9	71.7	119.5		
	17-4 pH H1150	Bearing on Clevis Lugs	6.5	19.5	32.5		
4	Clevis	Tension @ 4.018 Dia. Hole	5.2	15.6	26.0	95	110
	ASTM A471	Bearing @ 4.018 Dia. Hole	6.5	19.5	32.5		
	Class 3	Shear Tear-out @ 4.018 Dia. Hole	5.2	15.6	26.0		
	Steel Forging						
		Thread Shear	5.2	15.6	26.0		

(a) See figure 5-2 for location of item number 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

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value W[b]	3W	5W	Material Allowable (ksi) Sy[c]	S_{ult}[d]
5	Sling Rod ASTM A434 Class BC AISI 4340	Thread Shear	5.2	15.6	26.0	85	110
		Tension @ Thread Relief	12.0	36.0	60.0		
		Tension @ Thread	11.3	33.9	56.5		
6	Lower Sling Rod Clevis ASTM A471 Class 3 Steel Forging	Bearing	27.6	82.8	138.0	95	110
		Tension @ 4.018 Dia. Hole	31.3	93.9	156.5		
		Thread Shear	4.3	12.9	21.5		

(a) See figure 5-2 for location of item number 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

Item[a] No.	Part Name And Material	Calculated Stresses (ksi) Designation	Value $W^{(b)}$	3W	5W	Material Allowable (ksi) $S_y^{(c)}$	$S_{ult}^{(d)}$
7	Clevis Pin ASTM A564 Type 630 17-4 pH H 1150	Bearing	27.6	82.8	138.0	105	135
		Shear	6.8	20.4	34.0		
		Bending	12.4	37.2	62.0		
8	Spreader Lug ASTM A516 GR 70 STL Plate Normalized or ASTM A537 Gr. A	Combined Stresses, Bending and Tensile	10.3	30.9	51.5	38	70
		Bearing Stress	15.4	46.2	77.0		

(a) See figure 5-2 for location of item number 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

Item[a] No.	Part Name And Material	Calculated Stresses (ksi) Designation	Value $W^{(b)}$	3W	5W	Material Allowable (ksi) $S_y^{(c)}$	$S_{ult}^{(d)}$
9	Spreader Block ASTM A350 LFI Forging Steel	Bearing from Arm	4.1	12.3	20.5	30	60
10	Spreader Arm ASTM A500 GR B	Nominal Compression Stress	4.1	12.3	20.5	F_a = 23.0[e]	

(a) See figure 5-2 for location of item number 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) F_a = allowable compression stress to prevent buckling in absence of bending moment

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS 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_{ult}[d]
11	Leg Lug	Combined Stress Bending &	14.9	44.7	74.5	38	70
	ASTM A516	Tensile @ 4.015 Dia. Hole					
	Grade 70	Bearing	25.4	76.2	127.0		
	Steel,	Weld Stresses	4.1	12.3	20.5	21[f]	
	Normalized						
12	Leg Channels	Tensile	2.5	7.5	12.5	36	58
	ASTM A36						
	CS, HR						
	Forging Steel						

(a) See figure 5-2 for location of item number 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)

(f) Stress limit for fillet welds from ASME Boiler and Pressure Vessel Code, Section III, Division 1 - Subsection NF 1980 Edition, Table NF-3292.1-1, page 43.

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG

Item[a] No.	Part Name And Material	Calculated Stresses (ksi) Designation	Value W[b]	3W	5W	Material Allowable (ksi) Sy[c]	S_{ult}[d]
13	Mounting Block	Bearing to Load Nut	14.1	42.3	70.5	30	60
	ASTM A350 LF1	Shear in Welds	6.1	18.3	30.5	18[f]	
14	Load Nut	Bearing to Mounting Block	14.1	42.3	70.5	30	75
	ASTM A276	Thread Shear	5.4	16.2	27.0		
	Type 304						

(a) See figure 5-2 for location of item number 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)

(f) Stress limit for fillet welds from ASME Boiler and Pressure Vessel Code, Section III, Division 1 - Subsection NF 1980 Edition, Table NF-3292.1-1, page 43.

TABLE 5-2 (cont)

SUMMARY OF RESULTS

REACTOR VESSEL INTERNALS LIFT RIG

Item[a] No.	Part Name And Material	Designation	Calculated Stresses (ksi) Value			Material Allowable (ksi)	
			W[b]	3W	5W	Sy[c]	S_{ult}[d]
15	Rod Housing	Tension @ Thread Relief	11.2	33.6	56.0	30	75
	ASTM A276	Thread Shear on Upper	6.4	19.2	32.0		
	Type 304	Threads					
		Lower Threads Shear	5.1	15.3	25.5		
16	Guide Sleeve	Thread Shear	5.1	15.3	25.5	30	75
	ASTM A276	Tension @ Thread Relief	12.0	36.0	60.0		
	Type 304 SST	Bearing to Stud	14.6	43.8	73.0		

(a) See figure 5-2 for location of item number 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

Item[a] No.	Part Name And Material	Calculated Stresses (ksi) Designation	Value W[b]	3W	5W	Material Allowable (ksi) Sy[c]	S_{ult}[d]
17	Rotolock Stud ASTM A564 Type 630 17-4 pH H 1100	Tensile Stress @ Cross-Section	19.6	58.8	98.0	115	140
		Combined Shear Stress on Land Root	24.0	72.0	120.0		
		Bearing on Land Surfaces	18.9	56.7	94.5		
		Bearing on Stud Head	14.6	43.8	73.0		

(a) See figure 5-2 for location of item number 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)

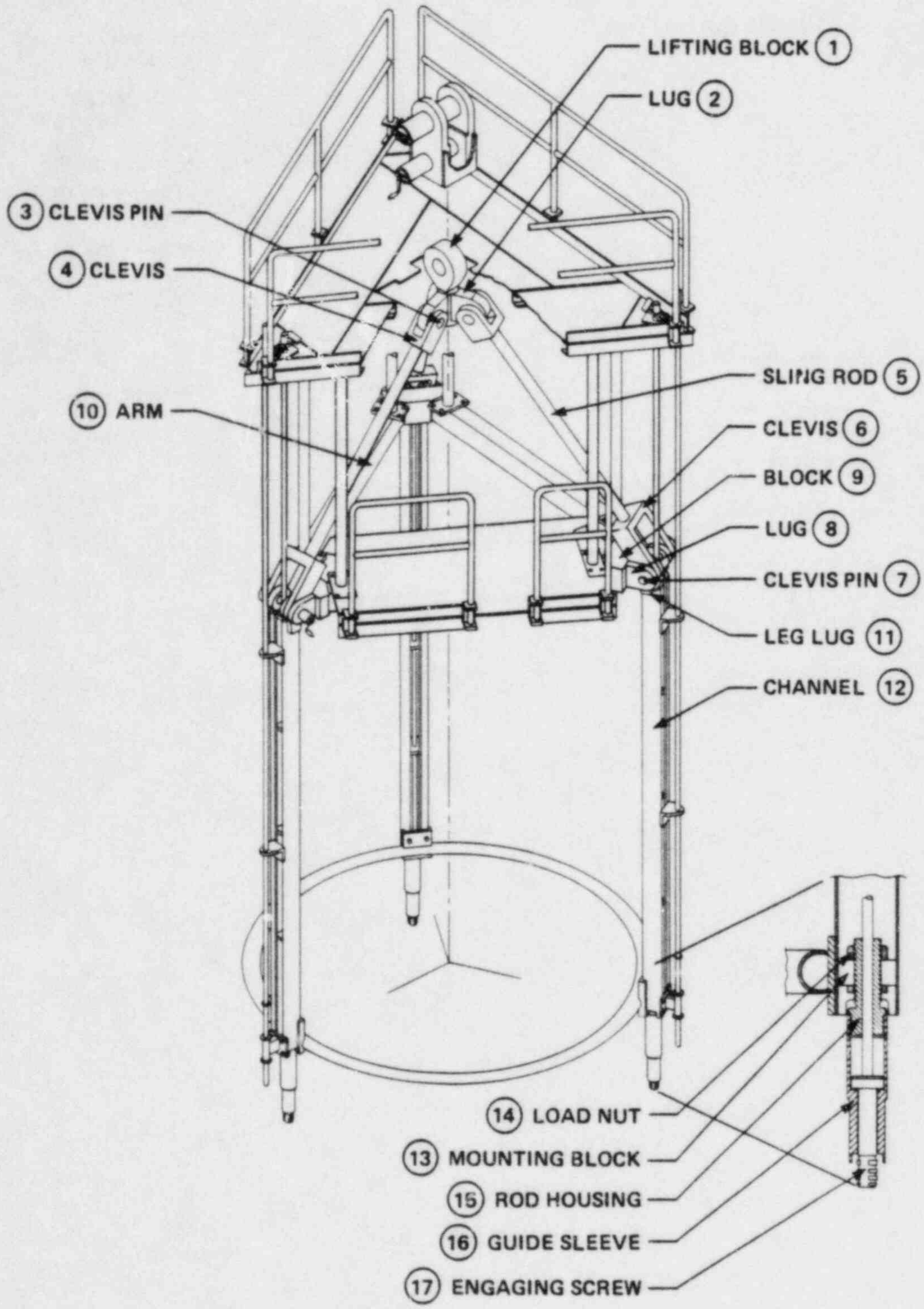


Figure 5-2. Reactor Vessel Internals Lift Rig

APPENDIX A

DETAILED STRESS ANALYSIS - REACTOR VESSEL HEAD LIFT RIG

This appendix provides the detailed stress analysis for the Millstone reactor vessel head lift rig in accordance with the requirements of ANSI N14.6. Accentance 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
NKVJ-188	Millstone, Unit 3	1 of 40

TITLE	CALCULATIONS NO.
R.V. Internals Lift Rig Stress Analysis	PDC-

AUTHOR & DATE	CHECKED BY & DATE
R. Blaushild R Blaushild 8.84.	J. W. Richard JW Richard 8/84

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 most stresses are within the allowable stresses.

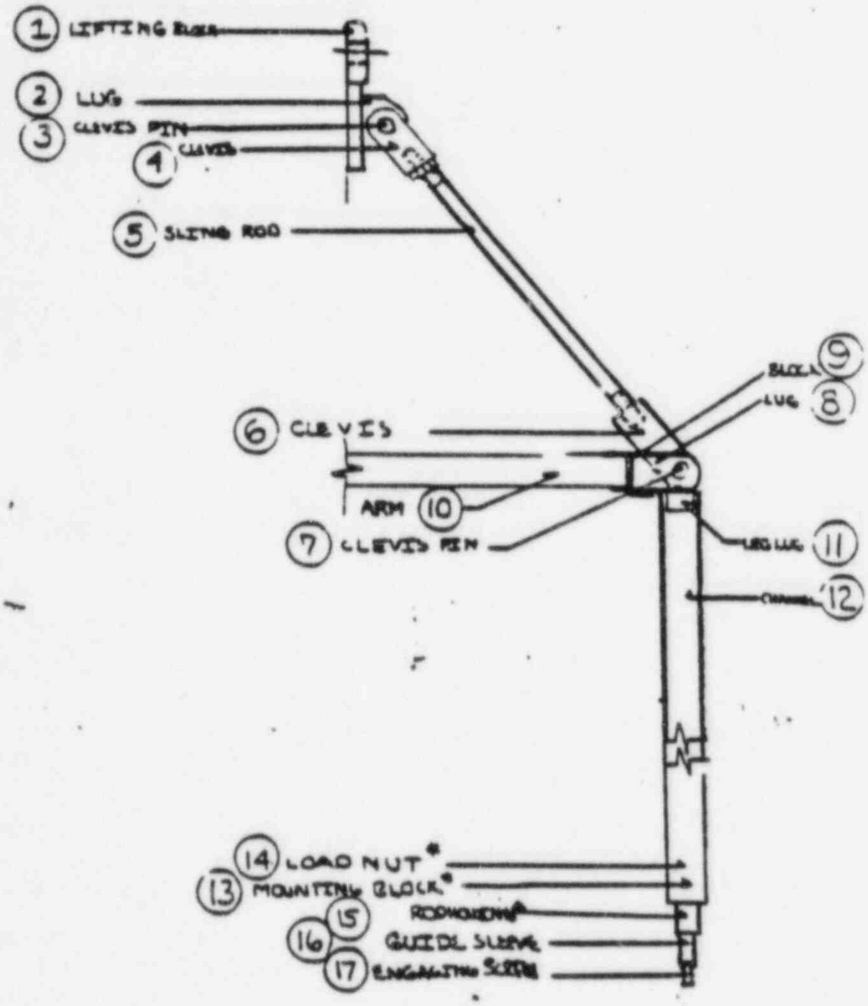
COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
JOSEPH W. RICHARD
ENGINEER
NO. 007167-E

Joseph W. Richard

REVISION NO.	DATE	DESCRIPTION	BY
		Original Issue	F.C.Peduzzi

RESULTING REPORTS, LETTERS OR MEMORANDA:

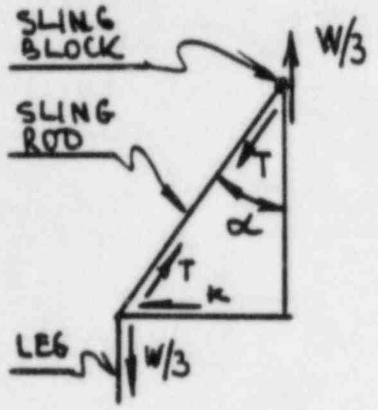
TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 2 OF 40
PROJECT NEU	AUTHOR R. Blanchfield DATE 6/12/84	CHK'D. BY Jw Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE



SEE DETAIL SKETCHES AT POINT OF ANALYSIS IN CALCULATIONS FOR DETAILS— THESE ITEM NUMBERS GIVE GENERAL LOCATION ON ASSEMBLY ONLY.

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 3 OF 40
PROJECT NEW	AUTHOR R. Blauschild DATE 6.84	CHK'D. BY J W Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE



W = 300 000 LB
(INCLUDS WEIGHT OF THE LOWER INTERNALS AND LIFTING RIG ASSEMBLY)

$\alpha = 37°12' = 37.2°$

$\cos\alpha = 0.796$

$\sin\alpha = 0.604$

$\tan\alpha = 0.759$

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

$T = 100\,000 / 0.796 = 125\,628$ LB

$K = T \cdot \sin\alpha = 75\,879$ LB

VARIABLES USED THROUGHOUT THESE CALCULATIONS

P – A SPECIFIC FORCE APPLYED TO THE MEMBER

f_t – TENSILE STRESS

f_c – COMPRESSION STRESS OR BEARING STRESS

f_b – BENDING STRESS

f_v – SHEAR STRESS

A – AREA

d – DIAMETER

I – MOMENT OF INERTIA

S – SECTIONAL MODULUS

b – BREADTH

h – HEIGHT

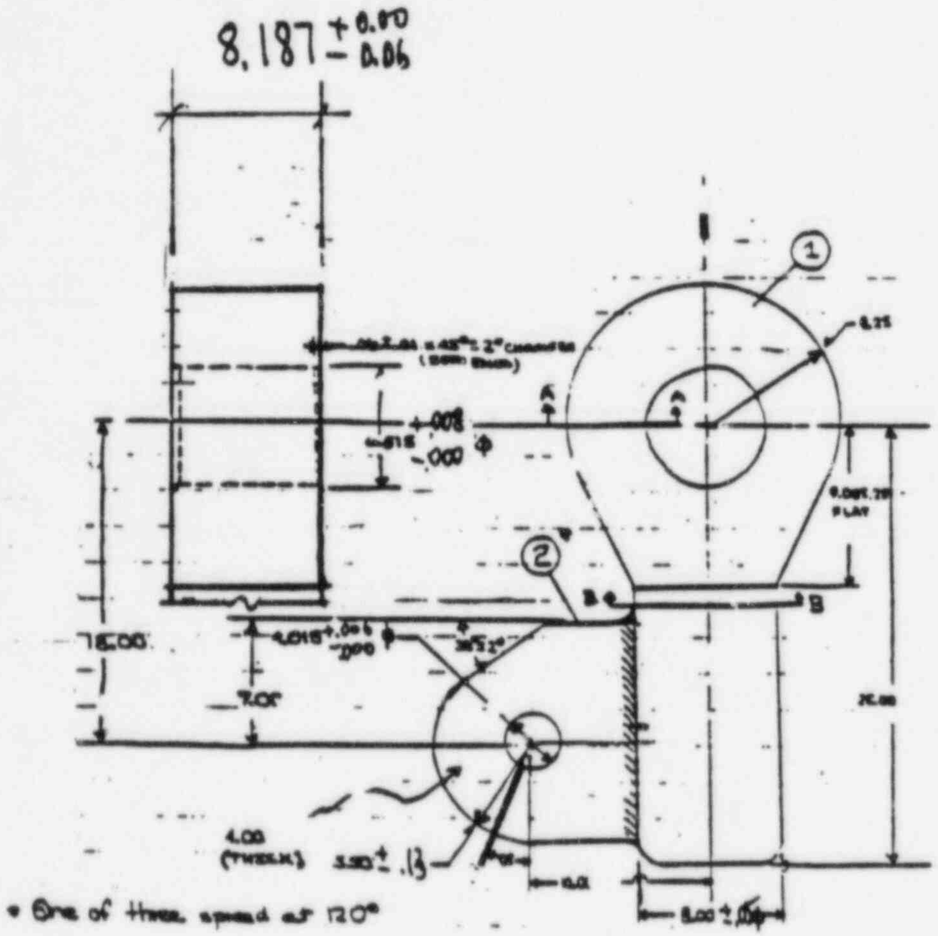
C – DISTANCE FROM NEUTRAL AXIS TO EXREME FIBER

M – MOMENT

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

TITLE INTERNAL LIFTING RIG STRESS ANALYSIS			PAGE 4 OF 40
PROJECT HEU	AUTHOR R.B. Blauschild DATE 6-84	CHK'D. BY J.W. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

SLING BLOCK ASSEMBLY (1) (2)



MAT'L - (1) ASTM A350 GR LF2
(2) ASTM A516 GR 70

EST. WT. - 940 LB

WELDS - E7018 ELECTRODES

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

TITLE		PAGE
INTERNAL LIFTING RIG STRESS ANALYSIS		5 OF 40
PROJECT NEU	AUTHOR R. Fairchild DATE 6.84	CHK'D. BY J. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP REE

LIFTING SLING BLOCK ①

TENSILE STRESSES @ SECTION A-A

$f_t = P/A_t$

$P = W/2$

$A_t = (8.00 - 6.523/2) \times 8.12 - (0.07)^2$

$= 38.48 \text{ IN}^2$

$f_t = 150\,000 / 38.48 =$

$= 3898 \text{ psi}$

BEARING STRESSES AT SECTION A-A

$f_c = P/A_c$

$P = W$

$A_c = dl = 6.515(8.12 - 2(.07))$

$= 52.76 \text{ IN}^2$

$f_c = 5686 \text{ psi}$

TEAR-OUT SHEAR AT 6.515 ∅ HOLE

$f_v = P/2A_v$

$P = W$

$A_v = 38.48 \text{ IN}^2$

$f_v = 3898 \text{ psi}$

TENSILE STRESS AT SECTION B-B

$f_t = P/A_t$

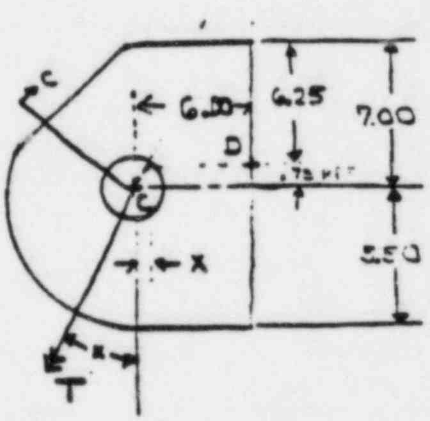
$P = W$

$A_t = \pi (7.95)^2/4 =$

$= 49.64 \text{ IN}^2$

$f_t = 6043 \text{ psi}$

LUG ②



TENSION STRESSES AT SEC. C-C

$T = 125\,628 \text{ LB}$

$f_t = P/A_t$

$P = T/2$

$A_t = \left((5.50 - 0.13) - \frac{4.27}{2}\right) \times 3.99 =$

$= 12.90 \text{ IN}^2$

$f_t = 4870 \text{ psi}$

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

TITLE INTERNAL LIFTING RIG STRESS ANALYSIS			PAGE 6 OF 40
PROJECT NEU	AUTHOR R.Blankenship 6-84	CHK'D. BY [signature] 8/84	CHK'D. BY / DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

