# Engineering Data Transmittal

## To: (Receiving Organization)

## From: (Originating Organization)

### Distribution

- Packaging Engineering

### Project/Program/Department/Division:

- 03E00

### Design Authority/Design Agent/Chief Engineer:

- E. P. Clements

### Originator Remarks:

- For approval.

### Receiver Remarks:

- 11A. Design Baseline Document? [ ] Yes [X] No

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### SIGNATURE OF EDT ORIGINATOR

- SS Shiraga

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- EP Clements

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### SIGNATURE OF EDT ORIGINATOR

- EP Clements
Spreader Beam Analysis for the CASTOR GSF Cask

E. P. Clements
Rust Federal Services Inc. Northwest Operations, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

Abstract: The purpose of this report is to document the results of the 150% rated capacity load test that was performed by DynCorp Hoisting and Rigging for the CASTOR GSF special lifting beams.

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Approved for Public Release

A-6400-073 (01/97) GEF321
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LIST OF TERMS

ANSI American National Standards Institute
ASTM American Society for Testing and Materials
IAEA International Atomic Energy Agency
SARP Safety Analysis Report for Packaging
SPREADER BEAM ANALYSIS FOR THE CASTOR GSF CASK

1.0 INTRODUCTION

The purpose of this report is to document the results of the 150% rated capacity load test performed by DynCorp Hoisting and Rigging on the CASTOR GSF special cask lifting beams. The two lifting beams were originally rated and tested at 20,000 kg (44,000 lb) by the cask manufacturer in Germany. The testing performed by DynCorp rated and tested the lifting beams to 30,000 kg (66,000 lb) +0%, -5%, for Hanford Site use.

The CASTOR GSF cask, used to transport Isotopic Heat Sources (canisters), must be lifted with its own designed lifting beam system (Figures 1, 2, and 3). As designed, the beam material is RSt 37-2 (equivalent to American Society for Testing and Materials [ASTM] A-570), the eye plate is St 52-2 (equivalent to ASTM A-516), and the lifting pin is St 50 (equivalent to ASTM A-515). The beam has two opposing 58 mm (2.3 in.) diameter by 120 mm (4.7 in.) length, high grade steel pins that engage the cask for lifting. The pins have a manual locking mechanism to prevent disengagement from the casks. The static, gross weight (loaded) of the cask 18,640 kg (41,000 lb) on the pins prevents movement of the pins during lifting. This is due to the frictional force of the cask on the pins when lifting begins.

2.0 SUMMARY OF RESULTS

The two lifting beams (1A and 1B) delivered as auxiliary equipment with the CASTOR GSF casks were designed, built, tested, and used by the cask manufacturer in Germany (Section 5.1). The beams were built and tested to International Atomic Energy Agency (IAEA) requirements. For use at the Hanford Site, the beams shall meet the requirements listed in the Hanford Site Hoisting and Rigging Manual, Section 11.0, "Below-the-Hook-Lifting Devices" (RL 1993) and the American National Standard Institute (ANSI) N14.6, Radioactive Materials Special Lifting Devices for Shipping Containers Weighing 10,000 lb (4500 kg) or More (ANSI 1993). To meet the Hanford Site and ANSI criteria, both lifting beams were analyzed to ensure 3 to 1 against yield, requirements are met (Section 5.3). The beams were physically load tested (Section 5.2) in accordance with the Hanford Site Hoisting and Rigging Manual, Section 11.0, "Below-the-Hook-Lifting Devices" and ANSI N14.6, Section 6.3(a), "Testing," to verify continuing compliance. The two lifting beams were tested to 150% 30,000 kg (66,000 lb) +0%, -5% for an actual load test of 29,345 kg (64,560 lb) held for 10 minutes. This test was performed with certified weights and rigging. The beams were inspected after testing as described in ANSI 6.3(a) and no discrepancies were found.

3.0 CONCLUSION

The two CASTOR GSF cask lifting beams are only intended and designed for their particular use as described in the CASTOR Safety Analysis Report for Packaging (SARP) (HNF-SD-TP-SARP-021). The beams meet both the Hanford Site Hoisting and Rigging Manual (Section 11.0) and ANSI N14.6 (Section 6.3.1(a)) criteria for use on the Hanford Site. Analysis demonstrates the beams meet a safety factor of 3 to 1 against yield for the approved load. The Hanford Site approved rating is 29,345 kg (64,500 lb).
Figure 1. Lift Test Adaptor.

