Attachment 5
0042090

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LIFTING DEVICES AND LIFTING POINTS
STRESS ANALYSIS FOR REACTOR PRESSURE VESSEL HEAD STRONGBACK, STEAM DRYER/SEPARATOR SLING AND SERVICE PLATFORM TO COMPLY WITH NUREG 0612 FOR PEACH BOTTOM UNITS 2 AND 3

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TABLE OF CONTENTS

0042090

ABSTRACT

The stress analyses have been performed for equipment handling heavy loads to determine whether the GE supplied lifting devices and lifting points of the Reactor Pressure Vessel (RPV) head strongback, steam dryer/separator sling and service platform of Peach Bottom Units 2 and 3 are in compliance with the recommendations of NUREG 0612. The analyses indicate that the RPV head strongback, dryer/separator sling, and the lifting points of the service platform do not fully meet the guidelines set by NUREG 0612 but exceed the safety factor of the original design criteria to which the devices were designed and built. The components which do not comply with the NUREC 0612 guidelines are identified. Recommendations to satisfy NUREG 0612 criteria are provided.

1.0 INTRODUCTION

In nuclear plant operation, maintenance, and refueling activities, heavy loads may be handled in several plant areas. If these loads were to drop, they could impact on stored fuel, fuel in the core, or equipment that may be required to achieve safe shutdown or permit continued decay heat removal. If sufficient stored fuel or fuel in the core were damaged and if the fuel is highly radioactive due to its irradiation history, the potential releases of radioactive material could result in offsite doses that exceed 10 CFR Part 100 limits.

For the purpose of NUREG 0612 a heavy load is defined as a load whose weight is greater than the combined weight of a single fuel assembly and its handling tool.

The heavy load stress analysis of the lifting devices and lifting points are in response to Philadelphia Electric Company (PECO) request (reference 2) regarding the extent of compliance with the criteria of NUREG 0612 (reference 1).

The purpose of this heavy load stress analysis is to evaluate whether the GE supplied lifting devices and lifting points meet the criteria of NUREG 0612 sections 5.1.1(4), 5.1.6(1) and 5.1.6(3).

The workscope includes (1) search of existing QA records for material mechanical properties and any material deviation, (2) field survey to document the hardware as-built configuration, (3) stress calculation to check compliance with NUREG 0612 criteria, and (4) identification of alternatives for PECO to evaluate if non-compliance is indicated. The following lifting devices and lifting points are analyzed:

1. RPV Head Strongback and Lifting Points
   GE drawing #729E413 for both units (reference 3).

2. Steam Dryer/Separator Sling and Lifting Points
   GE drawing #730E146 for Peach Bottom Unit 2 (reference 4)
   GE drawing #762E152 for Peach Bottom Unit 3 (reference 5).

3. Service Platform Sling* and Lifting Points
   GE drawing #719E129 for both units (reference 6).

2.0 NUREG 0612 AND ANSI N146-1978 GUIDELINES

The sections which are related to special lifting devices and lifting points are as follows:

2.1 NUREG 0612

5.1.1(4) Special lifting devices should satisfy the guidelines of ANSI N14.6-1978, "Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 pounds (4500 kg) or More for Nuclear Materials." This standard should apply to all special lifting devices which carry heavy loads in areas as defined above. For operating plants certain inspections and load tests may be accepted in lieu of certain material requirements in the standard. 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.

5.1.6(1) Lifting Devices:

(a) Special lifting devices that are used for heavy loads in the area where the crane is to be upgraded should meet ANSI N14.6 1978, "Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More for Nuclear Materials." As specified in Section 5.1.1(4) of this report except that the handling device should also comply with Section 6 of ANSI N14.6-1978. If only a single lifting device is provided instead of dual devices, the special lifting device should have twice the design safety factor as required to satisfy the guidelines of Section 5.1.1(4). However, loads that have been evaluated and shown to satisfy the evaluation criteria of Section 5.1 need not have lifting devices that also comply with Section 6 of ANSI N14.6.

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*The Service Platform Sling has been replaced with non-GE supplied equipment as indicated in Reference 7. Therefore, conformance analysis is not included.

5.1.6(3) Interfacing lift points such as lifting lugs or cask trunnions should also meet one of the following for heavy loads handled in the area where the crane is to be upgraded unless the effects of a drop of the particular load have been evaluated and shown to satisfy the evaluation criteria of Section 5.1:

(a) Provide redundancy or duality such that a single lift point failure will not result in uncontrolled lowering of the load; lift points should have a design safety factor with respect to ultimate strength of five (5) times the maximum combined concurrent static and dynamic load after taking the single lift point failure, or

(b) A non-redundant or non-dual lift point system should have a design safety factor of ten (10) times the maximum combined concurrent static and dynamic loads.

2.2 ANSI N14.6-1978 (reference 14)

3.2.1.1 The load-bearing members of a special lifting device shall be capable of lifting three times the combined weight of the shipping container with which it will be used, plus the weight of intervening components of the special lifting device, without generating a combined shear stress or maximum tensile stress at any point in the device in excess of the corresponding minimum yield strength of their materials at construction. They shall also be capable of lifting five times that weight without exceeding the ultimate strength of the materials. Some materials have yield strengths very close to their ultimate strength. When materials that have yield strengths above 80% of their ultimate strength are used, each case requires special consideration, and the foregoing stress design factors do not apply. Design shall be on the basis of the material's fracture toughness, and the designer shall establish the criteria.

6. Special Lifting Devices for Critical Loads

6.1 General When special requirements call for the handling of a critical load, the crane performing the hoisting and transporting shall have special features, such as increased stress design factors or a dual-load-path hoisting system. The special lifting device used with a crane such as this shall have either of the following:

(1) Load-bearing members with increased stress design factors for handling the critical load

(2) A design such that while handling critical loads a single component failure or malfunction will not result in uncontrolled lowering of the load.