BEARING AT 4.015Ø HOLE

$f_c = P/A_c$

$P = T$

$A_c = dl = 4.015 \times 3.99 =$

$= 16.020 \text{ IN}^2$

$f_c = 7842 \text{ psi}$

TEAR-OUT SHEAR AT 4.015Ø HOLE

$f_v = P/2A_v$

$P = T$

$A_v = \left(5.37 - \frac{4.021}{2}\right) \times 4.00 =$

$= 13.438 \text{ IN}^2$

$f_v = 4674 \text{ psi}$

STRESS AT LUG ROOT

1) BENDING

$\alpha = 37.2°$

$x = 0.75 \tan\alpha = 0.569$

$M = T\cos\alpha(6.00 - 0.569) =$

$= 4.323T \text{ IN-LB}$

$C_{MAX} = 6.25$

$I = bh^3/12 =$

$= 4.00(12.5)^3/12$

$= 651.0 \text{ IN}^4$

$f_b = Mc/I =$

$= 4.323T(6.25)/651.0 =$

$= 5214 \text{ psi}$

2) TENSILE AT LUG ROOT

$f_t = P/A_t$

$P = T \cdot \sin\alpha$

$A_t = bh =$

$= 4.00(7.00 + 5.5) =$

$= 50 \text{ IN}^2$

$f_t = T\sin\alpha/50 =$

$= 1516 \text{ psi}$

$f_b + f_t = 6732 \text{ psi}$

SHEAR AT LUG ROOT

$f_v = P/A_v$

$P = T\cos\alpha$

$A_v = bh = 50.0 \text{ IN}^2$

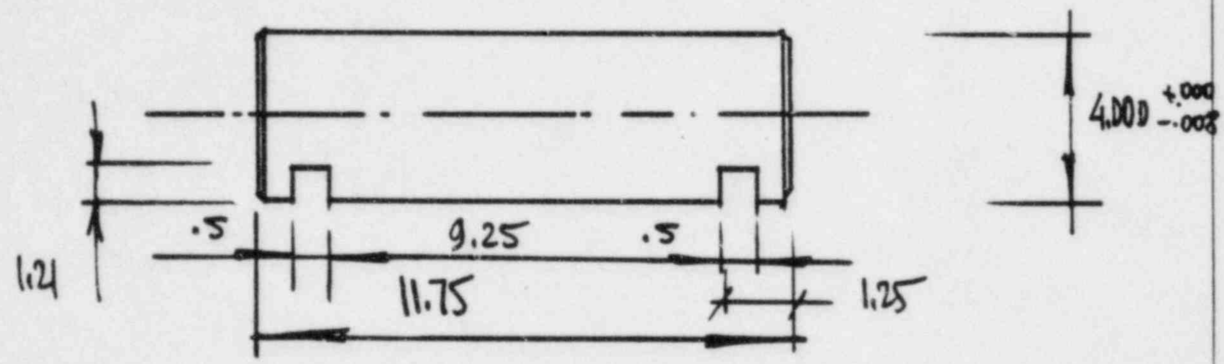
$f_v = T\cos\alpha/50 =$

$= 2000 \text{ psi}$

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

TITLE INTERNAL LIFTING RIG STRESS ANALYSIS			PAGE 7 OF 40
PROJECT NEU	AUTHOR R. Blaufuhild DATE 6/28	CHK'D. BY JWRichard DATE 8/8	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

CLEVIS PIN (3)



MAT'L'S ASTM A564 TYPE 630 PRECIPITATION HARDENING STAINLESS STEEL, AGE HARDENING AT 1150°F FOR 4 HOURS, AIR COOLED.
MIN. TENS STRENGTH S_t = 135.0 ksi
R_c = 28-31. EST. WEIGHT = 45 LB.

KEEPER PLATE THICKNESS = 0.375 IN.

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 8 OF 40
PROJECT NEU	AUTHOR R. Blanschild DATE 6.84	CHK'D. BY J. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

CLEVIS PIN (3)

SHEAR

$f_v = P/A_v$

$P = T/2$

$A_v = 3.992^2 \pi/4 = 12.57 \text{ in}^2$

$f_v = 4997$ psi

BEARING

$f_c = P/A_c$

$P_1 = T/2$

$A_c = ((9.25 - 4.26)/2 - 0.09) \times 3.992$

$= 9.62 \text{ in}^2$

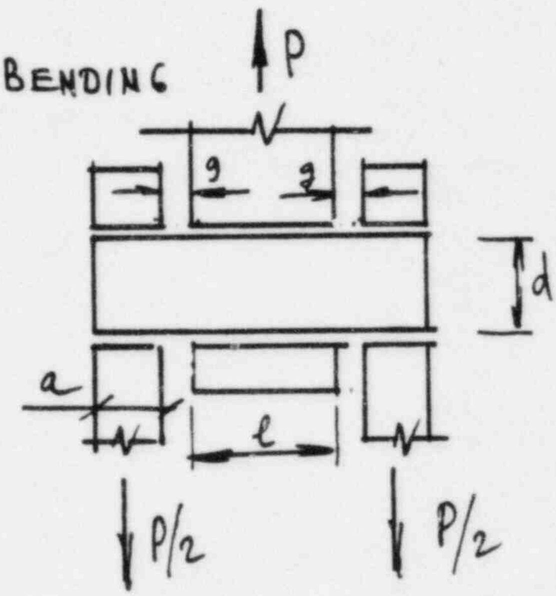
$f_{c1} = 6529$ psi

$P_2 = T$

$A_{c2} = 4.00 \times 4.00 = 16.00 \text{ in}^2$

$f_{c2} = T/16 = 7852$ psi

BENDING



$l = 4.00$

$a = (9.25 - 4.26)/2 = 2.49$

$g = (4.266 - 4.00)/2 = 0.133$

$d = 3.992$

$P = T$

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

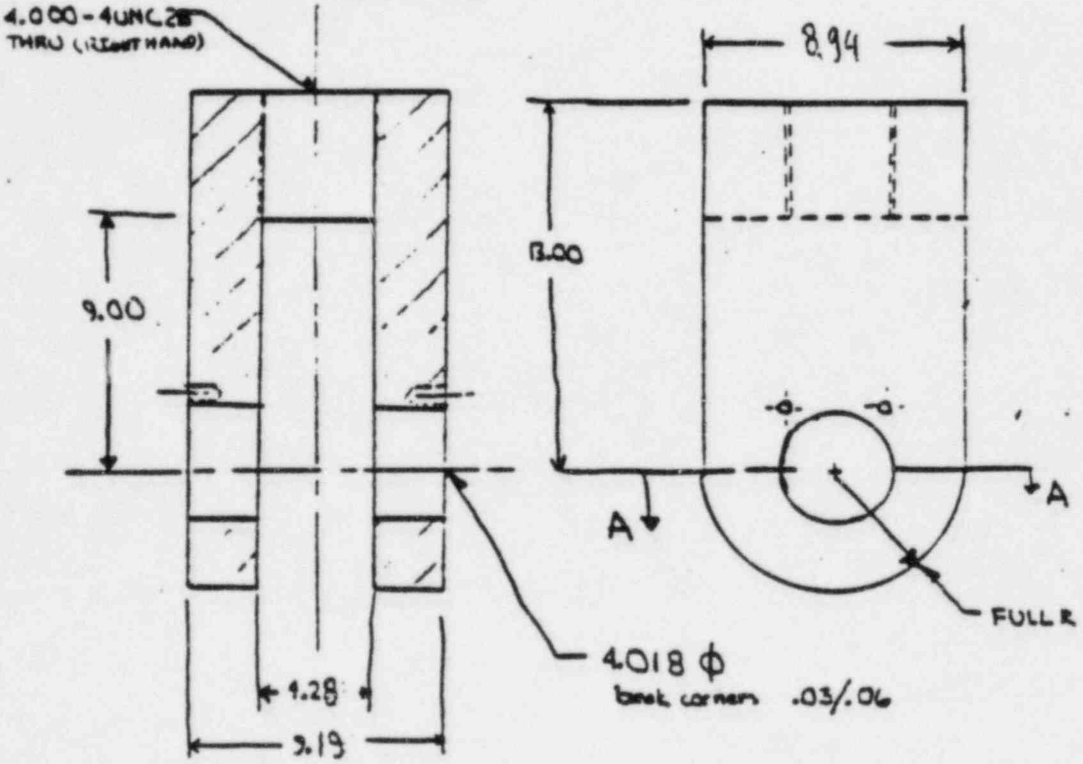
$= 23916$ psi

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 9 OF 40
PROJECT NEU	AUTHOR R.Blauzhild DATE 6.84	CHK'D. BY jw Rickard DATE 8/84	CHK'D. BY DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP REE

CLEVIS (4)

MAT'L ASTM A471 STEEL FORGING CLASS 3
EST WT 206 LB



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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 10 OF 40	
PROJECT NEU	AUTHOR R. Blaustylal	DATE 6/28	CHK'D. BY J. W. Richard	DATE 8/84	CHK'D. BY	DATE
S.O. NKVJ-188	CALC. NO.		FILE NO.		GROUP REE	

CLEVIS ④

TENSION STRESSES AT A-A:

$f_t = P/A_t$

$P = T/4$

$T = 125628$ LB

$A_t = ((8.94 - 4.018)/2) \times$
$\times (9.19 - 4.28)/2 - 0.045^2 =$
$= 6.04$ IN^2

$f_t = 5200$ psi

BEARING STRESS AT SEC. A-A:

$f_c = P/A_c$

$P = T/2$

$A_c = ((9.19 - 4.28)/2 - 0.045) \times$
$\times 4.018 = 9.68$ IN^2

$f_c = 6486$ psi

SHEAR TEAR-OUT

$f_v = P/2A_v$

$P = T/2$

$A_v = 6.04$ IN^2

$f_v = 5200$ psi

THREAD SHEAR

$f_v = P/A_v$

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

FOR 4.000-4UNC 2B

$D_{pitch} = 3.8376$ IN

$A_v = \pi(3.8376)(13-9)/2 =$
$= 24.112$ IN^2

$P = T$

$f_v = 5210$ psi

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

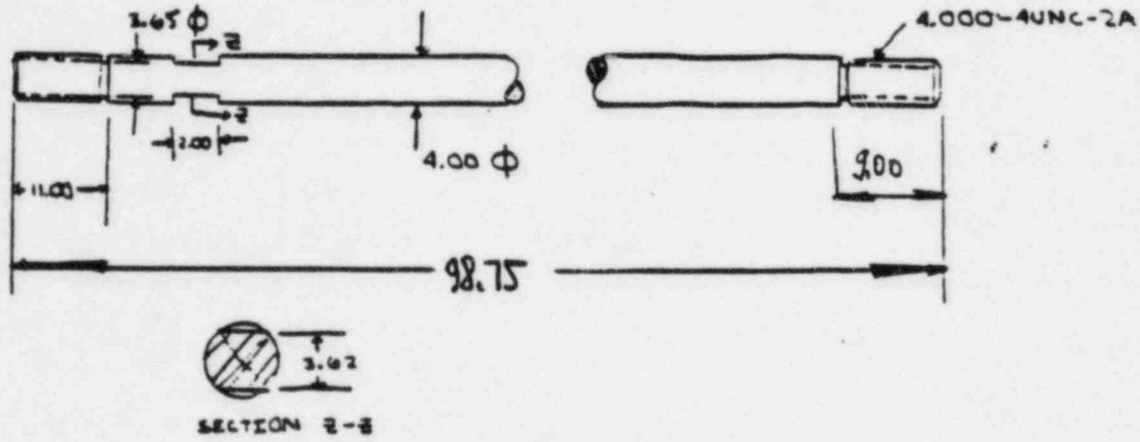
TITLE INTERNALS LIFTING RIG STRESS ANALYSIS		PAGE 11 OF 40	
PROJECT NEU	AUTHOR R Blankenship DATE	CHK'D. BY JW Richard DATE	CHK'D. BY DATE
S.O. NKWJ-188	CALC. NO.	FILE NO.	GROUP REE

SLING ROD

(5)

MAT'L - ASTM-A434 CLASS BC AISI 4340 STEEL. TURNED, GROUND, & POLISHED. MINIMUM YIELD STRENGTH 85,000 PSI;

EST WT - 320 LB



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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE: INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 12 OF 40
PROJECT: NEU	AUTHOR: R. Blauschild DATE: 6.28.84	CHK'D. BY: J. Rinehart DATE: 8/84	CHK'D. BY / DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

SLING ROD (5)

THREAD SHEAR

$f_v = P/A_v$

$P = T$

$A_v = \pi D_{pitch}\, \ell/2$

$D_{pitch} = 3.8376$

$\ell = 13-9 = 4$ IN

$A_v = 24.112$ IN^2

$f_v = 5210$ psi

TENSION AT THREAD RELIEF:

$f_t = P/A_t$

$P = T$

$A_t = (3.65)^2 \pi/4 = 10.463$ IN^2

$f_t = 12006$ psi

TENSION AT THREAD:

$f_t = P/A_t$

$P = T$

$A_t = 11.0805$ IN^2

$f_t = 11337$ psi

AREA AT Z-Z

$A_{zz} = \pi(4.00)^2/4 - 2A_s$

$\frac{3.62}{2} = 1.81$  $2 = \frac{4.00}{2}$ $\alpha = 25.177°$

$(2^2 - 1.81^2)^{1/2} = 0.8508$

$A_s = \frac{2(25.18)}{360}\left(\frac{\pi}{4}\right) \times 4^2 - [.8508(1.81)/2] \times 2$

$= 1.758 - 1.540 = 0.2179$ IN^2

$A_{zz} = 12.13$ IN^2

$A_{zz} > A_{THREAD\ RELIEF}$

$\therefore f_{t_{zz}} < f_{t\ THREAD\ RELIEF}$

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

WESTINGHOUSE FORM 55213D

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 13 OF 40
PROJECT NEU	AUTHOR R. Blauschild DATE 6/18/84	CHK'D. BY J W Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-138	CALC. NO.	FILE NO.	GROUP REE

THE SPREADER JOINT CONSISTS OF:

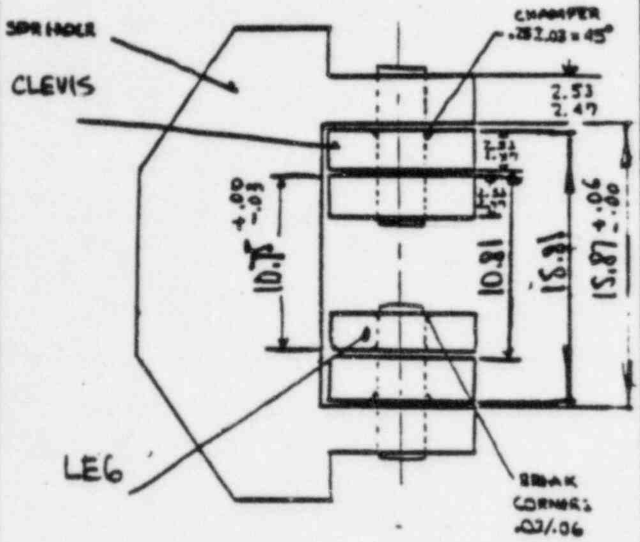
(6) - THE CLEVIS
(7) - THE CLEVIS PIN
(8) - THE SPREADER BLOCK LUG
(9) - THE LEG LUG

THE BEARING STRESSES ACTING BETWEEN THESE ITEMS ARE CALCULATED ON THE FOLLOWING THREE PAGES, ENTITLED THE SPREADER JOINT. THE RESULTING MOMENTS, FORCES AND STRESS DISTRIBUTIONS ARE THEN USED AS INPUTS TO DETERMINE THE LISTED ITEMS STRESSES IN THE FOLLOWING CALCULATIONS ON THESE ITEMS.

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

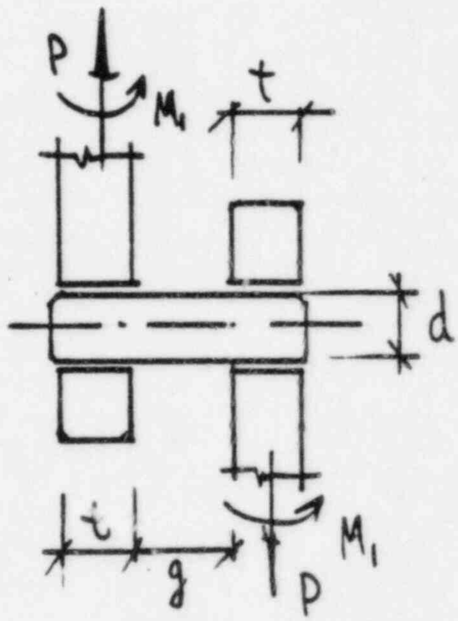
TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 14 OF 40
PROJECT NEU	AUTHOR R.Blaustein DATE 6.78	CHK'D. BY J.W. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

SPREADER JOINT



W = WEIGHT TO BE LIFTED = 300 000 LB
T = FORCE ON CLEVIS = 125628 LB
K = FORCE ON SPREADER = 75879 LB
L = FORCE ON LEG = 100 000 LB

THE DISTRIBUTION OF THE BEARING STRESS BETWEEN LUG AND PIN IS ASSUMED TO BE SIMILAR TO THE STRESS DISTRIBUTION THAT WOULD BE OBTAINED IN A RECTANGULAR CROSS-SECTION OF WIDTH d AND DEPTH t SUBJECTED TO A LOAD P AND MOMENT M.

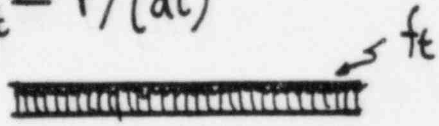


ONLY TWO LUGS ARE NEEDED IN THE MODEL AS THE LEG CARRIES ONLY VERTICAL FORCES.

THE CLEVIS HAS ONLY HORIZONTAL AND VERTICAL COMPONENTS ACTING ON IT SO THE STRESSES WILL BE SUPERIMPOSED FOR THE CLEVIS.

THE STRESS DUE TO THE FORCE P would be

$$f_t = P/(dt)$$



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

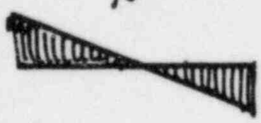
WESTINGHOUSE FORM 55213D

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 15 OF 40
PROJECT NEU	AUTHOR R. Blauschild DATE 6.84	CHK'D. BY [signature] DATE 8/84	CHK'D. BY DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP REE

SPREADER JOINT

THE STRESSES DUE TO THE MOMENT M WOULD BE

$f_b = Mc/I$



$f_{max} = P/dt + Mc/I$

FOR A RECTANGULAR SECTION

$I_x = bh^3/12$

$c = h/2$

$f_{max} = P/dt + 6M/dt^2$

THE MOMENT PRODUCED BY THE JOINT WILL BE

$M_{TOTAL} = P(t+g)$

DIVIDING THE JOINT MOMENT BETWEEN THE TWO ENDS:

$M = (P/2)(t+g)$

LEG MOMENT

IN THE VERTICAL PLANE

$M_{LEG} = (100000/2)\left(\frac{1}{2}\right)(2.44+0) = 61000$ IN-LB

IN THE HORIZONTAL PLANE

$M_{SPREADER} = (75879/2)\left(\frac{1}{2}\right)(2.47+0.0) = 46855$ IN-LB

THE COMBINED EFFECTS OF THE HORIZONTAL (SPREADER) AND VERTICAL (LEG) MOMENTS ACTING ON THE SLING LEG LUG ARE OBTAINED USING THE METHOD OF SEC. 10-11, PAGE 336 OF E.P. POPOV'S MECHANICS OF MATERIAL, 2nd EDITION:

CLEVIS MOMENT

$\sqrt{61000^2 + 46855^2} = 76918$ IN-LB

THE BEARING COMPONENT DUE TO THE MOMENT IS

$f_b = 6M/dt^2$ WERE M IS GIVEN ABOVE.