Figure 2. CASTOR Lifting Beam.

1. Made from AISI A-36 Carbon Steel
2. Inspect all dimensions and tolerances
3. Tolerance on dimensions ± 1/16".
4. Safety factor of 3 on load

E. S. Storage 3/16/97

From Section

From Section
Figure 3. Lift Test Arrangement.

4.0 REFERENCES


Prüfnachweis für Lastaufnahme- und Anschlagmittel  

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Typ Baujahr 1987  

| Eigengewicht | ca. 250 kg |

Instandsetzung und Wärmebehandlung von Ketten der Güteklasse 3, 5, 6 und 8 nur von Kettenherstellern und Werkstätten, die hierzu vom Fachausschuß Eisen und Metall, Sachgebiet Ketten, ermächtigt sind.

Mit Normlast geprüft: 04.07.1996

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Instandsetzung und Wärmebehandlung von Ketten der Güteklassen 3, 5, 6 und 8 nur von Kettenherstellern und Werkstätten, die hierzu vom Fachausschuß Eisen und Metall, Sachgebiet Ketten, ermächtigt sind.

Mit Nennlast geprüft: 25.11.1996

[Signature]
### 5.2 Hanford Load Tests

---

**CRANE & RIGGING WORK ORDER**

**PAGE: 1** 03/07/97 07:59:56

---

**Job Number:** 3R-97-8754/W

---

1. **Requested By:** DONALD LARUE  
   Org. 408  
   Telephone No. 376-7105  
   MSIN G3-08

2. **Charge Code:** FK06

3. **Date of Request:** 03/04/97

4. **Response Required:** N/A

5. **Type of Work**

6. **Location**
   - **Area:** 1100AREA  
   - **Bldg:** 1171  
   - **Room:**  
   - **Other:**

7. **Description**
   
   **INSPECT- LOAD TEST 2 SPREADER BARS FOR LOADING GERMAN CASKS @ 324**
   
   CONTACT AT 324 TO GET THE SPREADER BARS IS STEVE HALSTEAD 376-3973. PERFORM A 150% LOAD TEST (66,000 LBS). ALSO PERFORM INSPECTION TO PROCEDURE 7-GN-100 & LOAD TEST TO A WRITTEN PROCEDURE IN THIS PACKAGE. RECORD ALL INFORMATION ON DATA SHEETS IN THIS PACKAGE.

---

8. **Released by:** R. J. GILLESPIE 03/03/97

9. **Craft Complete**

10. **Field Work Complete:**
    - **Cancelled**

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43 100e
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</tr>
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<td></td>
</tr>
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</table>
DATA SHEET (Sheet 4 of 5)

HOOK IDENTIFICATION RECORD

Inspection Type (Circle one): Initial/Monthly/Periodic
(Specify return to service, pre-Critical Lift, etc.)

Inspection Date ___________  Hook Location/Bldg. ___________
Hoist Mfg. ___________  Hook I.D. No. ___________
Hoist Serial No. ___________  Hook Capacity ___________
Hoist Capacity ___________  Hook Mfg. ___________
Hook Dimension "A" ___________  Hook Dimension "B" ___________
Hook Dimension "C" ___________  Original if Known

Caliper Serial No. ___________  Calibration Date ___________
Hook NDE Accept Reject Date ___________
Qualified Inspector ___________  Date ___________

NOTE: *Place numbers on hook as close to tip of hook as practical.

HOOK INSPECTION INFORMATION

1. See Attachment 1 or 2 for discontinuity repair guidelines.
2. If hook is twisted more than 10 degrees, replace hook.
3. Measure distance between "B" punch marks using calipers. The measurement between "A" punch marks is a reference standard to compare this dimension with.
### HOOK IDENTIFICATION RECORD

- **Inspection Type**: (Circle one): Initial/Monthly/Periodic
- **Inspection Date**
- **Hook Location/Bldg.**
- **Hoist Mfg.**
- **Hoist Serial No.**
- **Hoist Capacity**
- **Hook Dimension "A"**
- **Hook Dimension "B"**
- **Hook Dimension "C"**
- **Original if Known**
- **Current**
- **Caliper Serial No.**
- **Calibration Date**
- **Hook NDE Accept**
- **Reject**
- **Date**
- **Qualified Inspector**
- **Date**