6.2 Design Criteria

6.2.1 A special lifting device designed with increased stress design factors instead of a dual-load path shall have its load-bearing members designed with at least twice the normal stress design factor for handling the critical load.

6.2.2 The attachment from a critical load handling crane with a dual-load-path hoisting system to the special lifting device shall be such that two separate and distinct load paths are provided. In the event that one path fails, the second path shall continue to hold the shipping container for transport to a setdown area.

The dual-load-path attachment points on the special lifting device shall be so designed that each load path will be able to support a static load of 3W ("W" being the weight of the critical load, including intervening components of the lifting device) plus the impact load due to any weight transfer that occurs due to failure of one load path, without exceeding the yield point of the material.

6.2.4 In the event of a failure of one of the dual-load paths, the weight of the container is transferred from one load path to the other. Any expected increase in stress level shall be within design limits of all components, including those of the crane hoisting system. Provision should be made to minimize the time and distance for load transfer.

6.2.5 If it is intended that the load be shared between the two load paths by maintaining approximately zero slack in either path, then provision shall be included to allow for load-path slack takeup.

6.2.6 The special lifting device shall be designed to maintain a vertical load balance about the center of lift during its normal attachment.

3.0 CONCLUSIONS

The lifting lugs of the RPV head and steam dryer/separator meet the NUREG 0612 criteria in that the maximum combined load does not exceed the allowable stress based on the ultimate strength of the material with dual load paths.

The RPV head strongback, dryer/separator sling and the lifting rings of the service platform do not comply with NUREG 0612 criteria in that the resulting stresses exceed the allowable stresses.

The components of the equipment which do not meet the criteria are tabulated in Tables 1 and 2. for the RPV head strongback and dryer/separator sling. The lifting rings of the service platform also do not meet the criteria.

4.0 RECOMMENDATIONS

4.1 RPV Head Strongback

Preliminary calculations indicate that the strongback can be modified to comply with NUREG 0612 guidelines. The suggested method of modification is (1) to weld a 1/2" thick plate along both sides of the webs for Sections A and B and on top and bottom for Section D (Figure 2) of the lifting arms, (2) to replace the 1" lifting lug plate with a thicker plate, (3) to replace the turnbuckles with higher rated safe working load turnbuckles, and (4) to replace lower hook pin with stronger one.

4.2 Steam Dryer/Separator Sling

The steam dryer/separator sling components which failed to satisfy the NUREG 0612 criteria are the wire rope assembly and the 6" wide flanged beam. The wire rope assembly consists of the 1-5/8" diameter 6x19 wire rope, open spelter socket, taper sleeve, thimble and turnbuckle. A larger diameter wire rope assembly, stronger socket pins and turnbuckles are needed to satisfy NUREG 0612 criteria. The 6" beam may be modified by welding a 1/2" plate on each side of the wide flanged beam to decrease the bending stress.

TABLE 1

RPV HEAD STRONGBACK

LOAD PATH	SATISFY NUREG 0612 Yes	No	REFERENCE SECTIONS
RPV head lifting lugs	✓		6.2.1
RPV head strongback			
hook pin (lower)		✓	6.2.2.1
(upper)	✓		
hook box (upper)	✓		6.2.2.2
(lower)	✓		
Section A-A*		✓	6.2.2.3
B-B		✓	
C-C	✓		
D-D		✓	
E-E	✓		
Lug plate		✓	6.2.2.4
Shackles	✓		6.2.2.5
Turnbuckles		✓	6.2.2.6

*See Figure 2. RPV Head Strongback Section layout.

TABLE 2

STEAM DRYER/SEPARATOR SLING

LOAD PATH	SATISFY NUREG 0612 YES	NO	REFERENCE SECTIONS
Dryer/Separator Sling			
Hook Box	✓		6.3.1.1
Hook Pin (Upper & Lower)	✓		6.3.1.2
W Beam		✓	6.3.1.3
Socket	✓		6.3.1.4
Socket Pins		✓	6.3.1.5
Wire Rope		✓	6.3.1.6
Turnbuckles		✓	6.3.1.7
Shroud Head/Separator Lifting Lug	✓		
Dryer Lifting Lug	✓		6.3.2

4.3 Service Platform Lifting Rings

0042090

One suggested modification to the service platform to satisfy NUREG 0612 criteria is to replace the three lifting rings on the service platform with lugs made from 1" thick plate with lifting eyes. With this modification, the hooks in the platform sling may have to be changed to accommodate pin connections.

5.0 RECORD SEARCH

The available records of the heavy load handling equipment indicates that the RPV head strongback and dryer/separator sling were fabricated at the manufacturer's site. The devices had been load tested, visual and spot dimension inspected before shipment to the reactor site. The load carrying members were inspected for permanent deformation from the load testing. No deformation or cracks were found.

Welding was performed according to the vendor welding procedures by qualified welders. The welder qualifications and approved welding procedures were in the QA record. The structure welds were inspected by magnetic partical method before and after the proof test by the manufacturer.

All materials, including structural channels and wide flanged beams (except the hook pins and lifting rings) are carbon steel per ASTM A 36. The majority of the certified mechanical properties in the QA record are for non-essential load carrying members which are not being analyzed.

Most materials used are as specified in the parts list of the drawings or specifications, although a few of the materials were replaced by materials with equivalent mechanical properties.

6.0 ANALYSIS

The RPV head strongback, dryer/separator sling and service platform lifting rings were not designed for carrying critical loads. Even though the travel path of the crane which carries the heavy load does not pass over the fuel storage pool or the safe shutdown equipment, a load drop could result in damage to equipment required for safe shutdown or decay heat removal, according to the Section 5.1.6(1) of NUREG 0612. Therefore, the above three heavy load handling devices are considered as carrying critical loads.