CLEVIS: $d_{pin} = 3.997"$ $t_{min} = 2.47 - 2(.06) = 2$

LEG: $d_{pin} = 3.997$; $t = 2.44 - (.28) = 2.16"$

Spreader $d_{pin} = 3.997$, $t = 2.47$ in

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 16 OF 40
PROJECT NEU	AUTHOR R. Blauschild DATE 6.84	CHK'D. BY J. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP REE

SPREADER JOINT

THE COMBINED BEARING STRESSES ARE

$$f_{max} = f_b + f_t$$

CLEVIS:

$$P/dt + 6M/dt^2$$

$$\left(\frac{125628}{2}\right)/(3.997*2.35) + 6(76918)/(3.997\times2.35^2)$$

$$f_b = 27595 \text{ psi}$$

SPREADER:

$$\left(\frac{75879}{2}\right)/(3.997*2.47) + 6(46855)/(3.997*2.47^2)$$

$$f_b = 15371 \text{ psi}$$

LEG:

$$f_b = \left(\frac{300000}{2\times3}\right)/(3.997*2.16) + 6(61000)/(3.997\times2.16^2)$$

$$f_b = 25418 \text{ psi}$$

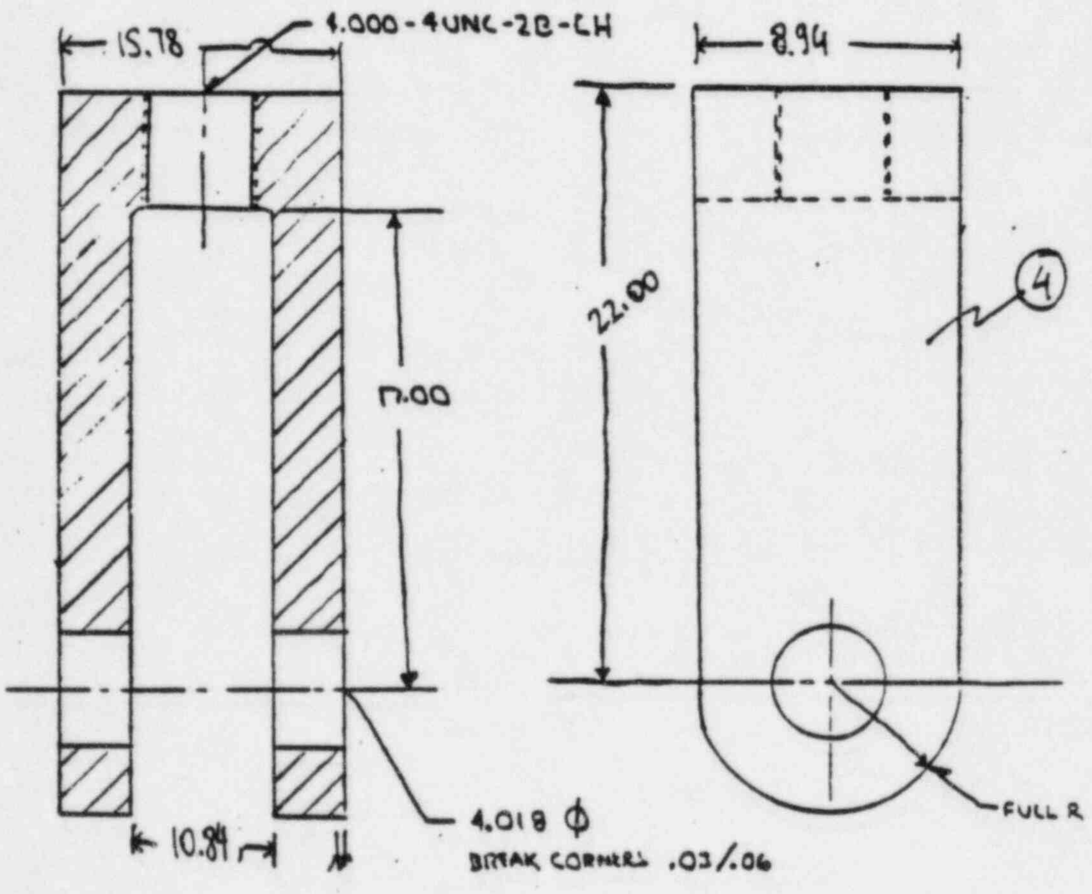
REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

WESTINGHOUSE FORM 55213D

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ANALYSIS			17 OF 40
PROJECT NEU	AUTHOR R. Blaughlin [illegible] DATE	CHK'D. BY J. Richard DATE 9/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

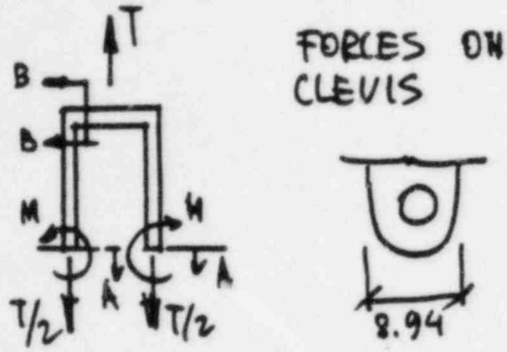
CLEVIS ⑥

MAT'L – ASTM A471 STEEL FORGING CLASS 3
EST. WT – 482 LB.



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

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ANALYSIS			18 OF 40
PROJECT: NEW	AUTHOR: R.B. Laughlin, DATE: 6.84	CHK'D. BY: [signature], DATE: 8/84	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE



FROM BEARING STRESS CALCS

$M_{max} = 113589$ IN-LB

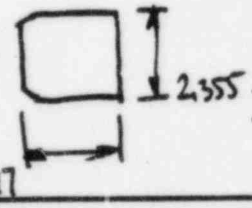
$T = 125628$ LB

BENDING STRESS AT A-A

$f_b = Mc/I$

$M = 113589$ IN-LB

$c = (15.78 - 10.84)/2/2 = 1.235$ IN

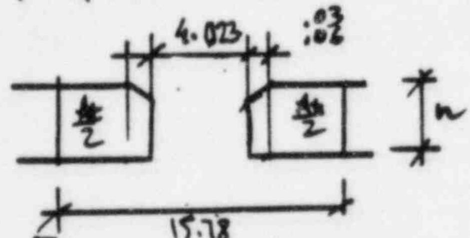


$I = 2.47 \times 2.355^3/12 = 2.688$ IN^4

TENSION STRESS AT SEC. A-A

$f_t = P/A_t$

$P = T/2 = 125628 = 62814$ LB



$n = [(15.78) - (10.84)]/2 = 2.47$

$A_t = [8.94 - 4.023] \times [2.47] - 0.06^2 \times 2 = 12.138$ IN^2

$f_t = 62814 / 12.138 = 5175.0$ psi

$f_b = 113589 \times 1.235 / 2.688 / 2 = 26094$ psi

COMBINED MAX. BENDING AND TENSILE AT SEC. A-A

$f_{comb} = f_b + f_t = 26094 + 5175 = 31269$ psi

THREAD SHEAR

$f_v = P/A_v$

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

$l_{min} = 21.94 - 17.06 = 4.88$

FOR 4.000-4UNC-20

$D_{pitch} = 3.8376$

$A_v = 29.42$ in^2

$P = T = 125628$ LB

$f_v = 4270$ psi

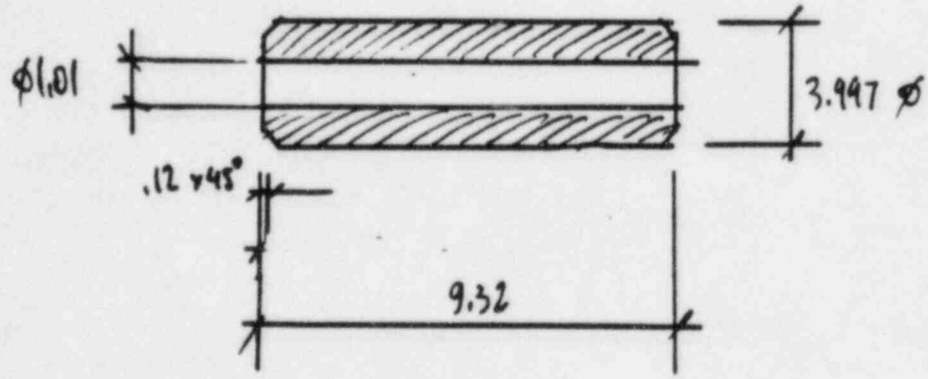
REV. NO.	REV. DATE	AUTHOR	DATE	CHK'D. BY	DATE	CHK'D. BY	DATE

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 19 OF 40
PROJECT NEU	AUTHOR R. Blaumshield 6/84	CHK'D. BY J. Richard 8/84	CHK'D. BY DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP REE

CLEVIS PIN (7)

MAT'L - ASTM A 564 TYPE 630 PRECIPITATION HARDENING STAINLESS STEEL, AGE TREAT AT 1150°F FOR 4 HRS AIR COOLED, 135000 PSI MIN TENSILE STRENGTH $R_c = 28-31$.

EST WT 32 LB

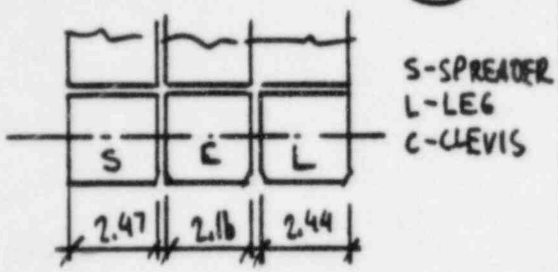


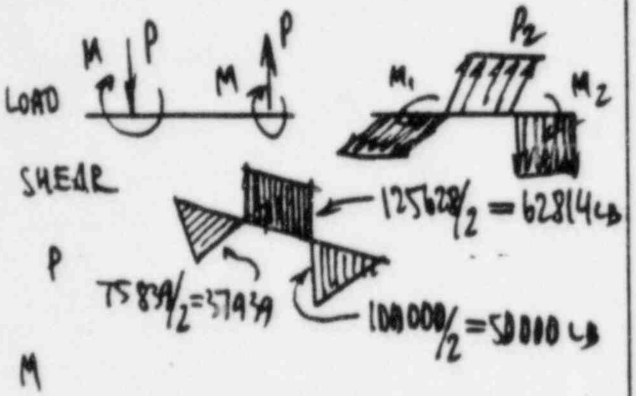
REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 20 OF 40
PROJECT NEU	AUTHOR R. Blanchfield DATE 6. 84	CHK'D. BY J. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

(07)

PIN





FOR THE SPREADER-CLEVIS FORCE PLANE

M = 46855 LB

FOR THE LEG-CLEVIS FORCE PLANE

M = 62500 IN-LB

COMBINED MOMENTS OF THE CLEVIS

M = 77514 IN-LB

SHEAR STRESSES

$f_v = P/A_v$

$A_v = \pi(3.997^2 - 1.01^2)/4 = 11.746$

$D = K/2$

$f_v = (125628/2)/11.746 = 5347$ psi

BY SIMILIAR ANALYSIS

FOR THE LEG-CLEVIS PLANE

$f_v = 300000/3/2/11.746$

$= 4257$ psi

$M_{max} = 62500$ IN-LB

COMBINED STRESSES DUE TO MOMENT AND SHEAR:

FOR THE CLEVIS

$M_{max} = 77514$ IN-LB

$C = d/2 = 3.997/2 = 1.998$ IN

$I = \frac{\pi}{64}(3.997^4 - 1.01^4) = 12.477$ IN

$f_{b\,max} = Mc/I = 77514 \times 1.998/12.477 =$

$= 12412$ psi

$f_{v\,max} = \sqrt{5347^2 + 4257^2} =$

$= 6835$ psi

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 21 OF 40
PROJECT NEU	AUTHOR [signature] DATE 6-84	CHK'D. BY [signature] DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP PEE

THE BENDING STRESS IS CONSERVATIVE IN THAT THE OTHER LUGS (SPREADER AND LEG) WILL CARRY SOME OF THE MOMENT; AND THE LUGS WOULD PROVIDE SUPPORT PREVENTING LARGE DEFLECTION.

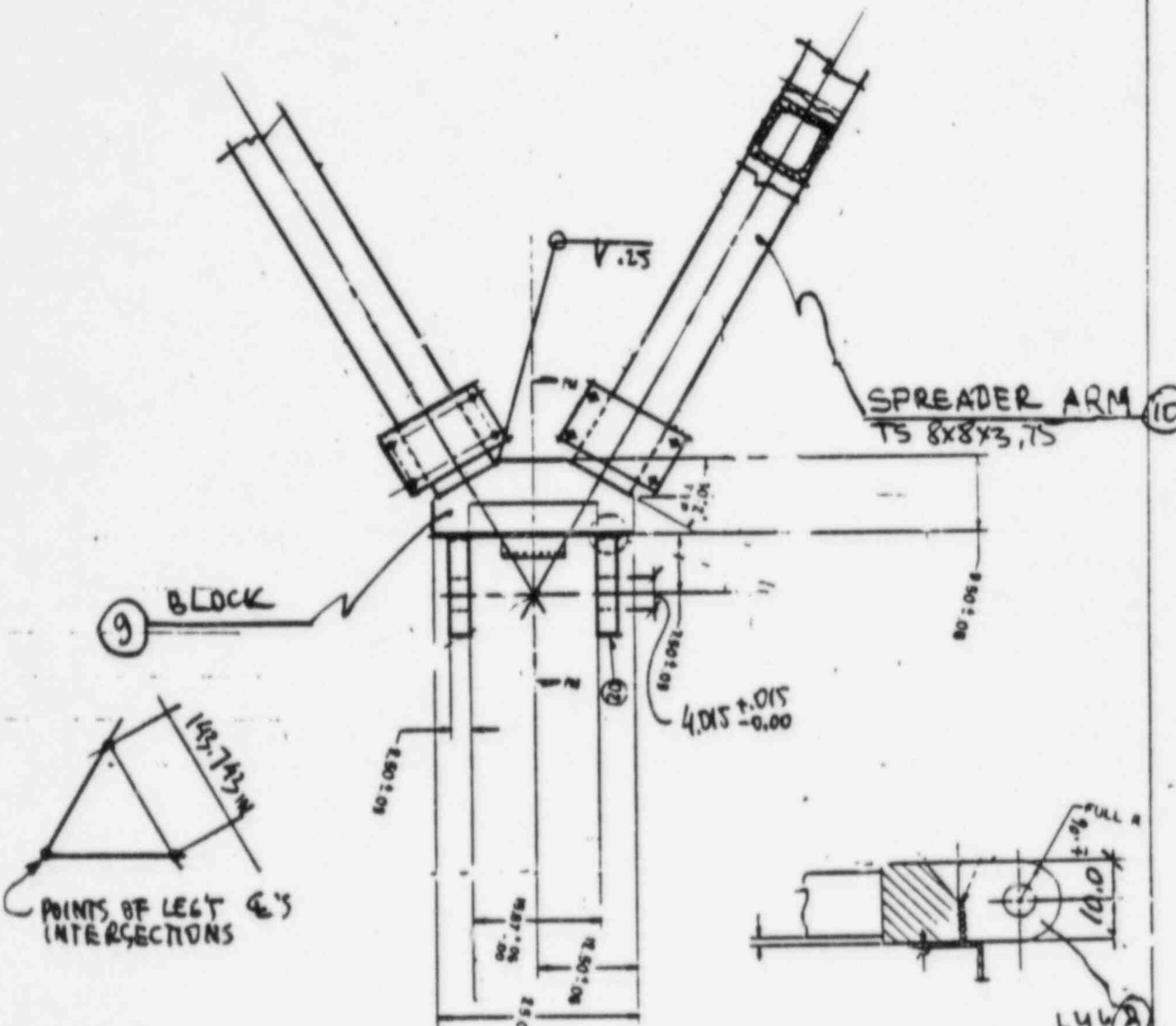
THE MAXIMUM BEARING STRESS WOULD BE THE SAME AS THE MAXIMUM LUG BEARING STRESS

$f_c = 27595$ psi

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 22 OF 40
PROJECT NEU	AUTHOR R.Hausleyld DATE 6.84	CHK'D. BY JWBirkhard DATE 8/84	CHK'D. BY DATE
S.O. NKWJ-188	CALC. NO.	FILE NO.	GROUP REE

SPREADER ASSEMBLY (8)(9)(10)



MAT'L:

LUG: ASTM A-516 GR.70 STL PLATE, NORMALIZED OR ASTM A532 GR.A

SPREADER ARM: ASTM A-500 GR.B

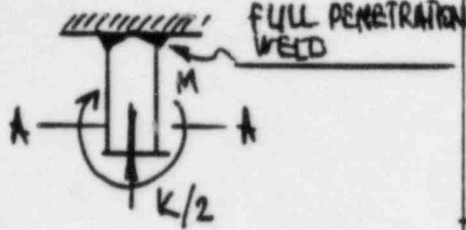
BLOCK: ASTM A-350 LF1 FORGING STL.

WELD: E7018 ELECTRODES

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 23 OF 40
PROJECT NEU	AUTHOR R.Blaushild DATE 6.84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

SPREADER LUG (B)



$M_{MAX} = 46855$ IN-LB
$K = 75879$ LB

TENSILE AT A-A

$f_t = P/A_t$

$A_t = (9.94 - 4.030) \times 2.47 =$
$= 14.598\ IN^2$

$P = K/2 = 37939$ LB

$f_t = 37939 / 14.598 =$
$= 2599$ psi

BENDING AT A-A

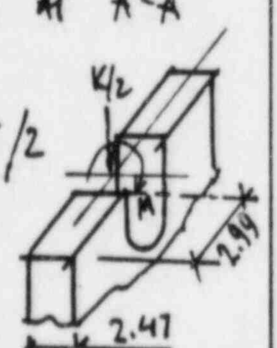
$f_b = Mc/I$

$M = 46855/2$

$c = 2.47/2 = 1.235$

$I = 2.94 \times 2.47^3/12 =$
$= 3.742\ IN^4$

$f_b = 23427 \times 1.235 / 3.742 = 7732.0$ psi



COMBINED TENSILE AND MAXIMUM BENDING

$f_{comb} = f_b + f_t =$
$= 7732 + 2599 = 10331$ psi

BEARING STRESS

CALCULATED AT SPREADER JOINT BEARING STRESS CALCULATIONS

$f_c = 15371$ psi

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

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ANALYSIS			24 OF 40
PROJECT: NEU	AUTHOR: R. Blaushild DATE: 6/28	CHK'D. BY: J. Richard DATE: 6/28	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

SPREADER ARM (10)

FROM AISC MANUAL OF STEEL CONSTRUCTION

7^{TH} ED P3-48

ASSUMING $L = 143.743$

AND $K_\ell' = 1$

K_ℓ - EFFECTIVE LENGTH FACTOR

EFFECTIVE LENGTH $\simeq$ 12 FT

$P_{ALLOWABLE}$ 248 000 LBS

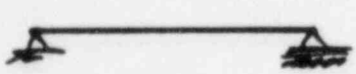
AREA = $10.8\ IN^2$

$I = 102\ IN^4$

$r = 3.06\ IN$

(ASSUMED A PIN CONNECTION).