**NOTE:** Place numbers on hook as close to tip of hook as practical.

### HOOK INSPECTION INFORMATION

1. See Attachment 1 or 2 for discontinuity repair guidelines.
2. If hook is twisted more than 10 degrees, replace hook.
3. Measure distance between "B" punchmarks using calipers. The measurement between "A" punchmarks is a reference standard to compare this dimension with.
LOAD TEST PROCEDURE
BELOW-THE-HOOK LIFTING DEVICE

APPROVAL: [Signature]
Facility Manager
Date

APPROVAL: [Signature]
Industrial Safety
Date

APPROVAL: [Signature]
Crane and Rigging Services Manager
Date

3/24/97
LOAD TEST INSTRUCTIONS

1.0 PURPOSE

1.1 The purpose of this procedure is to provide a sequence of operations for load testing a below-the-hook lifting device.

2.0 REFERENCES

2.1 Hanford Site Hoisting and Rigging Manual DOE-RL-92-36
2.2 WHC-CM-4-4, VOL. 1-3, Industrial Safety Manual
2.3 Environmental, Safety, and Health Program Manual.

3.0 RESPONSIBILITIES

3.1 The equipment custodian (designated by the Facility manager) is responsible for ensuring maintenance inspections and testing of equipment are not delinquent. He is also responsible for maintaining records of the repairs, inspections, tests, and any maintenance performed. He will assure these records are available for audit.

3.2 Industrial Safety shall ensure compliance with hoisting and rigging equipment requirements.

3.3 A designated leader shall be appointed to all hoisting and rigging (H&R) activities, which include both critical and noncritical lifts. For critical lifts, the designated leader may also be the PIC. For ordinary lifts, the designated leader may be a crew member.

3.4 Designated Leader or (if needed) Site Crane and Rigging Services (SC&RS) Supervisor/or Designee is responsible for (1) coordinating the test lift, (2) ensuring a procedure is prepared and approved, (3) ensuring that personnel are qualified to perform the work, (4) ensuring that all equipment and rigging are qualified.

3.4.1 Designated Leader or Supervisor shall conduct a pre-job meeting with all personnel involved in the test.

3.5 QC/NDE shall conduct NDE test of welds after load test. NDE requirements, if required, will be called out on design drawing or listed on the work package.
4.0 REQUIREMENTS

4.1 Before each load test, confirm that all equipment inspections and maintenance are current.

[Signature] Date

Equipment Custodian or Supervisor

4.2 The Equipment Custodian or the SCARS Supervisor shall verify that all rigging and accessories inspections are current.

[Signature] Date

Equipment Custodian or SCARS Supervisor

4.3 Load test weight 64.560 is known and documented within a tolerance of ±0%, ±5%. Weights shall be traceable to a recognized standard, verified by: Engineering calculations, a calibrated (±0%, ±5%) load measuring device or calculating load based on known unit weights and dimensions of test fixture.

4.3.1 Load test units accepted prior to test.

[Signature] Date

Designated Leader or SCARS Supervisor

5.0 PRE-JOB MEETING

5.1 The Designated Leader or Supervisor shall conduct a pre-job meeting prior to work start to review this procedure with all involved personnel and resolve any safety concerns. The Supervisor shall ensure involved personnel wear appropriate safety attire (e.g., hard hat, safety shoes, gloves, safety glasses, and any other personal protective equipment required). A designated signal person shall be appointed by the SCARS Supervisor.

[Signature] Date

Designated Leader or SCARS Supervisor

6.0 LOAD TEST

6.1 Barricade or rope off work area to warn unauthorized personnel of load test in progress.

6.2 Position hook or device over center of gravity of load.

6.3 Attach rigging to hook or attachment as directed by the supervisor. Stop and inspect, adjust rigging as needed.

6.4 Hoist load a few inches and hold for 5 minutes.
6.5 Set load down and remove rigging or test weight assembly. Visually inspect load bearing parts to verify that no damage has been done.