6.1 Assumptions

- The RPV head strongback and the steam dryer/separator sling are considered to be carrying critical load and provided with dual load paths. The lifting devices should be capable of lifting the combined static and dynamic loads with two arms (two lifting points) without exceeding the allowable stresses. Therefore the allowable stresses are as follows:

For Lifting Devices (RPV head strongback and steam/dryer separator sling)

dual load path* (Section 2 (5.1.6(1))

$\sigma_{Allowable} = \frac{\sigma_y}{3}$ or $\frac{\sigma_u}{5}$ whichever is smaller

where σ_y - yield strength

σ_u - ultimate strength

*Dual load path - each load path will be able to support a combined static and dynamic load due to any weight transfer that occurs resulting from failure of one of the load paths.

<u>For Lifting Points</u> (RPV head lifting lugs and steam dryer/separator lifting lugs)

dual load path (Section 2 (5.1.6(3b))

$$\sigma\text{Allowable} = \frac{\sigma u}{5}$$

- o The service platform lifting rings were analyzed based on critical load criteria for a single load path. Therefore, the allowable stresses are:

$$\sigma\text{allowable} = \frac{\sigma y}{6} \text{ or } \frac{\sigma u}{10} \text{ whichever is smaller}$$

- o The allowable shear stress is half of the allowable tensile stress based on maximum-shear stress theory (reference 13).

- o A single component failure in the lifting device will not result in uncontrolled lowering of the load.

- o For lifting devices and lifting points carrying a critical load with a redundant load path, the safety factor (with respect to the material ultimates strength) is five times the maximum combined static and dynamic loads.

- o The turnbuckles are assumed to evenly distribute the load among lifting lugs by achieving zero slack so that the lifting devices are horizontal during transportation.

- o The dynamic load is 15% of the static load for a maximum crane speed of 5 FPM (reference 8).

- o Conservative values of field-measured dimensions of Peach Bottom Units 2 and 3 were utilized for one set of stress calculations. These calculations are applicable to both units.

- The hook box was designed to accommodate the redundant crane hook design which provides for at least two separate load paths.

- Usually the ultimate and yield strength from the actual material mechanical properties (if available) are higher than the values given in the ASTM specification. Therefore, if the calculated stress is higher than the allowable stress which is derived from the ASTM specification, the allowable stress derived from the actual mechanical properties was used.

6.2 RPV Head Strongback

The RPV head strongback is designed for lifting the RPV head and drywell head in conjunction with the crane hook. The single failure-proof hook is not in the scope of this analysis. The strongback is a cruciform shaped structure with four equally spaced lifting points and a hook box in the center for engaging it to the crane hook. Turnbuckles and shackles are suspended on each arm for engaging to the lifting lugs of the RPV head (see Figure 1 for illustration). The maximum bending moment for this evaluation is considered to be the combined load concentrated on a span equal to the span of the RPV head lugs or the combined load concentrated on a span equal to the span of the drywell head lugs, whichever is greater.

RPV Head Weight

Static weight by calculation (which agrees with the value in reference 1) = 96 tons

Combined Load = 1.15 (96 x 2000) = 220.8 kips

6.2.1 RPV Head Lifting Lugs (Quantity = 4)

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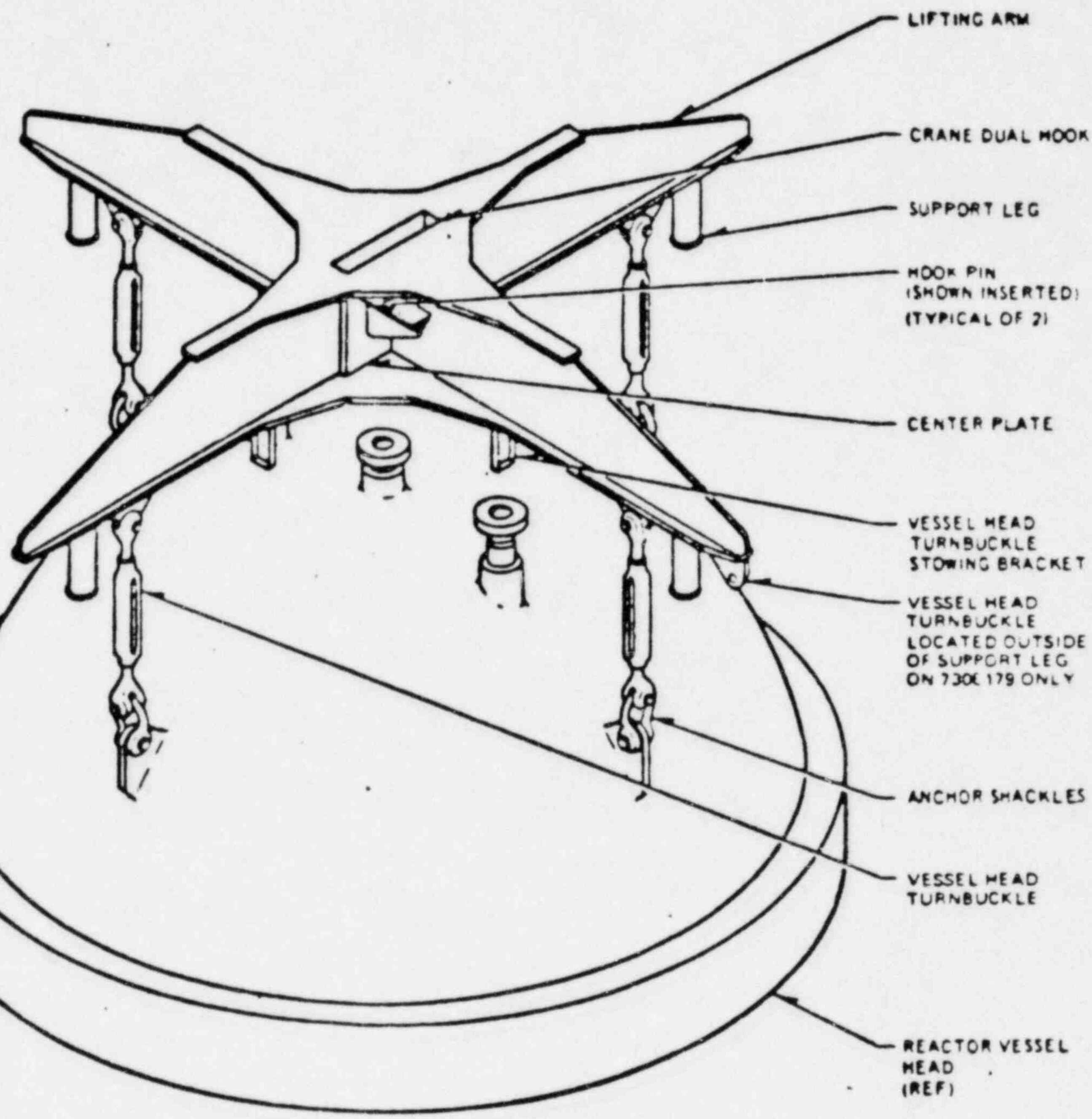