P5-138 $K_\ell = 1.0$



$f_{ALLOWABLE} =$
$= 248000/10.8 =$
$= 22963$ psi

COMPRESSIVE STRESS IN SPREADER ARM

$f_c = P/A_c$

$P = S = (K/2)/\cos 30^\circ =$
$= (75879/2)/0.866 =$
$= 43809$ LB

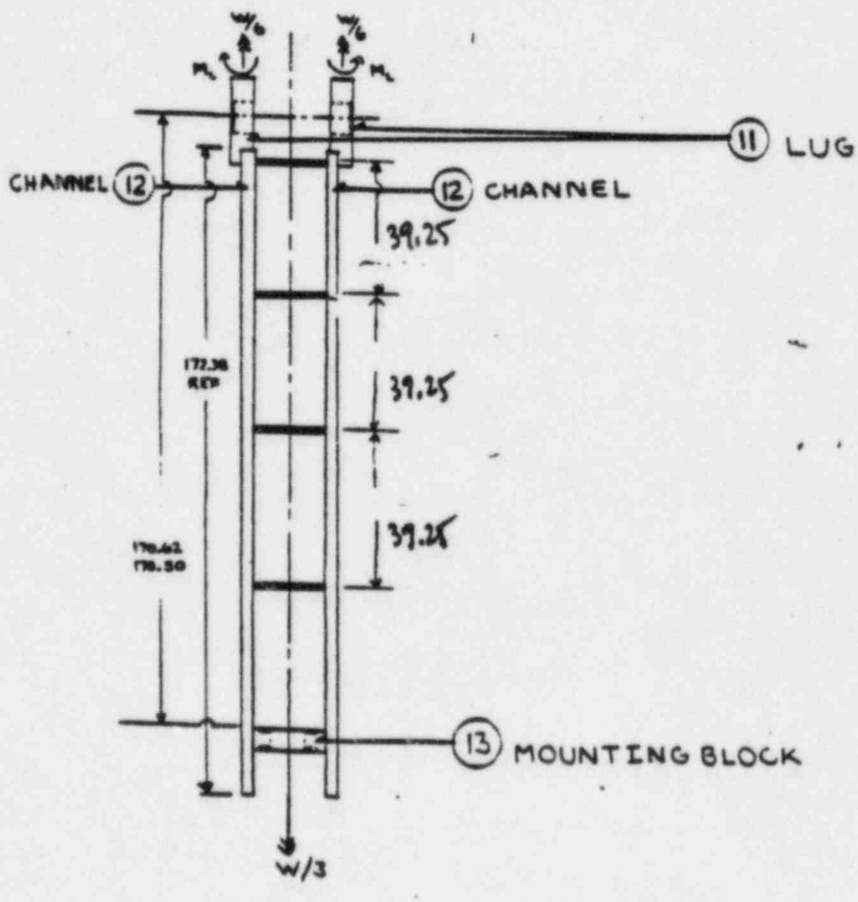
$A_c = 10.8\ IN^2$

$f_c = 43809/10.8 = 4056$ psi

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 25 OF 40
PROJECT NEU	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

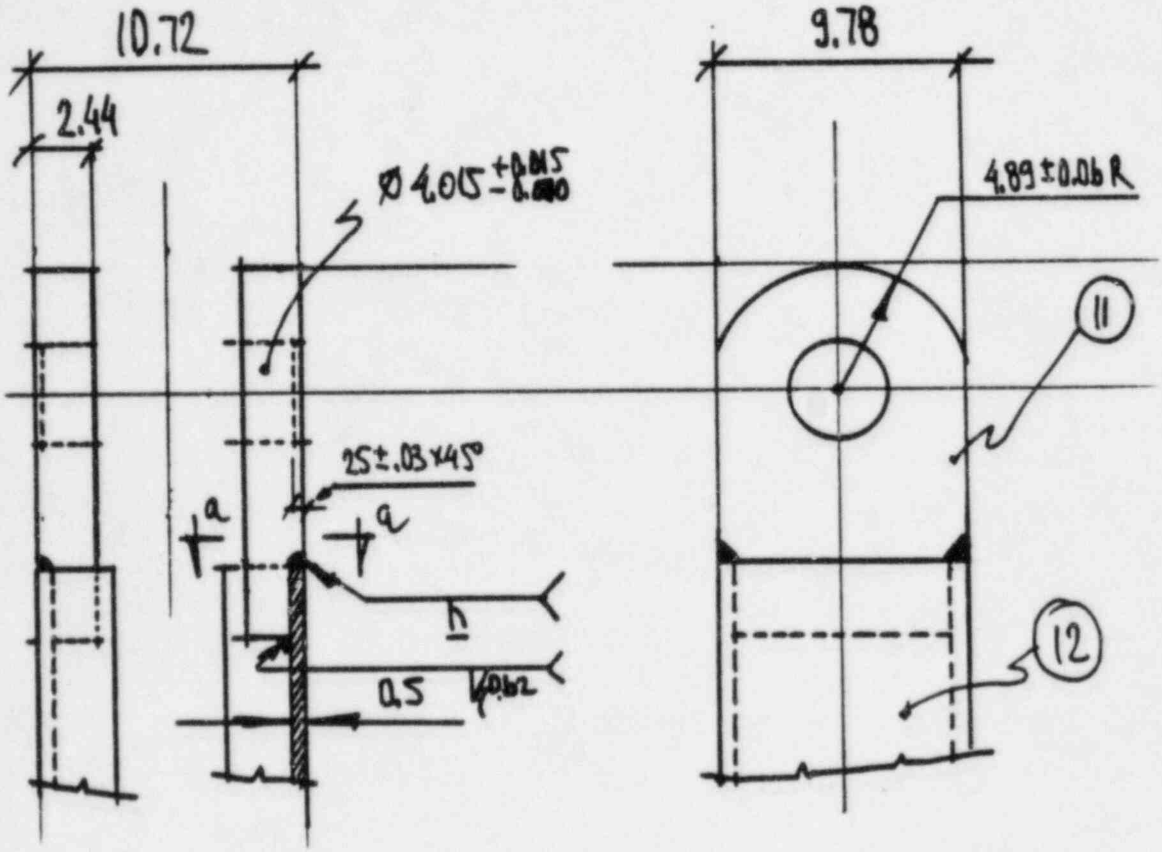
LIFTING RIG LEG ASSEMBLY (11)(12)(13)



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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 26 OF 40
PROJECT NEU	AUTHOR R. Blauschild DATE 6.28	CHK'D. BY J. Brickhart DATE 8/82	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

LIFTING RIG LEG DETAILS (11) (12) (13)



MAT'L: (11) LUG - ASTM A-516 GR70, NORMALIZED
(12) CHANNELS - ASTM A-36 CS, HR

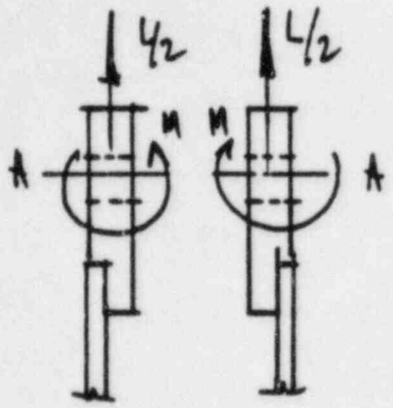
NOTE: SECTION a-a SEE ON PAGE 28

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 27 OF 40
PROJECT NEU	AUTHOR [signature] DATE 6.84	CHK'D. BY [signature] DATE 8/84	CHK'D. BY DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP REE

LEG. LUG (11)



$M = 62500$ IN-LB
$L = 100\,000$ LB

TENSILE AT A-A:

$f_t = P/A_t$
$P = L/2 = 50\,000$ LB
$\frac{1}{2} A_t = 2.44 \times (9.66 - 4.03) - 0.28^2 = 13.658 \text{ IN}^2$

$f_t = 50000/13.658 =$
$= 3661$ psi

BENDING AT A-A

$f_b = Mc/I$

$M = 62500/2 = 31250$ IN-LB
$c = 2.44/2 = 1.22$
$I = ((9.66 - 4.03)/2) \times 2.44^3/12 =$
$= 3.41 \text{ IN}^4$

$f_b = 31250 \times 1.22 / 3.41 =$
$= 11188$ psi

COMBINED MAX BENDING AND TENSILE AT A-A:

$f_{COMB} = 3661 + 11188 =$
$= 14849$ psi

BEARING
(THE SAME AS FOR SPREADER JOINT)
$f_c = 25418$ psi

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

WESTINGHOUSE FORM 56213D

TITLE	INTERNALS LIFTING RIG STRESS ANALYSIS		PAGE 28 OF 40
PROJECT: HEU	AUTHOR: R. Blaustein, DATE 6.7.84	CHK'D. BY: [illegible], DATE	CHK'D. BY, DATE
S.O.: NKUJ-188	CALC. NO.	FILE NO.	GROUP: REE

LEG LUG WELD

For $t_w = 0.5$:

$l_w = 2\times 2.44 + (9.72 - 2\times 0.5) = 13.6$ IN

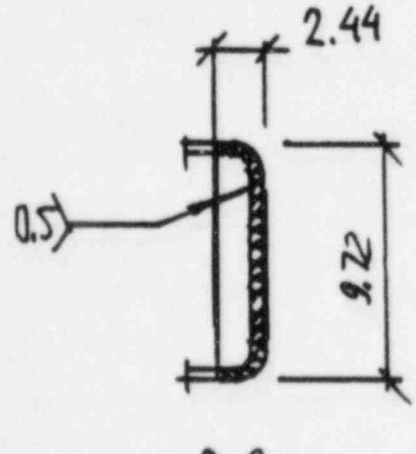
For $t_w = 0.62$:

$l_w = 8.72 + 2\times(2.44 - 0.5) = 12.6$ IN

$A_w = 13.6\times 0.5 + 12.6\times 0.62\times 0.707 =$
$= 12.32\ IN^2$

TENSION STRESS IN WELD:

$f_t = P/A_w = (L/2)/A_w =$
$= 50000/12.32 =$
$= 4057$ psi



a-a
(SEE PAGE 26)

REFERENCE:
LINCOLN ELECTRIC CO.
SOLUTION TO DESIGN OF WELDMENTS
D 910.17 PAGE 3
E-70-18 ELECTRODES

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 29 OF 40
PROJECT NEU	AUTHOR R. Blausfield DATE 7/84	CHK'D. BY [signature] DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

LEGS ⑫

CROSS-SECTIONAL AREA OF LEG CHANNELS (SEE MOUNTING BLOCK ⑬ ON NEXT PAGE).

$$A = (2.97 - 1.00 - 0.49)(4)(0.49) + 2 \times (8.78 - 2) \times 0.49 + \left(\frac{\pi}{4}\right)(2.98^2 - 2.00^2) = 13.379 \text{ IN}^2$$

TENSILE STRESS IN LEGS:

$$f_t = P/A_t$$

$$A_t = 13.379 \text{ IN}^2$$

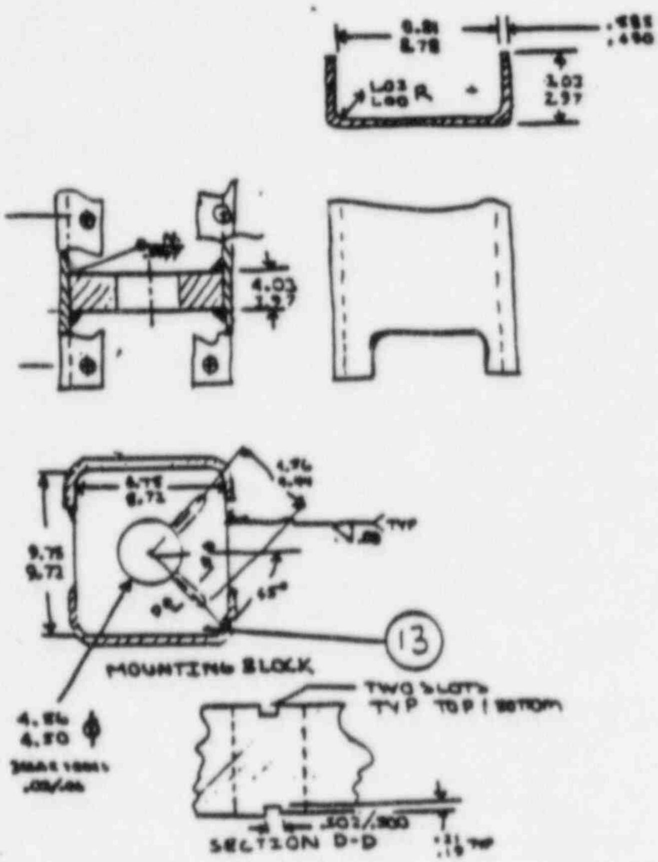
$$P = W/3$$

$$f_t = (300000/3) \times 0.024915 = 2492 \text{ psi}$$

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

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ASSEMBLY			30 OF 40
PROJECT: NEU	AUTHOR: R. Blauschild DATE: 7.84	CHK'D. BY: J. Richard DATE: 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

MOUNTING BLOCK DETAILS (13)



NOTE:
THE LOWER ASSEMBLY SEES ONLY THE INTERNAL'S WEIGHT
W = 267000 LB.

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE: INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 31 OF 40
PROJECT: NEU	AUTHOR: R. Hauptfield DATE 7.84	CHK'D. BY: [signature] DATE 8/84	CHK'D. BY / DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP: REE

MOUNTING BLOCK (13)

BEARING OF LOAD NUT TO MOUNTING BLOCK

$D_1 = (5.995 - 2(.21))$

$D_2 = (4.56 + 2(.06))$

$A_1 = D_1^2 \pi/4 = 24.4107 \text{ IN}^2$

$A_2 = D_2^2 \pi/4 = 17.2021 \text{ IN}^2$

$A_3 \simeq \frac{(D_1 - D_2)}{2} \times 2 \times 0.502 = 0.8986 \text{ IN}^2$

$f_c = P/A_c$

$A_c = A_1 - A_2 - A_3 = 6.310 \text{ IN}^2$

$P = W/3$

$f_c = (W/3)(0.15848)$

$f_c = (267000/3) \times 0.15848 =$

$= 14104 \text{ psi}$

SHEAR IN MOUNTING BLOCK WELDS

$f_v = P/A_v$

$P = W/3$

$A_v = 2(0.707)[\pi(2.) + 2(8.78 - 2.) + 4(2.97 - 0.585 - 1.)] \times 0.5 + 0.707(.5) 4 \times 3.97 =$

$= 14.587 \text{ IN}^2$

$f_v = (W/3)(0.068554) =$

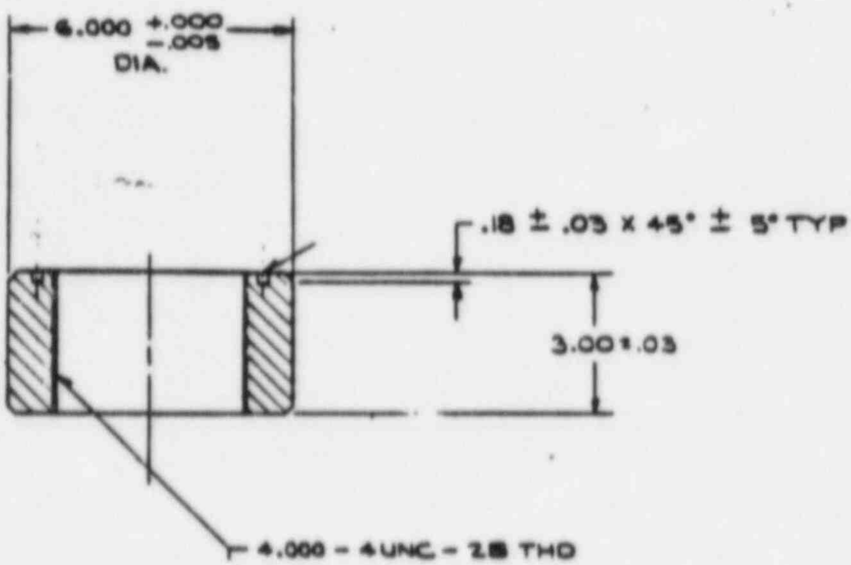
$= 6101 \text{ psi}$

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

WESTINGHOUSE FORM 55213D

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 32 OF 40
PROJECT NEW	AUTHOR R.Blansfield 7/84	CHK'D. BY JWRichard 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

LOAD NUT (14)



EST. WT — 17#
MAT'L - ASTM A276 TYPE 304, HOT ROLLED, COND A.

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ANALYSIS			33 OF 40
PROJECT NEU	AUTHOR R. Blanchfield DATE 7-84	CHK'D. BY [signature] DATE 8/84	CHK'D. BY DATE
S.O. NKUJ-188	CALC. NO.	FILE NO.	GROUP REE

LOAD NUT (14)

THREAD SHEAR

$f_v = P/A_v$

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

FOR 4.0-4UNC-2B THD

[M-840] $D_{pitch} = 3.8376$

$l = 2.97$

$A_v = \pi (D_p)(2.97/2 - 2.97^*(0.52))$

$A_v = 16.359 \text{ IN}^2$

$P = W/3$

$f_v = (267000/3) \times 0.061128 =$

$= 5440$ psi

*for notch cut FROM rod housing

BEARING OF LOAD NUT TO MOUNTING BLOCK

$A_1 = (5.995 - 2(.21))^2 \frac{\pi}{4}$

$= 24.4107 \text{ IN}^2$

$A_2 = (4.50 + 2(0.06))^2 \frac{\pi}{4} =$

$= 17.2021 \text{ IN}^2$

$A_3 = (D_1 - D_2) \times 2 \times 0.502 =$

$= 0.89861 \text{ IN}^2$

$f_c = P/A_c$

$P = W/3$

$A_c = A_1 - A_2 - A_3 =$

$= 6.310 \text{ IN}^2$

$f_c = W \times 0.05283 =$

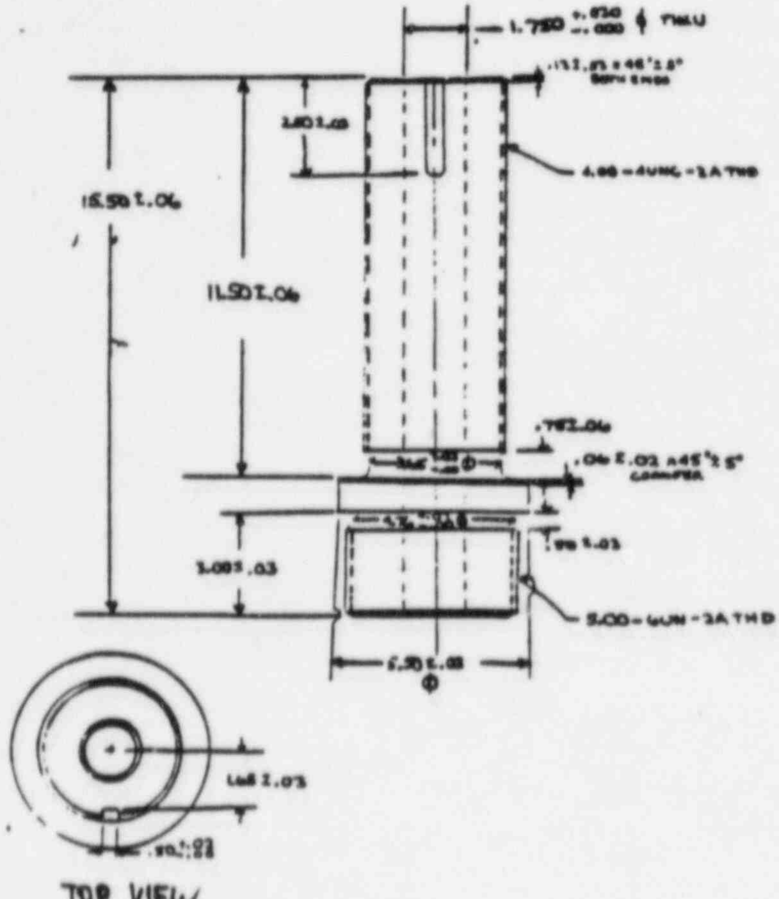
$= 14104$ psi

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

WESTINGHOUSE FORM 58213D

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 34 OF 40
PROJECT NEW	AUTHOR R. Blausler 8.84	CHK'D. BY J. Richard 8/16/84	CHK'D. BY DATE
S.O. NKWJ-188	CALC. NO.	FILE NO.	GROUP REE

ROD HOUSING (15)



TOP VIEW

MAT'L - ASTM A276, TYPE 304, HOT ROLLED, COND A
EST WT - 55#

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 35 OF 40
PROJECT NEU	AUTHOR [signature] DATE 7/84	CHK'D. BY [signature] DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

ROD HOUSING (15)

TENSION AT THREAD RELIEF

$f_t = P/A_t$

$P = W/3$

$A_t = \left(\frac{\pi}{4}\right)(3.65^2 - 1.78^2) = 7.975 \text{ in}^2$

$f_t = W \times 0.0418 = 11160.6 \text{ psi}$

THREAD SHEAR ON LOWER THREADS

$f_v = P/A_v$

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

FOR 5.00-6UN-2A THD

M(8-10) $D_{pitch} = D - \frac{3\sqrt{3}}{8N} = 4.8917$

$l = 2.97 - 0.53 - 0.15$

$A_v = \pi (D_p)(2.29)/2 = 17.596 \text{ in}^2$

$f_v = (W/3A_v) = W \cdot 0.01894 = 5057 \text{ psi}$

THREAD SHEAR ON UPPER THREADS

$f_v = P/A_v$

$A_v = \pi D_{pitch}\, l/2 - l(0.52)$

FOR 4.000-4UNC-2B THD

$D_{pitch} = 3.8376$

$l = 2.53$

$A_v = \pi (D_p)(2.53)/2 - 2.53(0.52)$

$A_v = 13.93 \text{ in}^2$

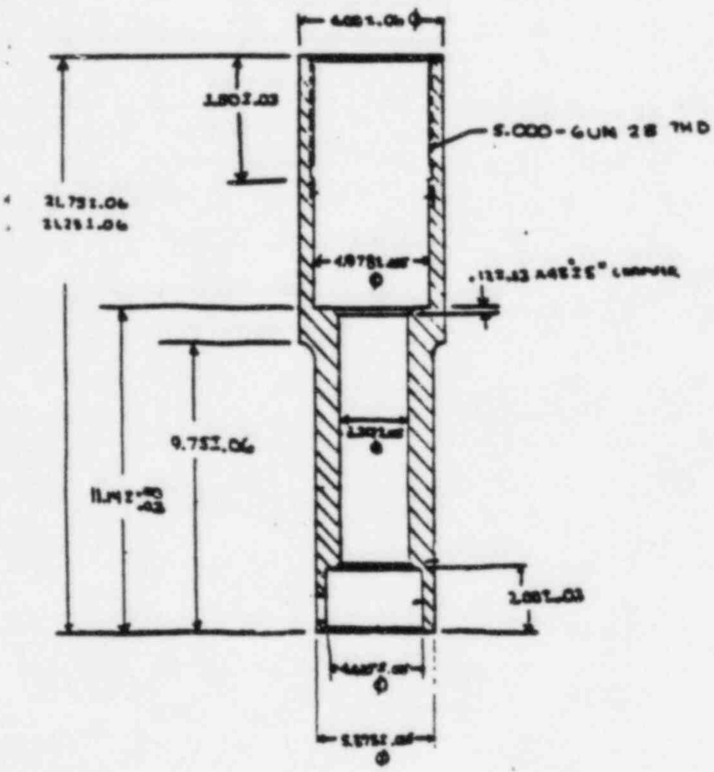
$P = W/3$

$f_v = W \times 0.0239 = 6386 \text{ psi}$

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

TITLE INTERNALS LIFTING RIG STRESS ANALYSIS			PAGE 36 OF 40
PROJECT NEU	AUTHOR / DATE	CHK'D. BY / DATE	CHK'D. BY / DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

GUIDE SLEEVE (16)



MAT'L

ASTM A 276, TYPE 304 SST
HOT ROLLED, ANNEALED, & PICKLED. COND A.