6.6 NDE of load bearing welds after load test (if required).
Type of NDE: MT PT VISUAL

NDE Accept NDE Reject

7.0 LOAD TEST REPORT

7.1 Complete load test report.

7.2 The reports shall be placed in the Crane History file by the equipment custodian.
# LOAD TEST REPORT FORM

* Building No./Facility: 324 Blq
* I.D. No.: 1-A
* Model No.: W/A
* Manufacturer: Hersteller
* Rated Capacity: 44,000
* Last Load Test Date: N/A
* Weight(s) Lifted: 64,560
* This Load Test: Weight Lifted: 64,560
* Dynamometer: Calibration ID No. 815-20-06-038
   Range: 100 Ten 15,000
   Recal Due Date: 3-5-98

Remarks:

[ ] Quality Assurance
[ ] Third Party Verification
(Check One)

Signature: W/A
Date:

After Load Test Place This Document in the Crane History File.
### 7.0 INSTRUCTIONS

(Record S - Satisfactory, U - Unsatisfactory or N/A - Not Applicable on steps below)

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<thead>
<tr>
<th>STEP</th>
<th>S-U-N/A</th>
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<th>INITIAL/DATE</th>
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DATA SHEET (Sheet 2 of 5)

7.0 INSTRUCTIONS (Record S - Satisfactory, U - Unsatisfactory or N/A - Not Applicable on steps below).

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### DATA SHEET (Sheet 3 of 5)

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DATA SHEET (Sheet 4 of 5)

HOOK IDENTIFICATION RECORD

Inspection Type (Circle one): Initial/Monthly/Periodic ____________________________
(Specify return to service, pre-Critical Lift, etc.)

Inspection Date __________________ Hook Location/Bldg. __________________
Hoist Mfg. __________________ Hook I.D. No. __________________
Hoist Serial No. ______________ Hook Capacity ______________
Hoist Capacity ______________ Hook Mfg. ______________
Hook Dimension "A" ______________ Hook Dimension "B" ______________
Hook Dimension "C" ______________

Original (If Known) Current

Caliper Serial No. __________________ Calibration Date __________________
Hook NDE Accept Rejct Date __________________
Qualified Inspector __________________ Date __________________

NOTE: *Place numbers on hook as close to tip of hook as practical.

HOOK INSPECTION INFORMATION

1. See Attachment 1 or 2 for discontinuity repair guidelines.
2. If hook is twisted more than 10 degrees, replace hook.
3. Measure distance between 'B' punchmarks using calipers. The measurement between 'A' punchmarks is a reference standard to compare this dimension with.
DATA SHEET (Sheet 5 of 5)

HOIST IDENTIFICATION RECORD

Inspection Type (Circle one): Initial/Monthly/Periodic (Specify return to service, pre-Critical Lift, etc.)

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<table>
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<tr>
<th>Original if Known</th>
<th>Current</th>
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<tbody>
<tr>
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<td></td>
</tr>
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</table>

Caliper Serial No. | Calibration Date | Date |
-------------------|------------------|------|
|                   |                  |      |

Hook MDE Accept | Reject | Date |
----------------|--------|------|
|                 |        |      |

Qualified Inspector | Date |
---------------------|------|
|                     |      |

NOTE: *Place numbers on hook as close to tip of hook as practical.

HOOSE INSPECTION INFORMATION

1. See Attachment 1 or 2 for discontinuity repair guidelines.
2. If hook is twisted more than 10 degrees, replace hook.
3. Measure distance between 'B' punchmarks using calipers. The measurement between 'A' punchmarks is a reference standard to compare this dimension with.

THESE PHRASES IN ALL 4 C 72
LOAD TEST PROCEDURE
BELOW-THE-HOOK LIFTING DEVICE

APPROVAL:  

W/IA  V2.6  
Facility Manager  Date

APPROVAL:  

W/IA  V2.6  
Industrial Safety  Date

APPROVAL:  

[Signature]  3/24/97  
Crane and Rigging Services Manager  Date
LOAD TEST INSTRUCTIONS

1.0 PURPOSE
1.1 The purpose of this procedure is to provide a sequence of operations for load testing a below-the-hook lifting device.