Figure 1. RPV HEAD STRONGBACK

Material: SA302 GR.B (reference 9)

Minimum Ultimate Stress = 80 ksi

Allowable Tensile Stress = 16 ksi

Allowable Shear Stress = 8 ksi

Applied Load per Lug = 110.4 kips

Tangential Force on Lug = 84.2 kips

Radial Force on Lug = 71.4 kips

Tangential Moment = 673.6 in-kips

Combined Tensile Stress = 11.34 ksi < 16 Ksi (allowable Tensile Stress)

Tangential Shear Stress = 2.34 < 8 ksi (allowable shear stress)

Bearing Stress in Lug = 6.8 < 16 ksi

Tension Stress across Hole = 4.3 < 16 ksi

Welds are fully penetrated and ultrasonically examined. No calculation is necessary.

Therefore RPV head lifting lugs satisfies NUREG 0612 criteria.

6.2.2 RPV Head Strongback (GE Drawing #729E413)

6.2.2.1 Hook Pins (Lower Pin) (Quantity = 1) (GE Drawing #131C7969)

Material: ASTM A 519

Ultimate Stress = 120 ksi

Yield Stress = 100 ksi

Allowable Tensile Stress = 24 ksi

Allowable Shear Stress = 12.0 ksi

Estimated Static Weight of the Strongback = 17 tons

Applied Load = 1.15 (96 + 17) x 2000 = 260 kips

Shear Stress = 14.56 ksi > 12.0 ksi (allowable shear stress)

Bending Stress = 23.5 ksi < 24 ksi

Therefore the lower hook pin does not satisfy NUREG 0612 criteria.

Hook Pins (Upper Pins) (Quantity = 2)

0042090

The same material is used for the upper hook pins as in the lower hook pin. The applied load is reduced by half because two hook pins are supporting the same weight. Pins are undercut 1/4" for the hook. It is conservatively assumed that the undercut is 1/4" around the circumference

Shear Stress = 7.28 < 12.0 ksi
Bending Stress = 19.7 < 24 ksi

Therefore the upper hook pin satisfies NUREG 0612 criteria.

6.2.2.2 Hook Box

Material: ASTM A36
Ultimate Strength = 67.8 ksi (from certified material properties)
Yield Strength = 43.8 ksi (from certified material properties)
Allowable Tensile Stress = 13.6 ksi
Allowable Shear Stress = 6.8 ksi
Allowable Bending Stress = 15.0 ksi for "I" sections
Allowable Bearing Stress = 2 x σ_A = 27.2 ksi

Upper Hook Box

Bearing Stress = 9.13 < 27.2 ksi
Tensile Stress across the Hole = 6.6 < 13.6 ksi
Shear Stress on Plate (tearout) = .81 < 6.8 ksi
Welds for Hook Box to Lifting Arm = 1.61 < 13.6 ksi

Lower Hook Box

Bearing Stress = 18.3 < 27.2 ksi
Tensile Stress Across the Hole = 9.3 < 13.6 ksi
Shear Stress on Plate (tearout) = 5.17 < 6.8 ksi

The hook box satisfies the NUREG 0612 criteria.

6.2.2.3 Cruciform Arms

0042090

Sections A, B, C, D and E are shown on Figure 2.

Material: ASTM A36 (the allowable stresses are the same as hook box)

Section A	Compressive Stress = 13.5 < 15 ksi (allowable bending stress)
	Tensile Stress = 19.4 > 15 ksi
Section B	Compressive Stress = 17.4 > 15 ksi
	Tensile Stress = 17.4 > 15 ksi
Section C	Compressive Stress = 9.63 < 15 ksi
	Tensile Stress = 9.63 < 15 ksi
Section D	Compressive Stress = 10.68 < 15 ksi
	Tensile Stress = 15.81 > 15 ksi
Section E	Compressive Stress = 7.67 < 15 ksi
	Tensile Stress = 7.67 < 15 ksi

The local/lateral buckling, flange stress, web crippling and web depth have been examined and satisfy the AISC specifications (reference 10) for all above sections.

Sections A, B, and D of the cruciform arms do not satisfy NUREG 0612 criteria.