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

TITLE	INTERNALS LIFTING RIG STRESS ANALYSIS		PAGE 37 OF 40
PROJECT NEU	AUTHOR [signature] DATE 7.84	CHK'D. BY [signature] DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

GUIDE SLEEVE (16)

THREAD SHEAR

$f_v = P/A_v$

$P = W/3$

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

$l = 2.97 - 0.53 - 0.15$

Pre 5.00-6UN-2A THD

$D_{pitch} = 4.8917$

$A_v = \pi(4.8917)(2.29)/2 = 17.596\ in^2$

$f_v = W/3A_v = W \times 0.01894 = 5057\ psi$

TENSION AT THREAD RELIEF

$f_t = P/A_t$

$P = W/3$

$A_t = \frac{\pi}{4}(5.94^2 - 5.08^2) = 7.443\ in^2$

$f_t = W \times 0.04478 = 11956\ psi$

BEARING OF GUIDE SLEEVE TO BOLT

$A_1^* = [4.785 - 2(.11)]^2 \times \frac{\pi}{4}$

$A_2 = [3.317 + 2(.15)]^2 \times \frac{\pi}{4}$

$A_c = A_1 - A_2 = 6.092\ in^2$

$f_c = P/A_c$

$P = W/3$

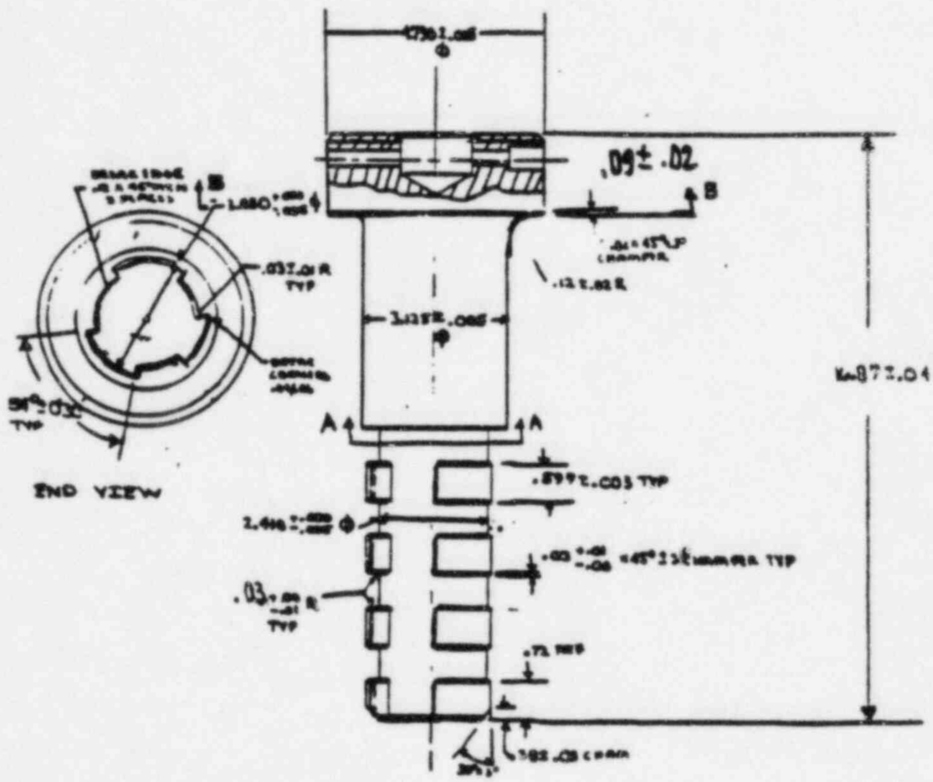
$f_c = W \times 0.05472 = 14610\ psi$

* NORMAL DIMENSIONS AND CENTRALLY ALIGNED.

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

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ANALYSIS			38 OF 40
PROJECT: NEU	AUTHOR: [illegible] DATE: 7/84	CHK'D. BY: [illegible] DATE: 8/84	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

ROTO-LOCK STUD (17)



MAT-L

ASTM A-564 TYPE 630 17-4 PRECIPITATION HARDENING STAINLESS STEEL AGE TREATED AT 1100F° FOR 4 HRS AND AIR COOLED. 140 000 PSi MIN TENSILE STRENGTH

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

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ANALYSIS			39 OF 40
PROJECT: NEU	AUTHOR: [signature] DATE: 7, 84	CHK'D. BY: [signature] DATE: 8/84	CHK'D. BY DATE
S.O. MKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

ROTO-LOCK STUD (17)

W - TOTAL LOAD
W/3 - LOAD PER STUD
N - NUMBER OF LANDS

TENSILE STRESS AT A-A:

$f_t = P/A$

$P = W/3$

$A = \pi d^2/4 =$

$= \pi (2.405)^2/4 = 4.54 \text{ in}^2$

$f_t = W/(3 \times 4.54) =$

$= W \times 0.07319 =$

$= 19604$ psi

SHEAR OF STUD LANDS

$f_v = P/A_v$

$A = L_c d$

L_c = LENGTH OF LANDS

d = DEPTH OF LANDS

$d = 0.594$ in

$L_c = (54/360) \pi \times 2.405 \times N$

$P = W/3$

$A = 1.13 \times 0.594 \times N = 0.673 N$

$f_v = (W/N)/(3 \times 0.673) =$

$= (W/N) \times 0.495 =$

$= 11017$ psi

COMBINED SHEAR AND BENDING IN LANDS

$f_b = M/Z$

$Z = L_c d^2/6 =$

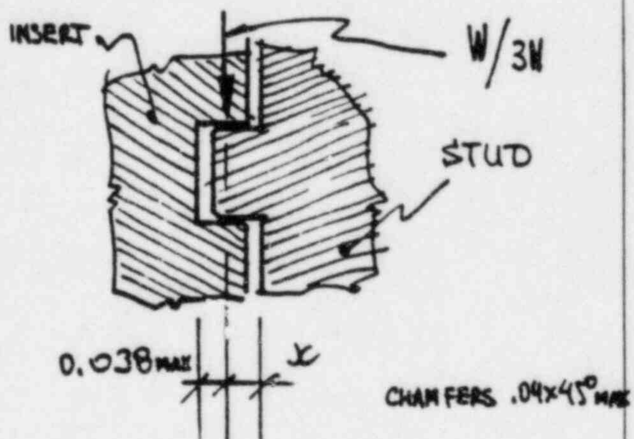
$= N \frac{54}{360} \pi (2.405)(.594^2)/6 =$

$= N \times (.06740)$

M = BENDING MOMENT = Px

$P = W/3$

MOMENT ARM (WORST CASE)



WORST CASE HAS BEEN GOTTEN FOR MINIMUM STUD DIMENSIONS AND MAX DIMENSIONS ON THE INSERT. STUB IS TIGHT AGAINST RIGHT SIDE.

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

TITLE			PAGE
INTERNALS LIFTING RIG STRESS ANALYSIS			40 OF 40
PROJECT: NEU	AUTHOR: R. Stanford — DATE 7/84	CHK'D. BY: J. Richard — DATE 8/84	CHK'D. BY — DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

W — WIDTH OF BEARING SURFACE

$= (3.025 - 2.405)/2 - 0.035 - 2(.04) = 0.195$ min

X — MOMENT ARM OF FORCE

$= \frac{w}{2} + 0.04 + 0.035 =$

$= 0.1725$ max

$f_c = \frac{W}{3} \times 0.1725 / 0.0674 N =$

$= \frac{0.1725}{0.0674} \times \frac{W}{3 \times N} =$

$= \frac{W}{N} \times 0.8531 = 18981$ psi

$f_v = \left[\left(\frac{f_c}{2}\right)^2 + f_v^2\right]^{1/2} + \frac{f_c}{2} =$

$= 24031$ psi

$A'_c = N \frac{54}{360} A_c$

$f_c = P/A'_c$

$P = W/3$

$f_c = \frac{W}{N} / \left(3 \times \frac{54}{360} \times A_c\right) =$

$= \frac{W}{N}(0.819) =$

$= 18922$ psi

COMPRESSIVE BEARING STRESS ON LAND SURFACES

$A_1 = \left[3.025 - 2(0.04)\right]^2 \frac{\pi}{4} =$

$= 6.81 \text{ in}^2$

$A_2 = \left[2.44 + 2(0.04)\right]^2 \frac{\pi}{4} =$

$= 4.99 \text{ in}^2$

$A_c = A_1 - A_2 = 1.82 \text{ in}^2$

COMPRESSIVE BEARING STRESS ON STUD HEAD - SEC B-B:

$A_1 = \left[4.785 - 2(0.11)\right]^2 \frac{\pi}{4}$

$A_2 = \left[3.317 + 2(0.15)\right]^2 \frac{\pi}{4}$

$A_c = A_1 - A_2 = 6.092 \text{ in}^2$

$f_c = P/A_c$

$P = W/3$

$f_c = W \times 0.0547 =$

$= 14610$ psi

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

APPENDIX B

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

This appendix provides the detailed stress analysis for the Millstone 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

S.O.	PROJECT	PAGE
NKVJ-188	Millstone, Unit 3	1 of 31

TITLE	CALCULATIONS NO.
R.V.Head Lift Rig, Load Cell & Linkage Assy Analysis	PDC-

AUTHOR & DATE	CHECKED BY & DATE
F. C. Peduzzi F.C. Peduzzi 8/84	J. W. Richard JW Richard 8/74

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 tensile and shear stresses are within the allowable stresses.

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

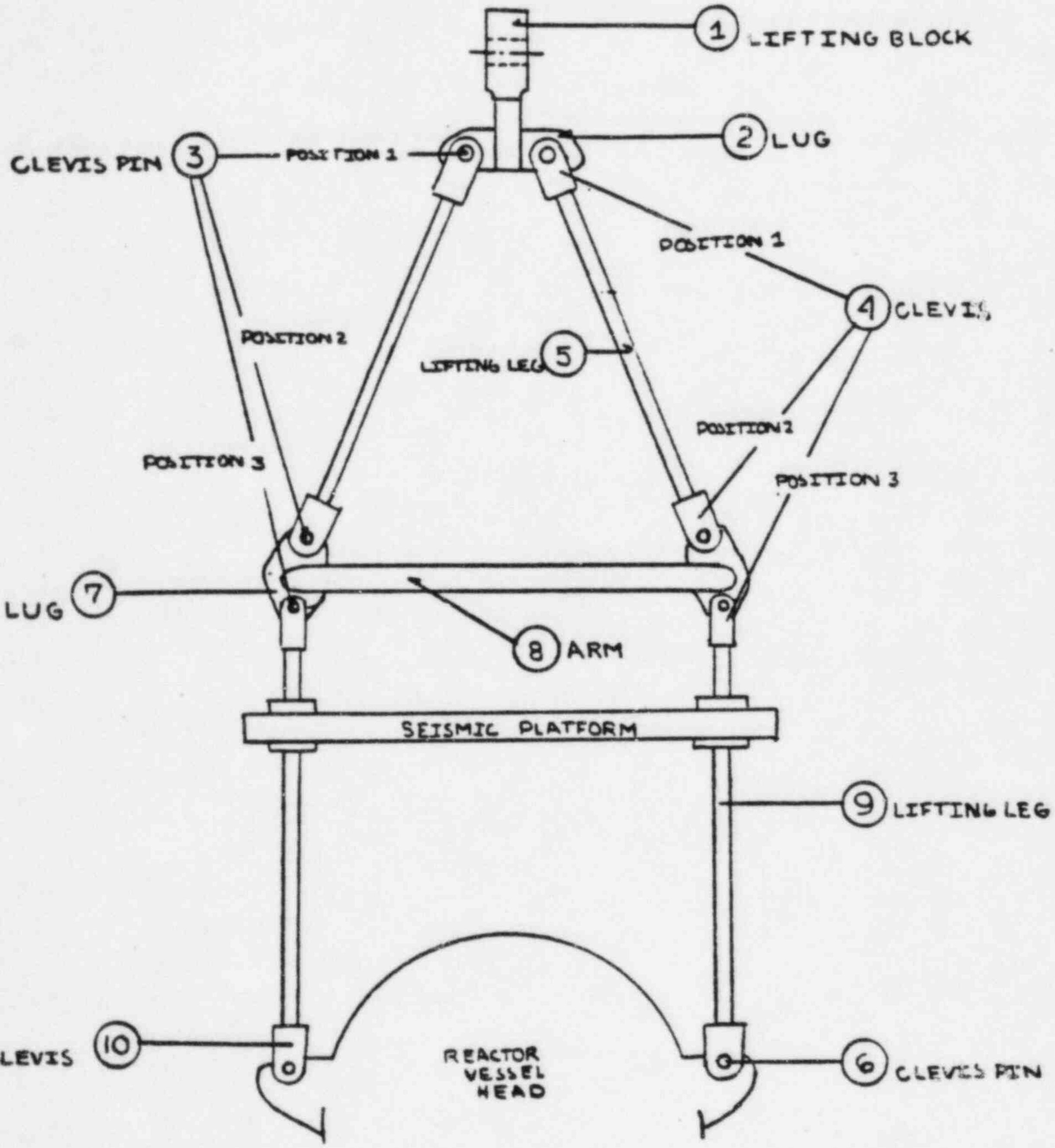
Joseph W. Richard

REVISION NO.	DATE	DESCRIPTION	BY
		Original Issue	F.C.Peduzzi

RESULTING REPORTS, LETTERS OR MEMORANDA:

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 2 OF 31
PROJECT NEU	AUTHOR F.C. Pedrazzi DATE 8/84	CHK'D. BY JW Richards DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

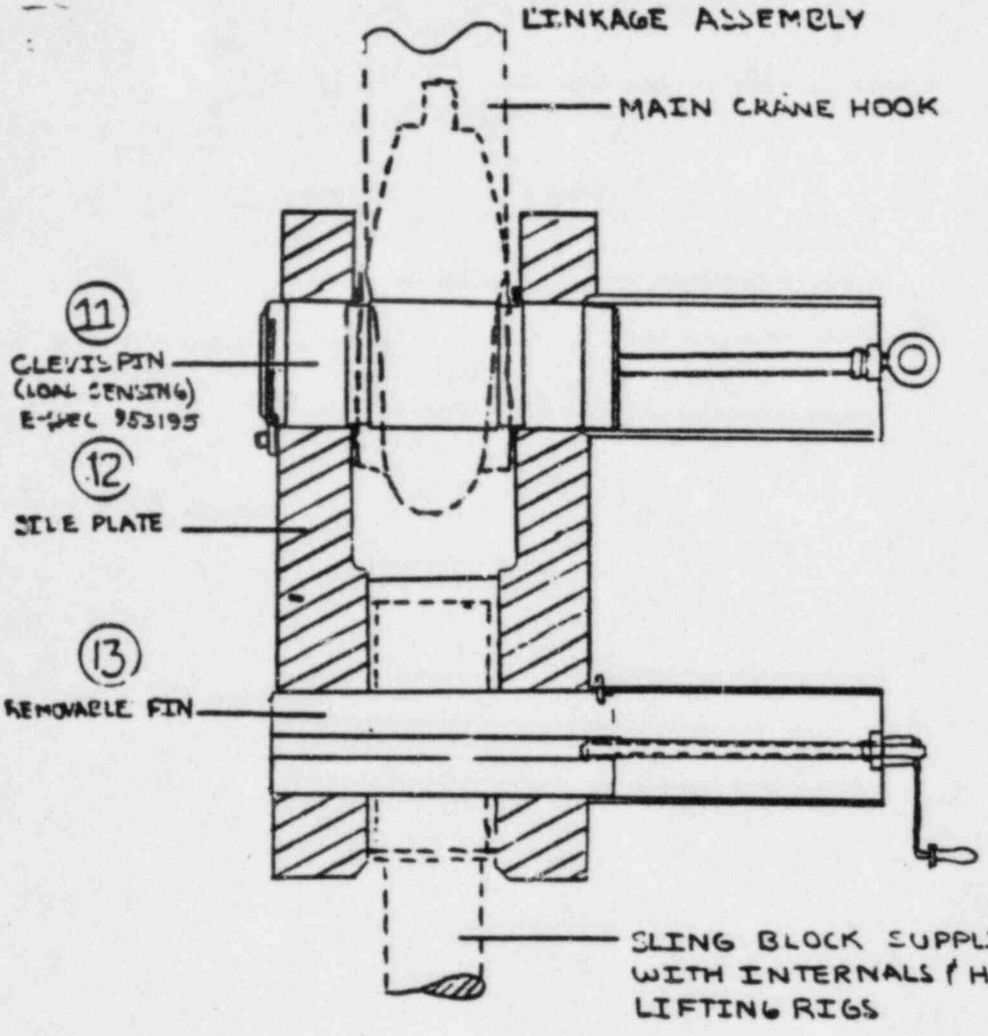
HEAD LIFTING RIG ASSEMBLY
DWG 1212E27



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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 3 of 31
PROJECT NEU	AUTHOR F.C. Pedruzzi DATE 8/84	CHK'D. BY J.W. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

HEAD & INTERNALS LIFTING RIG LOAD CELL LINKAGE ASSEMBLY



SLING BLOCK ANALYSIS INCLUDED IN HEAD AND INTERNALS LIFT RIG ANALYSIS.

WEIGHT = GREATER OF INTERNALS OR HEAD LIFT RIG DESIGN WEIGHTS = 361,175 lb.

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 4 OF 31
PROJECT NEU	AUTHOR F.C. Peduzzi DATE 8/84	CHK'D. BY J.W. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

WEIGHT OF ASSEMBLY & LIFT RIG

WEIGHTS:	POUNDS
R.V. HEAD	165,150
STUDS, NUTS, & WASHERS	37,150
CRDM'S:	
FULL LENGTH	80,050
CAPPED LATCH HOUSINGS	2,900
ROD POSITION INDICATOR COIL STACKS	12,750
COOLING SHROUD	5,250
DUMMY CANS	2,000
LIFT RIG	15,125 *
STUD TENSIONER HOIST	900
SEISMIC PLATFORM	11,100 *
CONTINGENT ATTACHMENTS TO SEISMIC PLATFORM	15,000 *
HEAD INSULATION	1,700
CONTINGENCIES	12,100
TOTAL	361,175

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 5 OF 31
PROJECT NEU	AUTHOR F.C. Pedrazzi DATE 8/84	CHK'D. BY JWRichard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

CONSTANTS USED THROUGHOUT THE CALCULATIONS

α = angle upper sling leg makes to vertical

$\alpha = 25.142^\circ$ from DWG 1212E27

W = weight of head assembly plus rig assembly

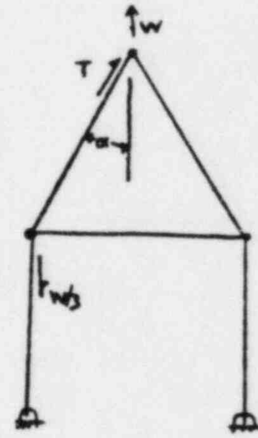
T=1 W = 361,175 pounds

W-2 T = tension in sling leg

$$T\cos\alpha = \frac{W}{3}$$

$$T = \frac{W}{3\cos\alpha} = \frac{361,175}{3\cos 25.142} =$$

T = 132,991 lb



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

TITLE	PAGE
R.V. Head Lift Rig Stress Analysis	6 OF 31

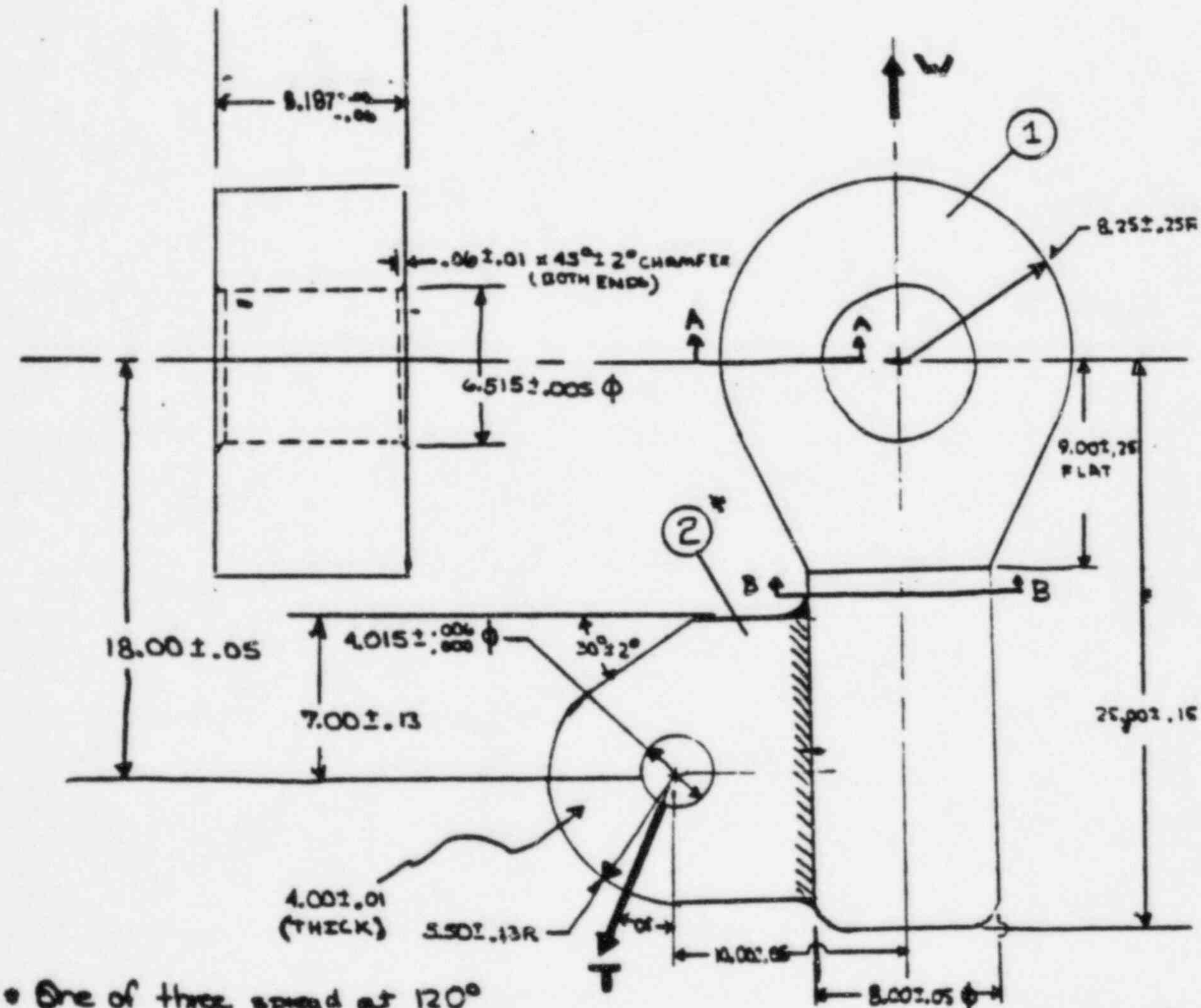
PROJECT	AUTHOR / DATE	CHK'D. BY / DATE	CHK'D. BY / DATE
NEU	F.C. Peduzzi 8/84	JW Rickard 9/84	

S.O.	CALC. NO.	FILE NO.	GROUP
NKVJ-188			REE

LIFTING BLOCK ASSEMBLY (1)(2)

MAT'L - LIFTING BLOCK, IT1 - ASTM A350 GRADE LF2
- LUG IT2 - ASTM A516 GRADE 70
- WELDS E7018 ELECTRODES

EST. WT. 940#



* One of three spaced at 120°

(LUG ROTATED INTO VIEW)

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			7 OF 31
PROJECT: NEU	AUTHOR: F.C. Pedrazzi DATE: 8/84	CHK'D. BY: JW Richard DATE: 9/84	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

LIFTING BLOCK (1)

TENSILE @ A-A

W = 361,175 lb

$f_t = P/A_t$

$P = W/2$

$A_t = (8.25 - \frac{6.515}{2})(8.187) - (.06)^2$

$= 40.87\ in^2$

$f_t = W/(2 \times 40.87)$

$f_t =$ 4419 psi

TENSILE @ B-B

W = 361,175 lb

$f_t = P/A_t$

$P = W$

$A_t = \pi(8.00)^2/4$

$= 50.265\ in^2$

$f_t = W/50.265$

$f_t =$ 7185 psi

BEARING @ A-A

W = 361,175 lb

$f_c = P/A_c$

$P = W$

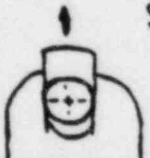
$A_c = d\,l$

$= 6.515(8.187 - 2(.06))$

$= 52.56\ in^2$

$f_c = W/52.56$

$f_c =$ 6872 psi



SHEAR tear-out

W = 361,175 lb

$f_v = P/2A_v$

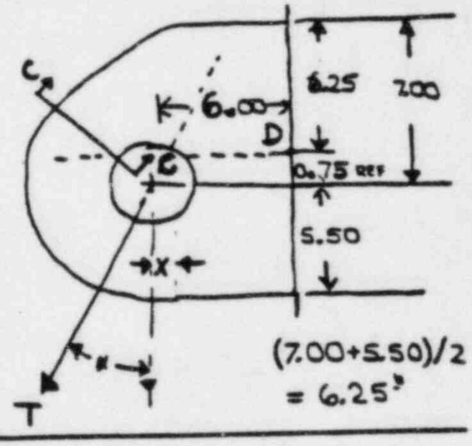
$P = W$

$A_v = 40.87\ in^2$

$f_v = W/(2 \times 40.87)$

$f_v =$ 4419 psi

LUG (2)



TENSION @ C-C

T = 132,991 lb

$f_t = P/A_t$

$P = T/2$

$A_t = (5.50 - \frac{4.015}{2})(4.00)$

$= 13.97\ in^2$

$f_t = T/(2 \times 13.97)$

$f_t =$ 4760 psi

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

WESTINGHOUSE FORM 58213D

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			8 OF 31
PROJECT: NEU	AUTHOR: F.C. Peduzzi DATE: 8/84	CHK'D. BY: JWRichard DATE: 8/84	CHK'D. BY: - DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

BEARING

$T = 132{,}991$ lb

$f_c = P/A_c$

$P = T$

$A_c = d\ell$

$= 4.015(4.00)$

$= 16.06 \text{ in}^2$

$f_c = T/16.06$

$f_c = \underline{8{,}281 \text{ psi}}$

SHEAR - tear-out

$T = 132{,}991$ lb

$f_v = P/2A_v$

$P = T$

$A_v = (5.50 - \frac{4.015}{2})(4.00)$

$= 13.97 \text{ in}^2$

$f_v = T/(2 \times 13.97)$

$f_v = \underline{4{,}760 \text{ psi}}$

STRESSES @ LUG ROOT

$T = 132{,}991$ lb

Bending moment about point D: ccw +

$\alpha = 25.142°$

$X = .75 \tan\alpha$

$X = 0.3520$ in

$M = T\cos\alpha(6 - X)$

$M = 679{,}969$ in-lb

$c_{max} = 6.25$ in

$I = bh^3/12$

$= 4.00(12.5)^3/12$

$= 651.0 \text{ in}^4$

$f_b = Mc/I$ tensile

$= \underline{6{,}528 \text{ psi}}$

TENSILE @ LUG ROOT

$f_t = P/A_t$

$P = T\sin\alpha = 132{,}991\# \sin 25.142°$

$A_t = bh$

$= 4.00(7.00 + 5.50)$

$= 50 \text{ in}^2$

$f_t = T\sin\alpha/50$

$f_t = \underline{1130 \text{ psi}}$

$f_b + f_t = \underline{7{,}658 \text{ psi}}$

SHEAR @ LUG ROOT

$T = 132{,}991\#$; $\alpha = 25.142°$

$f_v = P/A_v$

$P = T\cos\alpha$

$A_v = bh = 50 \text{ in}^2$

$f_v = T\cos\alpha/50$

$f_v = \underline{2{,}408 \text{ psi}}$

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

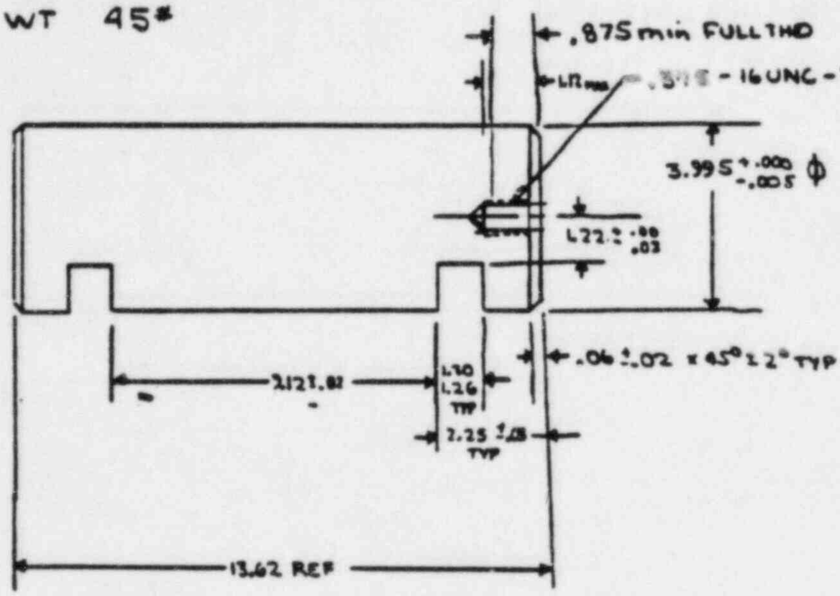
TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			9 OF 31
PROJECT: NEU	AUTHOR: F.C. Pedrazzi DATE: 8/84	CHK'D. BY: JW Richard DATE: 8/84	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

(3)

CLEVIS PIN

MAT'L ASTM A-434
AISI 4340 STEEL
CLASS BD
140,000 PSI MIN TENSILE STRENGTH

EST WT 45#



KEEPER PLATES ARE 1.00 ±.02 THICK

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			10 OF 31
PROJECT: NEU	AUTHOR / DATE: F.C. Pedrazzi 8/84	CHK'D. BY / DATE: JWRichard 8/84	CHK'D. BY / DATE:
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

THIS SAME PIN IS USED TO CONNECT THE SLING BLOCK TO THE LIFTING LEG (POSITION 1), LIFTING LEG TO SPREADER ASSEMBLY (POSITION 2) AND SPREADER ASSEMBLY TO VERTICAL LIFTING LEG (POSITION 3).

SHEAR

T = 132,991 #
W = 361,175 #

$f_v = P/A_v$

$A_v = \pi d^2/4$

$= \pi (3.995)^2/4$

$= 12.5350 \text{ in}^2$

POSITIONS ① & ② $P = \frac{T}{2}$

POSITION ③ $P = \frac{(W/3)}{2}$

②① f_v = 5305 psi

③ f_v = 4802 psi

BEARING

$f_c = P/A_c$

POSITION ①

$A_{cI} = d\,l = 3.995(2.5-2(.045)) = 9.6280 \text{ in}^2$

$P_I = T/2 = 66,496$ #

$A_{cII} = d\,l = 3.995(4.00) = 15.980 \text{ in}^2$

$P_{II} = T = 132,991$ #

f_{cI} = 6907 psi. f_{cII} = 8322 psi

POSITION ②

$A_{cI} = d\,l = 3.995(2.44-2(.045)) = 9.388 \text{ in}^2$

$P_I = T/2 = 66,496$ #

$A_{cII} = d\,l = 3.995(3.88) = 15.501 \text{ in}^2$

$P_{II} = T = 132,991$ #

f_{cI} = 7083 psi f_{cII} = 8580 psi

POSITION ③

$A_{cI} = d\,l = 3.995(2.44-2(.045)) = 9.388 \text{ in}^2$

$P_I = (W/3)/2 = 60,196$ #

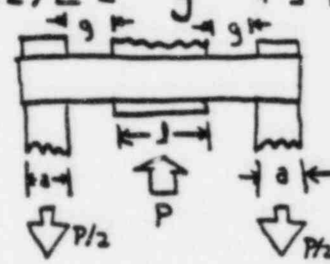
$A_{cII} = d\,l = 3.995(3.88) = 15.501 \text{ in}^2$

$P_{II} = (W/3) = 120,392$ #

f_{cI} = 6412 psi f_{cII} = 7767 psi

BENDING

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



POSITION ①

$a = 2.50 - 2(.045) = 2.41$ in

$l = 4.00 = 4.00$ in

$d = 3.995 = 3.995$ in

$g = [4.38 + 2(.045) - 4.00]/2 = 0.235$ in

$P = T = 132,991$ lb

$f_b = \frac{P}{2}\left(\frac{2.41}{2} + .235 + \frac{4}{4}\right)\frac{32}{\pi(3.995)^3}$

$= T(.19490)$

$= 25,920$ psi

* derivation ON PAGE 31

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

WESTINGHOUSE FORM 58213D

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			11 OF 31
PROJECT: NEU	AUTHOR: F.C. Pedruzzi DATE: 8/84	CHK'D. BY: J.W. Richard DATE: 8/84	CHK'D. BY / DATE
S.O.: MKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

POSITION ②

$a = 2.44 - 2(.045) = 2.35$ in

$l = 3.88 = 3.88$ in

$d = 3.995 = 3.995$ in

$g = [4.50 + 2(.045) - 3.88]/2 = 0.355$ in

$P = T = 132{,}991$ lb

$f_b = P\left(\frac{1}{2}\right)\left(\frac{a}{2} + g + \frac{l}{4}\right)\frac{32}{\pi d^3}$

$= T(.5)\left(\frac{2.35}{2} + .355 + \frac{3.88}{4}\right) \frac{32}{\pi(3.995)^3}$

$= T(.19969)$

$f_b =$ 26,557 psi

POSITION ③

$a = 2.44 - 2(.045) = 2.35$ in

$l = 3.88 = 3.88$ in

$d = 3.995 = 3.995$ in

$g = [4.50 + 2(.045) - 3.88]/2 = 0.355$ in

$P = W/3 = 120{,}392$ lb

$f_b = \frac{W}{3}(.19969)$

$f_b =$ 24,041 psi

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

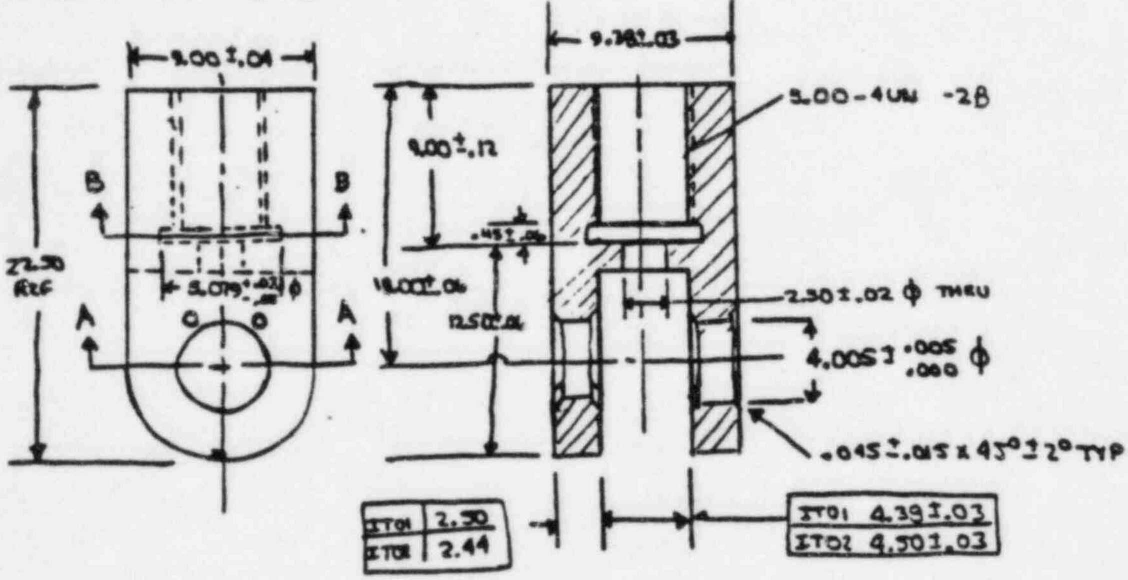
TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			12 OF 31
PROJECT NEU	AUTHOR F.C. Pedrazzi DATE 8/84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

④

CLEVIS

MAT'L... ASTM A668 FORGING & CLASS L, AISI 4340 STEEL
MINIMUM YIELD STRENGTH...85,000 PSI.

EST. WT 340 #



RH 1T02 AT BOTTOM OF LIFTING LEG
LH 1T01 AT TOP OF LIFTING LEG

7.00 MIN THD ENGAGEMENT (DWG 1212E27 VIEW S-S)

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 13 OF 31
PROJECT NEU	AUTHOR F.C. Peduzzi DATE 8/84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

T = 132,991 W = 361,175

TENSION @ A-A

$f_t = P/A_t$

$A_{t\,item\,1} = 2.50 \times (9-4.005)/2 - .045^2$
$= 6.242 \text{ in}^2$

A_t

$A_{t\,item\,2} = 2.44 \times (9-4.005)/2 - .045^2$
$= 6.092 \text{ in}^2$

ITEM 1 IS USED TO CONNECT THE SLING BLOCK TO THE LIFTING LEG...

① $P = T/4 = 33,248$ lb

ITEM 2 IS USED TO CONNECT THE SLING LIFTING LEG TO THE SPREADER ASSEMBLY...

② $P_1 = T/4 = 33,248$ lb

AND TO CONNECT THE SPREADER ASSEMBLY TO THE HEAD LIFTING LEG (VERTICAL)...