6.2.2.4 Strongback Lifting Lugs

Material: ASTM A36

Applied Load = 110.4 kips

Bearing Stress = 11.11 (RPV Head) < 27.2 ksi (allowable bearing stress)

= 8.68 (Drywell Head) < 27.2 ksi

Tensile Stress in Plate = 27.19 > 13.6 ksi

Shear Stress (tearout) = 6.8 = 6.8 ksi

Welds for plate to lifting arm = 3680 lb/in < 3975 lb/in

(3975 lb/in is for 3/8" fillet weld subject to transverse load)

The strongback lifting lugs do not satisfy NUREG 0612 criteria.

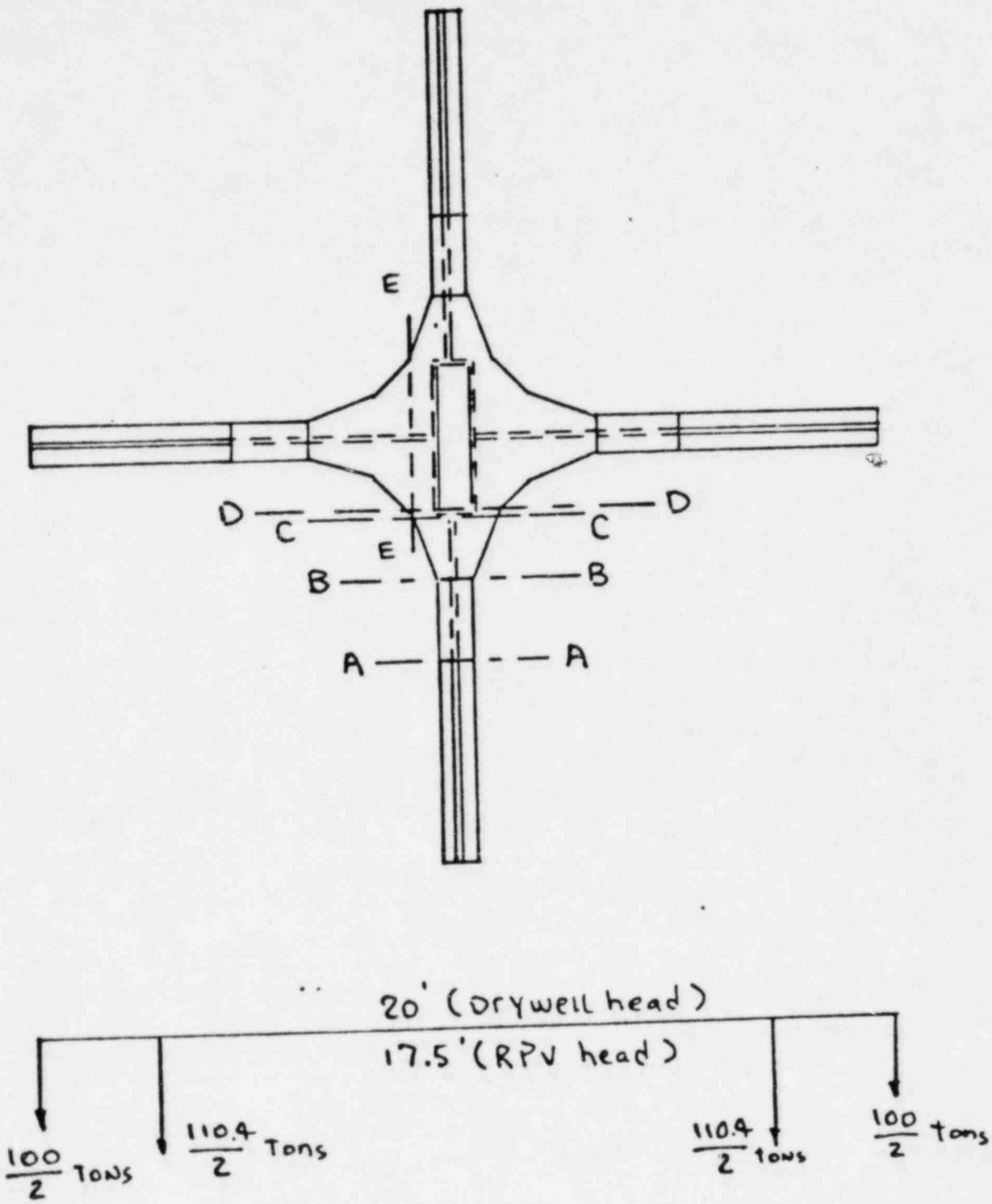


Figure 2. RPV HEAD STRONGBACK SECTION LAYOUT

6.2.2.5 3" Anchor Shackles Crosby Laughlin Cat. #213

Safe working load = 75 tons or 150 kips
Applied load (dual load path) = 110.4 < 150 kips

The anchor shackles satisfy NUREG 0612 criteria.

6.2.2.6 2-3/4" x 24" Turnbuckles Crosby Laughlin Cat. #G228

Safe working load = 75 kips
Applied load = 110.4 > 75 kips

The turnbuckles do not satisfy NUREG 0612 criteria.

6.3 Steam Dryer/Separator Sling

The steam dryer/separator sling is designed to remove the steam dryer or steam separator assembly and to install it in the reactor pressure vessel during refueling.

The sling consists of a hook box, four wire rope assemblies, a cruciform-shaped structure and four sockets with pneumatically operated lift pins which engage with the lifting eyes of the steam dryer or shroud head/separator (see Figure 3 for illustration).

Steam dryer weight (GE drawing #731E711 & 731E157) =
90 kips at 237.5" span

Shroud head/steam separator (GE drawing #729E476) =
139.6 kips at 224.75" span

Estimated sling weight = 4 Kips

6.3.1 Dryer/Separator Sling

6.3.1.1 Hook Box (GE drawing #105D5028)

Material: ASTM A 36

Minimum Ultimate Strength = 58 ksi (from ASTM spec.)