③ $P = \frac{W/3}{4} = 30,098$ lb

① $f_t = (T/4)/6.242$
$= 5326$ psi

② $f_t = (T/4)/6.092$
$= 5458$ psi

③ $f_t = W/3/6.092/4$
$= 4,941$ psi

BEARING @ A-A

$f_c = P/A_c$

① $P = T/2 = 66,496$ lb
$A_c = dl = 4.005 \times (2.50 - 2(.045))$
$= 9.652 \text{ in}^2$

② $A_c = dl = 4.005 \times (2.44 - 2(.045))$
$= 9.412 \text{ in}^2$
$P = T/2 = 66,496$ lb

③ $A_c = dl = 4.005 \times (2.44 - 2(.045))$
$= 9.412 \text{ in}^2$
$P = \frac{W/3}{2} = 60,196$ lb

$f_{c1} = (T/2)/9.652$
$f_{c1} = 6,889$ psi
$f_{c2} = (T/2)/9.412$
$f_{c2} = 7,065$ psi
$f_{c3} = (W/3)/2/9.412$
$f_{c3} = 6,396$ psi

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE: R.V. Head Lift Rig Stress Analysis			PAGE 14 OF 31
PROJECT: NEU	AUTHOR: F.C. Pedrazzi DATE: 8/84	CHK'D. BY: J.W. Richard DATE: 8/84	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

$T = 132{,}991^{\#}$, $W = 361{,}175^{\#}$

TENSION @ B-B

$f_t = P/A_t$

②① $P = T = 132{,}991$ lb

$A_t = 9.00(9.38) - \pi(5.079)^2/4$

$= 64.160 \text{ in}^2$

③ $P = W/3 = 120{,}392$ lb

$A_t = 64.160 \text{ in}^2$

②① $f_t = T/64.160$

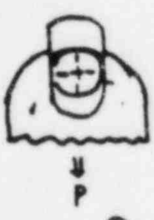
$f_t =$ 2,073 psi

③ $f_t = (W/3)/64.160$

$f_t =$ 1,876 psi

SHEAR - tear-out

$f_v = P/2A_v$



① $P = T/2 = 66{,}496$ lb

$A_v = 2.50\left(\frac{9.00 - 4.005}{2}\right) - .045^2$

$= 6.242 \text{ in}^2$

② $P = T/2 = 66{,}496$

$A_v = 2.44(9.00 - 4.005)/2 - .045^2$

$= 6.092 \text{ in}^2$

③ $P = (W/3)/2 = 60{,}196$

$A_v = 6.092 \text{ in}^2$

① $f_{v_1} = (T/2)/[2(6.242)]$

$f_v =$ 5,326 psi

② $f_v = (T/2) \div (2 \times 6.092)$

$f_v =$ 5,458 psi

③ $f_v = (W/3)/2 \div (2 \times 6.092)$

$f_v =$ 4,941 psi

THREAD SHEAR

$f_v = P/A_v$

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

$D_{pitch} = D_s - \frac{.64952}{n}$

D_s = major diameter = 5.00 in

n = threads per inch = 4

$D_{pitch} = 4.8376$ in

$l = 7.00$ in

$A_v = \pi(4.8376)7.00/2$

$= 53.19 \text{ in}^2$

②① $P = T$

$A_v = 53.19 \text{ in}^2$

③ $P = W/3$

$A_v = 53.19 \text{ in}^2$

②① $f_v = T/53.19$

$f_v =$ 2,500 psi

③ $f_v = (W/3)/53.19$

$f_v =$ 2,263 psi

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

WESTINGHOUSE FORM 58213D

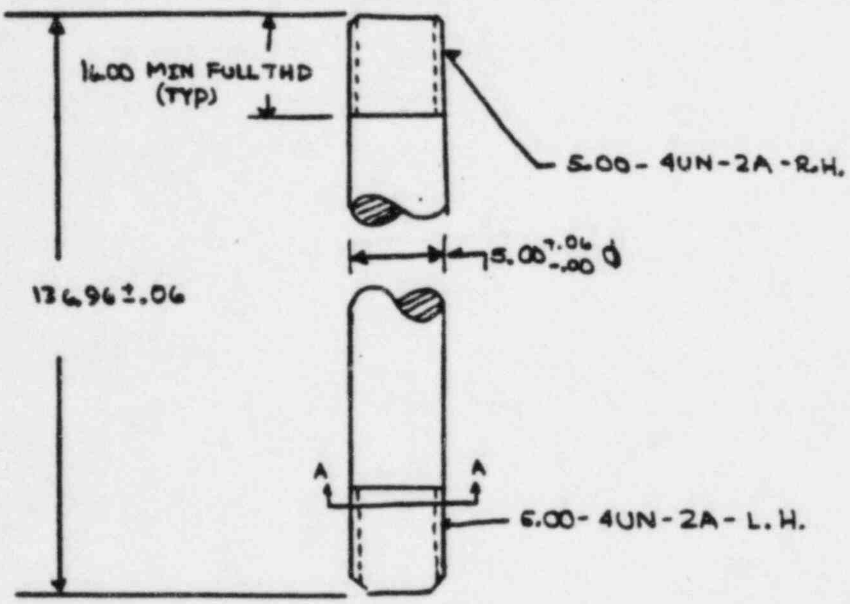
TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			15 OF 31
PROJECT: NEU	AUTHOR: F.C. Peduzzi DATE: 8/84	CHK'D. BY: JW Richard DATE: 8/84	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

LIFTING LEG

(5)

MAT'L ASTM - A434 CLASS BC AISI 4340 STEEL.
TURNED, GROUND, & POLISHED. MINIMUM YIELD STRENGTH 85,000

EST WT 770 #



7.00 MIN THD ENGAGEMENT (VIEW >S DWG 1212E27)

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

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			16 OF 31
PROJECT: NEU	AUTHOR: F.C. Peduzzi DATE: 8/84	CHK'D. BY: JW Richard DATE: 8/84	CHK'D. BY DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

THREAD SHEAR

$f_v = P/A_v$

$P = T = 132{,}991$ lb

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

from page 61 of American Standards unified screw threads (1960)

for external threads

D_s = major diameter

n = number of threads per inch

$D_{pitch} = \left(D_s - \frac{0.64952}{n}\right)$

$D_p = \left(5.00 - \frac{0.64952}{4}\right)$

$= 4.8376$ in

$A_v = \pi(4.8376) \times 7.00/2$

$= 53.19$ in^2

$f_v = T/53.19$

$=$ 2,500 psi

TENSION @ A-A

$f_t = P/A_t$

from page 59 of A.S.U.S.T. (1960)

TENSILE STRESS AREA

$A_t = \frac{\pi}{4}\left(D - 0.9743/n\right)^2$

D = basic major diameter

n = number of threads per inch

$A_t = \frac{\pi}{4}\left(5.00 - \frac{0.9743}{4}\right)^2$

$= 17.769$ in^2

$P = T = 132{,}991$ lb

$f_t = T/A_t =$ 7,484 psi

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

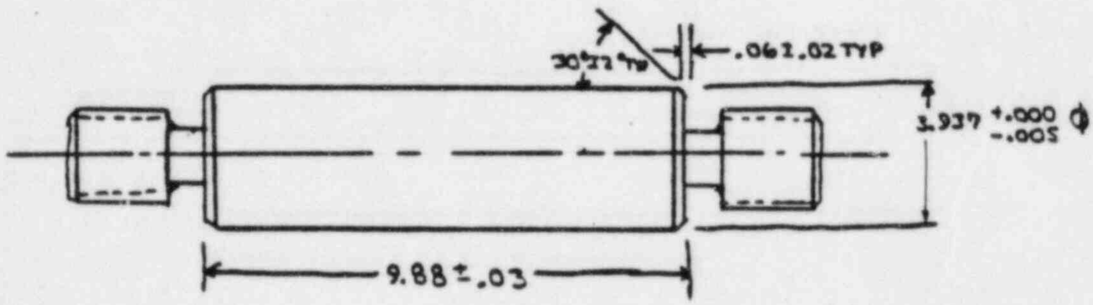
TITLE R.V. Head Lift Rig Stress Analysis			PAGE 17 OF 31
PROJECT NEU	AUTHOR F.C. Peduzzi DATE 8/84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

(6)

CLEVIS PIN

MAT'L ASTM A 434 AISI 4340 STEEL, CLASS BD, 140,000 PSI MINIMUM TENSILE STRENGTH

EST. WT 50*



ITEMS ON PAGE 4 MARKED WITH AN ASTERISK * DO NOT CONTRIBUTE TO THE LOAD ON THE CLEVIS PIN (6). THEREFORE, THE LOAD ON THE PIN IS W = 319,950 lb.

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			18 OF 31
PROJECT NEU	AUTHOR / DATE F.C. Peduzzi 8/84	CHK'D. BY / DATE J.W. Richard 8/84	CHK'D. BY / DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

; W = 319,950

SHEAR

$f_v = P/A_v$

$A_v = \pi d^2/4$

$= \pi(3.937)^2/4$

$= 12.1736 \text{ in}^2$

$P = (W/3)/2$

$f_v =$ 4380 psi

BEARING

$f_c = P/A_c$

$A_{cI} = [2.50 - 2(.045)]\,3.937 \text{ in}^2$

$P_I = (W/3)/2 = 53,325 \text{ lb}$

$A_{cII} = [4.00]\,3.937 = 15.748 \text{ in}^2$

$P_{II} = (W/3) = 106,650 \text{ lb}$

$f_{cI} =$ 5,620 psi

$f_{cII} =$ 6,772 psi

BENDING

$a = 2.50 - 2(.045) = 2.41 \text{ in}$

$l = 4.00 \text{ in}$

$g = [4.50 + 2(.045) - 4.00]/2$

$= 0.295 \text{ in}$

$d = 3.937 \text{ in}$

$P = (W/3) = 106,650 \text{ lb}$

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

*SEE PAGE 31

$f_b = \frac{W}{3}\left(\frac{1}{2}\right)\left(\frac{2.41}{2} + .295 + \frac{4}{4}\right)\frac{32}{\pi(3.937)^3}$

$= \frac{W}{3}(.20864)$

$f_b =$ 22,252 psi

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

WESTINGHOUSE FORM 58213D

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 19 OF 31
PROJECT NEU	AUTHOR F.C. Pedrazzi DATE 8/84	CHK'D. BY J.W. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

(7)(8)

4-LOOP SPREADER ASSEMBLY

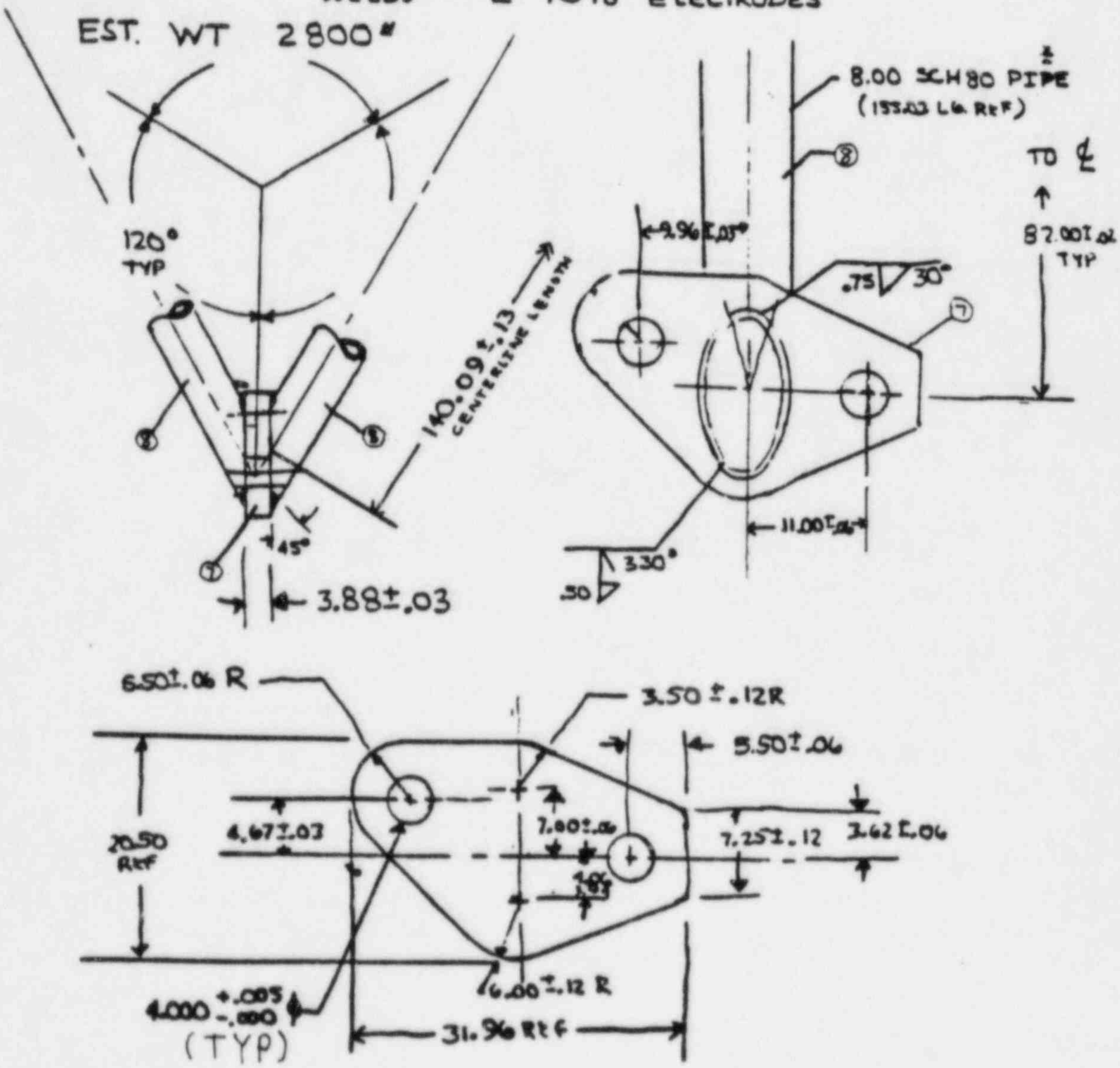
MAT'L:

⑧ ARM ASTM A106 GRADE B SEAMLESS

⑦ LUG ASTM A516 GRADE 70

WELDS E 7018 ELECTRODES

EST. WT 2800#

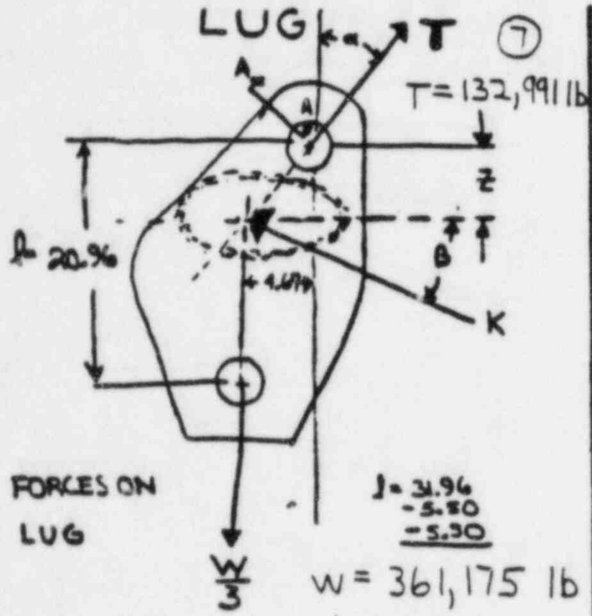


REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

WESTINGHOUSE FORM 58213D

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			20 OF 31
PROJECT: NEU	AUTHOR: F.C. Pedrazzi DATE: 8/84	CHK'D. BY: JW Richard DATE: 8/84	CHK'D. BY DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

⑦



w = 361,175 lb

$K_{HORIZONTAL} = T \sin\alpha$

$K_{VERTICAL} = T\cos\alpha - \frac{W}{3}$

$\tan\beta = \frac{K_V}{K_H} = \frac{0}{56,503}$

$\beta = \underline{\quad 0 \quad}°$

$K = \sqrt{K_H^2 + K_V^2}$

$K = \underline{56,503}$ lb

$\frac{4.67}{z} = \tan\alpha$

$z = \frac{4.67}{\tan\alpha}$

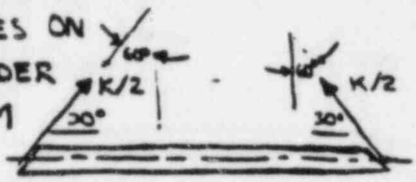
$= \underline{9.950}$ in

center of ellipse is also (20.96 - 11 = 9.96) same distance from upper hole.

∴ K acts through centroid of ellipse and is horizontal

FORCES ON SPREADER ARM

⑧



R = axial force

$R \cos 30° = K/2$

$R = K/(2\cos 30°)$

$= 56,503/(2 \times .8660)$

$\underline{R = 32,623 \text{ lb}}$

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

WESTINGHOUSE NUCLEAR TECHNOLOGY DIVISION

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 21 OF 31
PROJECT NEU	AUTHOR F. C. Peduzzi DATE 8/84	CHK'D. BY JW Rickard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

(7)

TENSILE STRESS @ UPPER HOLE

$f_t = P/A_t$

$P = T = 132,991$ #

$A_t = (5.50(2) - 4.00)\,3.88$

$= 27.16\ in^2$

$f_t = 132,991/27.16$

$f_t = 4897$ psi

SHEAR STRESS @ UPPER HOLE

$f_v = P/2A_v$

$P = T = 132,991$ #

$A_v = (5.50 - \frac{4.00}{2})\,3.88$

$= 13.58\ in^2$

$f_v = 132,991/(2 \times 13.58)$

$f_v = 4,897$ psi

TENSILE STRESS @ LOWER HOLE

$A = \frac{1}{2}(a+b)h$

$f_t = P/A_t$

$P = W/3 = 361,175/3$

$= 120,392$ lb

$A_1 = \frac{1}{2}(20.5 + l)\,11.0$

$A_2 = \frac{1}{2}(l + 7.25)\,5.5$

$A_3 = A_1 + A_2 = \frac{1}{2}(20.5 + 7.25)\,16.5$

solving simultaneously $l = 11.67$

$A_t = (l - d)\,t = (11.67 - 4)\,3.88 = 29.75\ in^2$

$f_t = 120,392/29.75\ in^2$

$f_t = 4,047$ psi

(7)

SHEAR @ LOWER HOLE

$f_v = P/2A_v$

conservatively

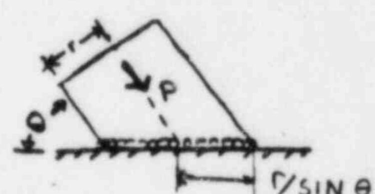
$A_v = (5.5 - \frac{4.00}{2})(3.88) = 13.58\ in^2$

$P = W/3 = 120,392$

$f_v = 120,392/(2 \times 13.58)$

$f_v = 4433$ psi

STRESS @ WELD



from Marks Handbook (ellipse)

l = length of perimeter of weld

$2a$ = major axis

$2b$ = minor axis

$\frac{b}{a} = \sin\theta$

$\theta = 30°$, $\sin 30° = 0.5$

$b = 4$

$a = 8$

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

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			22 OF 31
PROJECT NEU	AUTHOR F.C. Pedrazzi DATE 8/84	CHK'D. BY J.W. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

$\frac{a-b}{a+b} = \frac{1}{3}$

$\therefore \quad K = 1.029$

$l = \pi(a+b)K$

$= 12\pi(1.029)$

$= 38.79$

$throat_{min}$ height =

$.50 \times .707 = .3535$ in

$A_{weld} = 38.79 \times .3535$

$= 13.71 \text{ in}^2$

R = axial force in pipe

= 32,623 lb

$f_v = 32,623 / 13.71$

$\underline{f_v = 2,380 \text{ psi}}$

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 23 OF 31
PROJECT NEU	AUTHOR H.C. Pedruzzi DATE 8/84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

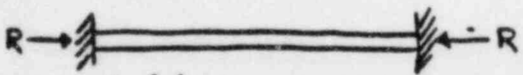
(8)

BUCKLING STRESS IN SPREADER ARM

R = axial force in spreader arm
= 32,623 lb

K = .5 (from AISC Handbook, PS-128, 7th ed.)
= effective length factor for fixed-fixed ends

l = length = 140.09 in
r = 2.878 for 8.00 SCH 80 Pipe
A = 12.76 in^2
I = 105.7 in^4



$Kl/r = .5(140.09)/2.878$
$= 24.338$

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}} = \sqrt{\frac{2\pi^2 \; 29{,}000{,}000}{35{,}000}} = 127.89$$

$Kl/r < C_c$

∴ FROM AISC HANDBOOK (PS-16)
1.5.1.3 COMPRESSION

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

F_a = Allowable axial stress permitted in the absence of bending moment

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

where F_y = yield stress

$A = \frac{24.338}{127.89} = 0.19030$

F_y = 35,000 psi

F_a = 19,783 psi

f_a = computed nominal compressive stress

$f_a = R/A$
$= 32,623 / 12.76$

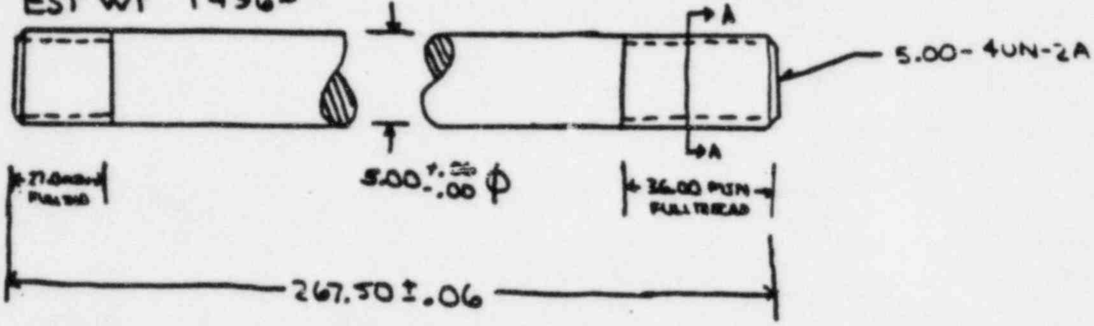
f_a = 2,557 psi

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 24 OF 31
PROJECT NEU	AUTHOR F.C. Paduzzi DATE 8/84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