Maximum Yield Strength = 36 ksi

Allowable Tensile Stress = 11.6 ksi

Allowable Shear Stress = 5.8 ksi

Shear Stress due to tearout (at hook pin hole)

= 5.19 <5.8 ksi (allowable shear stress)

Tensile Stress across hole = 3.35 < 11.6 ksi

Bearing Stress at Plate = 11.75 < 23.2 ksi

Welds for plate to hook box = 5.89 < 13.6 ksi

The hook box satisfies NUREG 0612 criteria.

6.3.1.2 Hook Pins (GE drawing #131C7969)

Material: ASTM A519

Yield Stress = 100 ksi

Allowable Tensile Stress = 33.3 ksi

Applied Load = 166 kips

Bending Stress = 27.6 < 33.3 ksi

Shear Stress = 9.30 < 16.7 ksi

The hook pins satisfy NUREG 0612 criteria.

6.3.1.3 6" W Beam Subject to eccentric loading
For carrying the steam separator assembly

Material: ASTM A36

Allowable Tensile Stress = 11.6 ksi

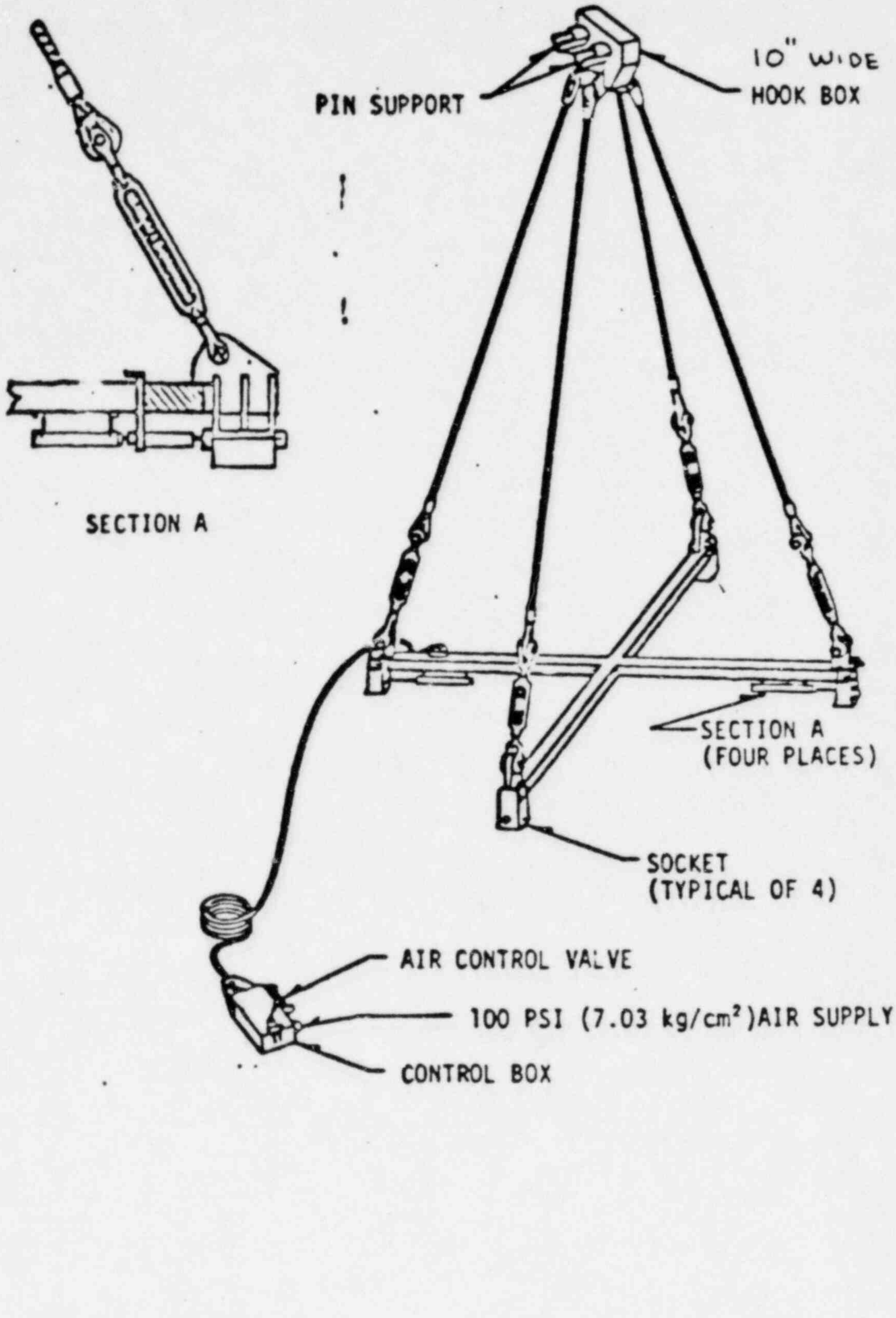


Figure 3. DRYER AND SEPARATOR SLING

Allowable Bending Stress = 13.11 ksi

Maximum combined stresses due to eccentric loading = 0042090

8.31 < 11.6 ksi (allowable stress)

The wide flanged beam satisifes the axial compression and bending requirements of reference 11 as follows:

$$\frac{fa}{Fa} = .13 < .15$$

$$\frac{fa}{Fa} + \frac{fb}{Fb} = .39 \leq 1.0$$

where fa = maximum axial stress

fb = maximum bending stress

Fa = allowable axial stress

Fb = Allowable bending stress

Therefore the wide flanged beams satisfy NUREG 0612 criteria when subject to combined axial compression and bending stresses for carrying the separator.

For Carrying Steam Dryer Assembly

Maximum bending stress = 16.55 > 13.1 ksi (allowable bending stress)

Maximum axial tension stress = 3.24 < 11.6 ksi

The wide flanged beams do not satisfy NUREG 0612 criteria. The higher maximum bending stress is contributed by the large moment arm when the dryer is carried.

6.3.1.4 Sockets

Material: ASTM A36

Bending Stress on Lug = 3.43 < 11.6 ksi

Shear Stress on Plate = 1.08 < 5.8 ksi (allowable shear stress)

Shear Stress in Eye = 5.50 < 5.8 ksi

Shear Stress at Pin Holes = 3.46 < 5.8 ksi

Tensile Stress across Eye = 9.86 < 11.6 ksi

Bearing Stress in 1" Plate = 20.75 < 23.2 ksi

Welds for Lug Plate to beam (applied stress) = 7.93 < 13.6 ksi

Welds for socket wall to lug plate (applied stress) = 1.94 < 13.6 ksi

The sockets satisfy NUREG 0612 criteria.

6.3.1.5 Socket Pin (GE drawing #117C4772)

Material: AMS 6414 RC 45-49

Ultimate Strength = 210 ksi

Applied Load = 80.27 kips

Allowable bending stress (Plastic design) = 71.41 ksi

Allowable Shear Stress = 29.67 ksi

Bending Stress on Pin = 88.0 > 71.4 ksi

Shear Stress on pin = 26.42 < 29.67 ksi

The socket pins do not satisfy NUREG 0612 criteria.

6.3.1.6 Wire Rope Assembly

1-5/8" galvanized 6x19 wire rope

Breaking Strength = 103 tons

Fittings, such as the taper sleeve, rope thimble, are rated the same.

Applied Load = 90.7 kips

Allowable Load = 103 x 2000/5 = 41.2 kips

Applied Load > Allowable Load

The wire rope assemblies do not satisfy NUREG 0612 criteria.

6.3.1.7 Turnbuckles (2-1/2" x 24") G228

Safe Working Load = 60 kips

Applied Load = 90.7 > 60 kips

The turnbuckles do not satisfy NUREG 0612 criteria.

6.3.2 Lifting Lug of the Separator/Dryer (GE drawing #135B9048)

Material: A276 or A479 TP304

Minimum Yield Strength = 30 ksi

Minimum Ultimate Strength = 75 ksi

Allowable Tensile Stress = $\frac{\sigma u}{5}$ = 15 ksi

Tensile Stress on Lug = 5.5 < 15 ksi (allowable tensile stress)

Bearing Stress = 9.2 < 30 ksi

Nut Thread Shear = 3.5 < 15 ksi

Screw Thread Shear = 3.9 < 7.5 ksi

Tensile Stress in Rod = 11.7 < 15 ksi

Welds for Lifting Lug to Nut (PB2)*

Actual Stress = 3.17 < 13.6 ksi

Welds for 3" rod to shroud head (GE drawing #729E476)

Actual Stress = 9.2 < 13.6 ksi

The Lifting Lugs satisfy the NUREG 0612 criteria.

6.4 Service Platform Lifting Rings (GE drawing #719E129)

The service platform is designed for general service during a reactor outage. The sling has been replaced with non-GE supplied equipment (reference 7). Therefore, compliance with NUREG 0612 criteria must be evaluated by the sling vendor. There are three lifting rings in the service platform. Two are inclined 45 degrees with respect to the 12" structural channel and one is vertical. The vertical lifting ring is illustrated on Figure 4.

*Peach Bottom Unit 3 lifting lugs are slightly different than Peach Bottom Unit 2 and are well within the safety margin. Therefore, no additional calculation is necessary.

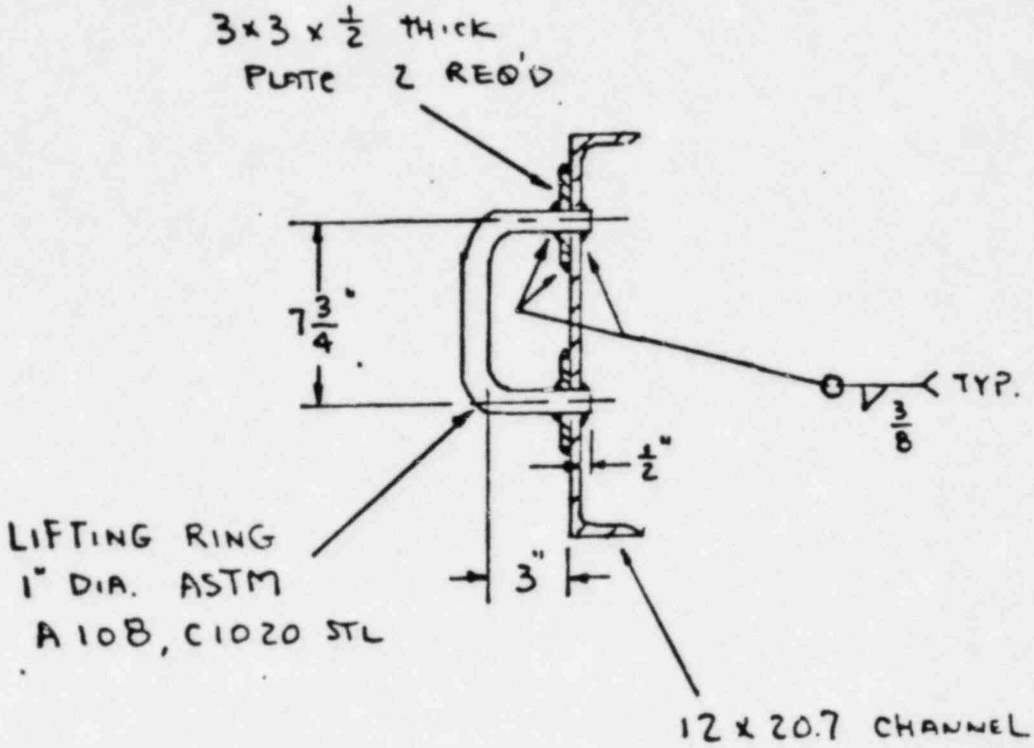


Figure 4

From force analysis, the vertical ring experiences a higher load than the inclined rings, therefore, only the vertical ring is analyzed. The ring is assumed as a rigid frame. The method given on Page 122 of Reference 11 was used.