LIFTING LEG (VERTICAL) (9)

MAT'L ASTM A434 CLASS BC AISI 4340, TURNED, GROUND, & POLISHED.
EST WT 1496#



MINIMUM YIELD STRENGTH ---- 85,000 PSI.
MINIMUM THD ENGAGEMENT--- 7.00 INCHES

7.00 MIN THD ENGAGEMENT (VIEW SS - DWG 1212E27)

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 25 OF 31
PROJECT NEU	AUTHOR F.C. Pedruzzi DATE 8/84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

THREAD SHEAR

$f_v = P/A_v$

$P = (W/3) = 120{,}392$ lb

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

from page 61 of American Standards unified screw threads (1960)

for external threads

D_s = major diameter

n = number of threads per inch

$D_{pitch} = \left(D_s - \frac{0.64952}{n}\right)$

$D_p = \left(5.00 - \frac{0.64952}{4}\right)$

$= 4.8376$

$A_v = \pi (4.8376) \times 7.00/2$

$= 53.19 \text{ in}^2$

$f_v = P/53.1$

$= \underline{2{,}267 \text{ psi}}$

TENSION @ A-A

$f_t = P/A_t$

from page 59 of A.S.U.S.T. (1960)

TENSILE STRESS AREA

$A = \frac{\pi}{4}(D - 0.9743/n)^2$

D = basic major diameter

n = number of threads per inch

$A_t = \frac{\pi}{4}\left(5.00 - \frac{0.9743}{4}\right)^2$

$= 17.769 \text{ in}^2$

$P = (W/3) = 120{,}392$ lb

$f_t = P/A_t = \underline{6{,}775 \text{ psi}}$

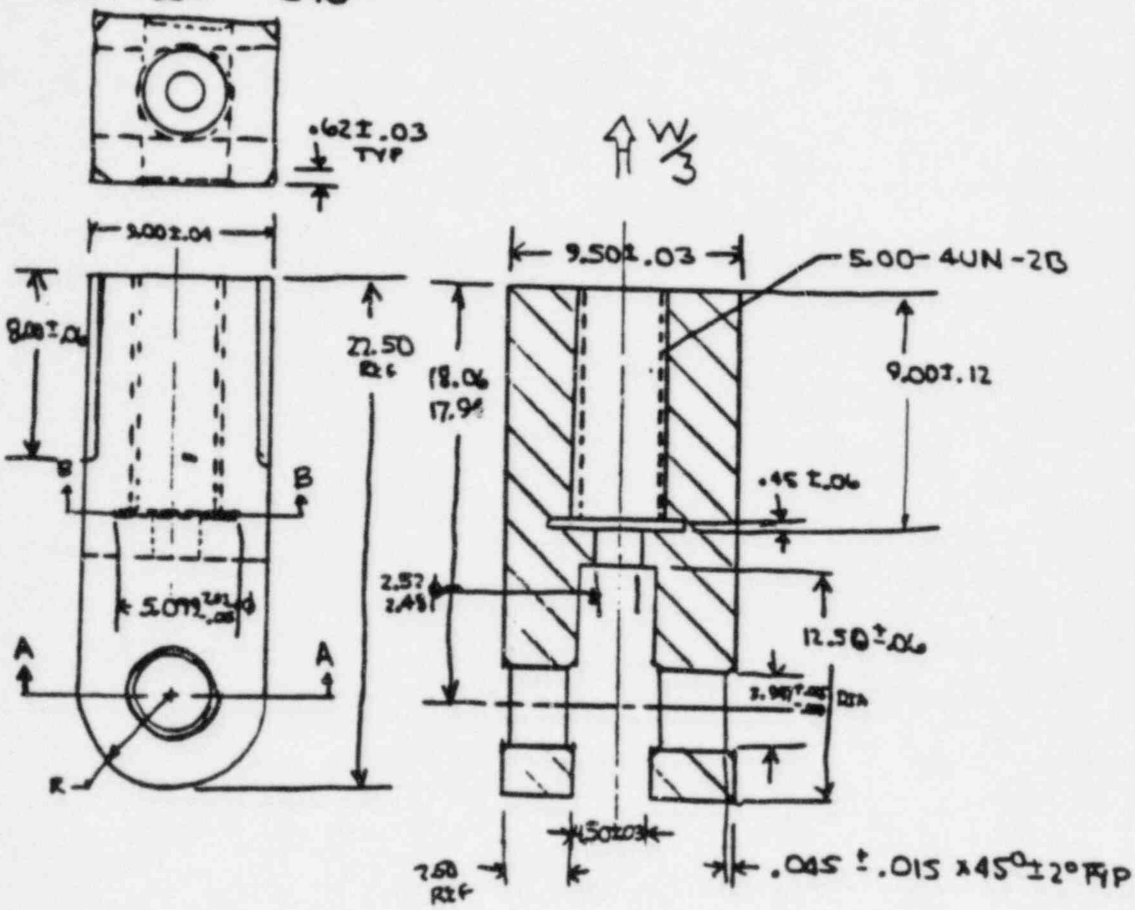
REV. NO.	REV. DATE	AUTHOR DATE	CHK'D. BY DATE	CHK'D. BY DATE

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			26 OF 31
PROJECT NEU	AUTHOR F.C. Pedrazzi DATE 8/84	CHK'D. BY JW Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

CLEVIS (10)

MAT'L ASTM A668 FORGING GRADE L, AISI 4340 STEEL
MINIMUM YIELD STRENGTH 85,000 PSI

EST WT. 340#



7.00 MIN THD ENGAGEMENT (VIEW S-S OF 1212E27)
HEAD LUG THICKNESS = 4.00 IN.

ITEMS ON PAGE 4 MARKED WITH AN ASTERISK * DO NOT CONTRIBUTE TO THE LOAD ON THE CLEVIS ITEM (10). THEREFORE THE LOAD ON THE CLEVIS IS W = 319,950 lb.

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 27 OF 31
PROJECT NEU	AUTHOR F.C. Pedurzi DATE 8/84	CHK'D. BY JW Rishard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

$T = 132{,}991^{\#}$; $W = 319{,}950^{\#}$

TENSION @ A-A

$f_t = P/A_t$

$P = (W/3)/4$

$= 26{,}663^{\#}$

$A_t = (9.00-3.947)(\frac{1}{2})(2.50)-(.045)^2$

$= 6.314 \text{ in}^2$

$f_t = (\frac{W}{3})(\frac{1}{4})/6.314$

$f_t =$ 4223 psi

TENSION @ B-B

$f_t = P/A_t$

$P = (W/3)$

$A_t = (9.00)(9.50) - \pi(5.079)^2/4$

$= 65.24 \text{ in}^2$

$f_t = (\frac{W}{3})/65.24$

$f_t =$ 1,635 psi

BEARING @ A-A

$f_c = P/A_c$

$P = (W/3)/2$

$A = d\,l$

$A_c = 3.947\,(2.50 - 2(.045))$

$= 9.512 \text{ in}^2$

$f_c = (\frac{W}{3})(\frac{1}{2})/9.512$

$f_c =$ 5,606 psi

THREAD SHEAR

$f_v = P/A_v$

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

$D_{pitch} = 4.8376$ in

$l = 7.00$ in

$A_v = 53.19 \text{ in}^2$

$P = (W/3)$

$f_v = (\frac{W}{3})/53.19$

$f_v =$ 2,005 psi

SHEAR - tear-out

$f_v = (P)/2A_v$

$P = (W/3)/2$

$A_v = (9.00-3.947)(\frac{1}{2})(2.50)-(.045)^2$

$= 6.314 \text{ in}^2$

$f_v = (\frac{W}{3})(\frac{1}{2})/(2 \times 6.314)$

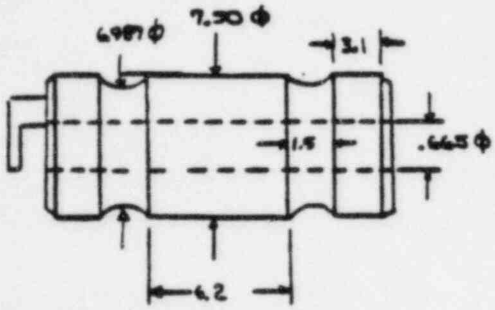
$f_v =$ 4,223 psi

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

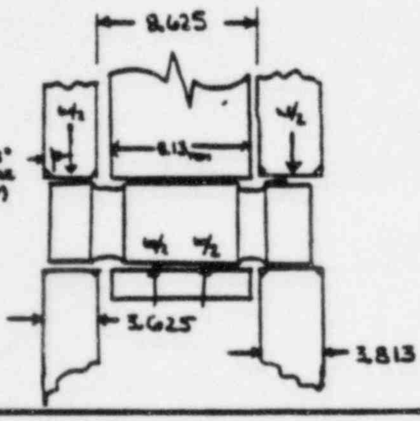
TITLE R.V. Head Lift Rig Stress Analysis			PAGE 28 OF 31
PROJECT NEU	AUTHOR F.C. Pedruzzi DATE 8/84	CHK'D. BY J.W. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

CLEVIS PIN (LOAD SENSING) (11)

MAT'L:
ASTM A 564 TYPE XM12
T_{min} = 135,000 PSI



W = 361,175 lb



PIN SHEAR

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

$A_{min} = \pi/4\,(6.987^2 - .665^2) = 37.99\ in^2$

$f_v = W/2/37.99 = W(.013160)$

$f_v = 4,754$ PSI

BEARING ON HOOK

$f_c = P/A_c$

$P = W$

$A_c = 7.50(6.2) = 46.5\ in^2$

$f_c = W/46.5$

$= W(.02151)$

$f_c = 7,769$ PSI

MAX BEARING ON SIDE PLATE

$f_c = P/A_c$

$P = W/2$

$A_c = 7.50(3.1)$

$= 23.25$

[3.1 < (3.625 - 2(.12))]

$f_c = W/(2 \times 23.25)$

$= W(.021505)$

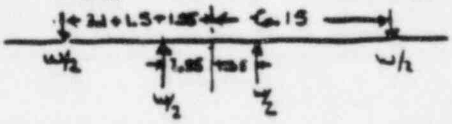
$f_c = 7767$ PSI

PIN BENDING

COMBINING THE WORST DIMENSIONS OF THE PIN

$I_{min} = \pi/64\,(6.987^4 - .665^4) = 116.98\ in^4$

$C_{max} = 7.50/2 = 3.75\ in$



$M = \frac{W}{2}(6.15 - 1.55) = 2.3\,W$

$f_b = Mc/I = 2.3W \times 3.75/116.98$

$= W(.07373)$

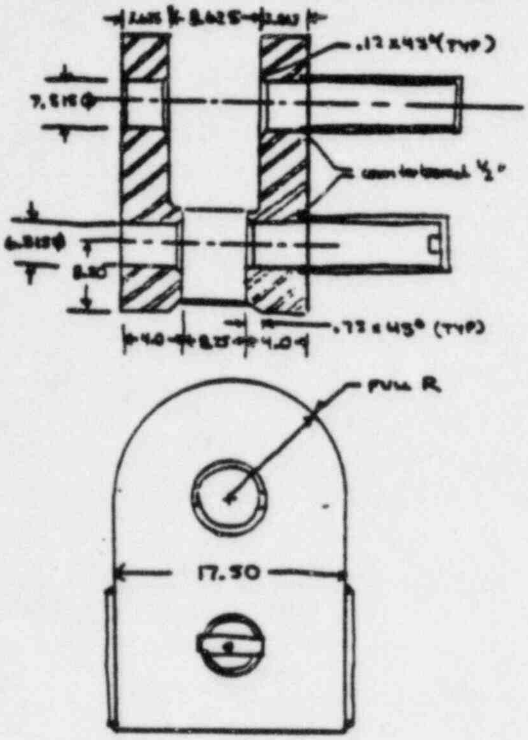
$f_b = 26,632$ PSI

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 29 OF 31
PROJECT NEU	AUTHOR F.C. Pedrazzi DATE 8/84	CHK'D. BY J. Richard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

SIDE PLATES (12)

MAT'L:
ASTM A 533 TYPE B
CLASS 1, 50 KSI. MIN Y.S.



BEARING AT 7½ ϕ HOLE

f_c IS THE SAME AS FOR THE BEARING OF THE CLEVIS PIN (11) ON THE SIDE PLATE

$f_c = W(.021505)$

$f_c = 7,767$ PSI

TENSION @ 7½ ϕ HOLE

$f_t = P/A_t$

$P = W/2$

$A_{t_{min}} = (17.50 - 7.515)(3.625) - 2(.12)^2$

$= 36.167 in^2$

$f_t = W/2/36.167$

$= W(.013825)$

$f_t = 4,993$ PSI

SHEAR-TEAR-OUT @ 7½ ϕ HOLE

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

$2A_{v_{min}} = (17.50 - 7.515)(3.625) - 2(.12)^2$

$\therefore f_v = f_t = W(.013825)$

$f_v = 4,993$ PSI

SHEAR TEAR-OUT @ 6½ ϕ HOLE

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

$A_v = (8.5 - \frac{6.515}{2})(4.00) - .75^2/2 - .12^2/2 - .500(.375)$

$= 20.494 in^2$

$f_v = W/(4 \cdot 20.494)$

$= W(.012199)$

$f_v = 4,406$ PSI

BEARING AT 6½ ϕ HOLE

f_c IS THE SAME AS FOR THE BEARING OF THE REMOVABLE PIN (8) ON THE SIDE PLATE

$f_c = W(.019826)$

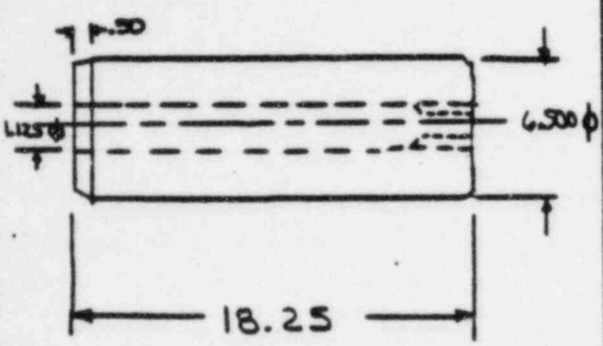
$f_c = 7,161$ PSI

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

TITLE			PAGE
R.V. Head Lift Rig Stress Analysis			30 OF 31
PROJECT: NEU	AUTHOR: G.C. Pedrazzi DATE: 8/84	CHK'D. BY: J.K. Richard DATE: 8/84	CHK'D. BY / DATE
S.O.: NKVJ-188	CALC. NO.	FILE NO.	GROUP: REE

REMOVABLE PIN (13)

MAT'L: ASTM A564, TYPE 630
PRECIPITATION HARDENING SS, AGE TREATED
@ 1150°F FOR 4 HRS, AIR COOLED. 135,000 PSI
MIN TENSILE STRENGTH R_c 28-32



SHEAR

$f_v = P/A_v$

$P = W/2$

$A_v = (6.5^2 - 1.125^2)\,\pi/4$

$= 32.189\ in^2$

$f_v = W/2/32.189$

$= W(.01553)$

$f_v = 5{,}609$ PSI

BEARING ON SIDE PLATE

THE END CHAMFER OF THE PIN FALLS ON THE LINE WITH THE SIDE PLATE CHAMFER WHEN THE PIN IS INVERTED ∴

$f_c = P/A_c$

$P = W/2$

$A_c = 6.500\,(4.00 - .12)$

$= 25.22\ in^2$

$f_c = W/2/25.22$

$= W(.019826)$

$f_c = 7{,}161$ PSI

BEARING ON SLING BLOCK

$f_c = P/A_c$

$P = W$

$A_c = dt$

$t = 8.187 - 2(.06) = 8.067$

$A_c = 8.067\,(6.500) = 52.43\ in^2$

$f_c = W/52.43$

$= W(.019073)$

$f_c = 6{,}888$ PSI

BENDING

$l = 8.187 - 2(.06) = 8.067$

$a = 4.00$

$g = [8.25 - 8.067 + 2(.12)]/2 = .2115\ in$

$P = W$

$f_b = \frac{P}{2}\left(\frac{a}{2} + g + \frac{l}{4}\right)\frac{d_o}{2} \times \frac{64}{\pi(d_o^4 - d_i^4)}$

$= W(.07848)$

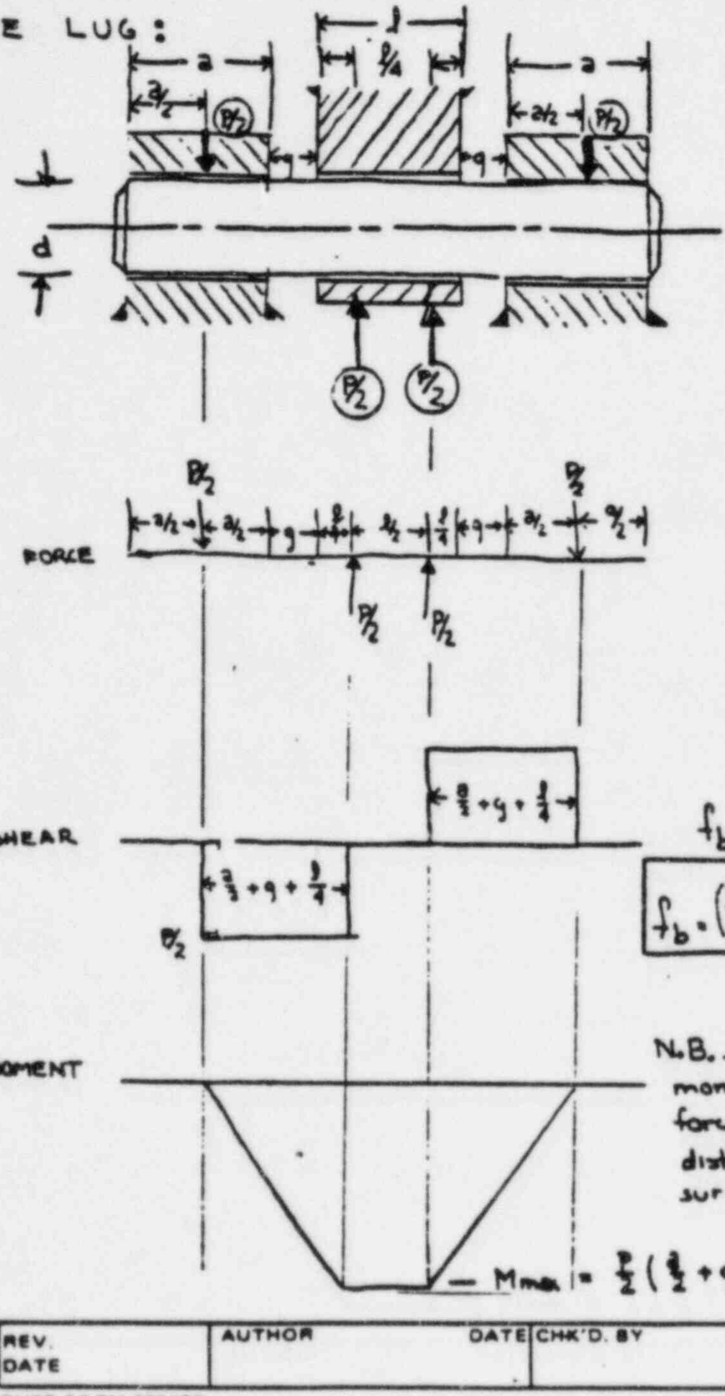
$f_b = 28{,}345$ PSI

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

TITLE R.V. Head Lift Rig Stress Analysis			PAGE 31 OF 31
PROJECT NEU	AUTHOR G.C. Pedrugzi DATE 8/84	CHK'D. BY JWRichard DATE 8/84	CHK'D. BY DATE
S.O. NKVJ-188	CALC. NO.	FILE NO.	GROUP REE

— 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 ¼ 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

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

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