The drawing (reference 6) does not indicate if the ring material is hot or cold rolled steel of A108 C1020. The analysis assumes that the ring material is cold rolled steel, which gives the maximum yield and ultimate strength. The purpose of this assumption is to indicate that the combined normal stress and bending stress of the ring exceeds the maximum allowable stress with respect to the yield and ultimate strength.

Allowable stress with respect to yield strength.

$$\sigma_{allowable} = \frac{\sigma y}{6} = \frac{51}{6} = 8.5 \text{ ksi}$$

Allowable stress with respect to ultimate stress.

$$\sigma_{allowable} = \frac{\sigma u}{10} = \frac{61}{10} = 6.1 \text{ ksi}$$

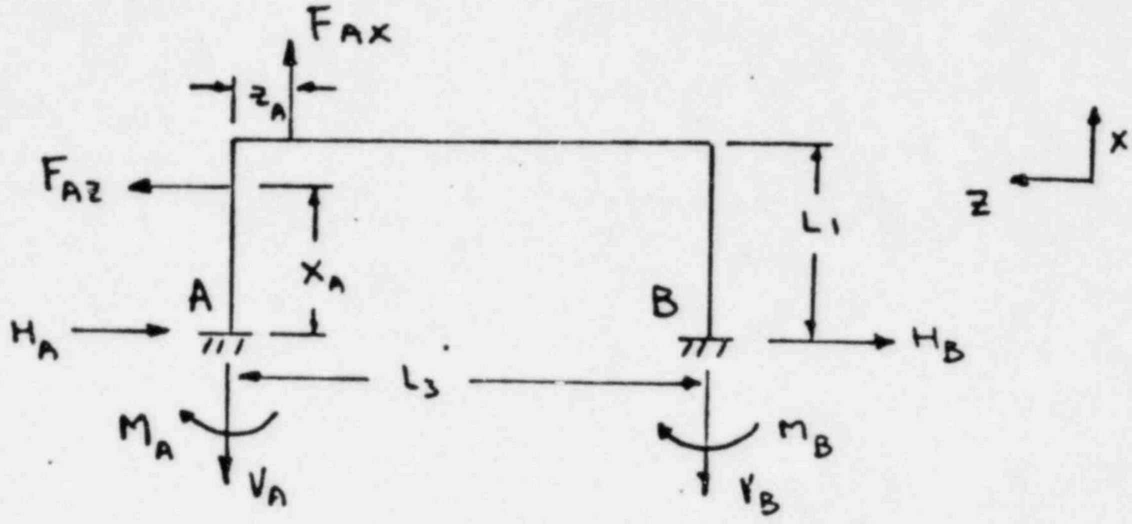
Use 6.1 Ksi for allowable tensile stress.

Allowable Shear Stress = 1/2 σ_A = 3.1 ksi

Allowable bending Stress = (Shape Factor*) σ_A
= (1.7)(6.1) = 10.37 Ksi

The summary of reaction force and moments are as follows:

*Shape Factor for plastic design for circular cross Section is 1.7 (reference 12) Section 5



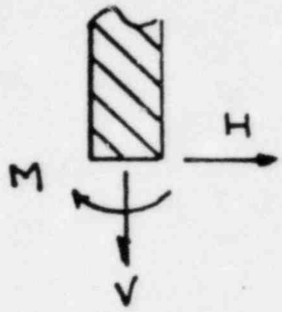
M_A = 4.21 in-kips
V_A = 4.82 kips
H_A = 2.77 kips

M_B = 5.63 in-kips
V_B = .97 kips
H_B = 2.990 kips

L_1 = 3.0 inch
L_3 = 7.75 inch
d = 1.0 inch

I = 0.0491 in.^{4}
C = d/2 = 0.5 in.
Z = I/C = 0.098 in.^{3}

End "A"



Shear Stress = $\frac{4}{3}\frac{H}{A}A$ = 4.71 > 3.1 ksi

Normal Stress = $\frac{V}{A}A$ = 6.133 ksi

Maximum bending Stress = $\pm$43 ksi

Maximum combined Stress = 49.14 > 10.37 ksi

End "B"

Normal Stress = 1.24 ksi

Bending Stress = $\pm$ 57.43 ksi

Maximum Combined Stress = 58.67 > 10.37 ksi

Shear Stress = 5.08 < 3.1 ksi

The lifting rings of the service platform do not satisfy NUREG 0612 criteria.

7.0 REFERENCES

1. NUREG 0612, "Control of Heavy Loads at Nuclear Power Plants". July, 1980

2. GE Proposal #424-TY481-HEO "Analysis for Determination of Conformance of GE Supplied Lifting Devices to NUREG 0612", dated September 16, 1981

3. RPV head strongback 729E413

4. Steam Dryer/Separator Sling (PB2) 730E146

5. Steam Dryer/Separator Sling (PB3) 762E152

6. Service Platform (719E129)

7. GE Letter G-HE-1-209, dated December 14, 1981

8. CMAA Specification #70

9. RPV Head Drawing 131873E Rev. 5 (A/E)

10. The Manual of Steel Construction (AISC) 7th ed.

11. Roark & Young "Formulas for Stress and Strain" 5th ed.

12. Mark's Mechanical Engineering Handbook, 7th ed.

13. J. E. Shigley, "Mechanical Engineering Design", 3rd ed.

14. ANSI N14.6-1978, "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 Kg) or more For Nuclear Materials"