2.0 REFERENCES
2.1 Hanford Site Hoisting and Rigging Manual DOE-RL-92-36
2.2 WHC-CM-4-4, VOL. 1-3, Industrial Safety Manual
2.3 Environmental, Safety, and Health Program Manual

3.0 RESPONSIBILITIES
3.1 The equipment custodian (designated by the Facility manager) is responsible for ensuring maintenance inspections and testing of equipment are not delinquent. He is also responsible for maintaining records of the repairs, inspections, tests, and any maintenance performed. He will assure these records are available for audit.

3.2 Industrial Safety shall ensure compliance with hoisting and rigging equipment requirements.

3.3 A designated leader shall be appointed to all hoisting and rigging (H&R) activities, which include both critical and noncritical lifts. For critical lifts, the designated leader may also be the PIC. For ordinary lifts, the designated leader may be a crew member.

3.4 Designated Leader or (if needed) Site Crane and Rigging Services (SC&RS) Supervisor/or Designee is responsible for (1) coordinating the test lift, (2) ensuring a procedure is prepared and approved, (3) ensuring that personnel are qualified to perform the work, (4) ensuring that all equipment and rigging are qualified.

3.4.1 Designated Leader or Supervisor shall conduct a pre-job meeting with all personnel involved in the test.

3.5 QC/NDE shall conduct NDE test of welds after load test. NDE requirements, if required, will be called out on design drawing or listed on the work package.
4.0 REQUIREMENTS

4.1 Before each load test, confirm that all equipment inspections and maintenance are current.

Eqipment Custodian or Supervisor

3/26/97

4.2 The Equipment Custodian or the SCARS Supervisor shall verify that all rigging and accessories inspections are current.

Eqipment Custodian or SCARS Supervisor

3/26/97

4.3 Load test weight is known and documented within a tolerance of +10%, -5%. Weights shall be traceable to a recognized standard, verified by: Engineering calculations, a calibrated (+10%, -5%) load measuring device or calculating load based on known unit weights and dimensions of test fixture.

4.3.1 Load test units accepted prior to test.

Designated Leader or SCARS Supervisor

3/24/97

5.0 PRE-JOB MEETING

5.1 The Designated Leader or Supervisor shall conduct a pre-job meeting prior to work start to review this procedure with all involved personnel and resolve any safety concerns. The Supervisor shall ensure involved personnel wear appropriate safety attire (e.g., hard hat, safety shoes, gloves, safety glasses, and any other personal protective equipment required). A designated signal person shall be appointed by the SCARS Supervisor.

Designated Leader or SCARS Supervisor

3/26/97

6.0 LOAD TEST

6.1 Barricade or rope off work area to warn unauthorized personnel of load test in progress.

6.2 Position hook or device over center of gravity of load.

6.3 Attach rigging to hook or attachment as directed by the supervisor. Stop and inspect, adjust rigging as needed.

6.4 Hoist load a few inches and hold for 5 minutes.
6.5 Set load down and remove rigging or test weight assembly. Visually inspect load bearing parts to verify that no damage has been done.

6.6 NDE of load bearing welds after load test (if required).

<table>
<thead>
<tr>
<th>Type of NDE</th>
<th>MT</th>
<th>PT</th>
<th>VISUAL</th>
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<tr>
<td>NDE Accept</td>
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<td></td>
</tr>
<tr>
<td>NDE Reject</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.0 LOAD TEST REPORT

7.1 Complete load test report.

7.2 The reports shall be placed in the Crane History file by the equipment custodian.
LOAD TEST REPORT FORM

* Building No./Facility 324 Bldg.  Load Test Date 3-26-97
* I.D. No. 1-18  Model No. W/A  Manufacturer Hersteller
* Rated Capacity 44,000
* Last Load Test Date 1-18  Weight(s) Lifted 64,560
* This Load Test: Weight Lifted 64,560
* Dynamometer: Calibration ID No. 815-24-J6-038  Recal Due Date 3-5-98
  Range 50 ton + 300 lbs

Remarks:

[ ] Quality Assurance
[ ] Third Party Verification
   (Check One)

Signature  Date

After Load Test Place This Document in the Crane History File.
5.3 CASTOR LIFTING BEAM EVALUATION

ENGINEERING SAFETY EVALUATION
Subject: CASTOR LIFTING BEAM EVALUATION
Originator: S. S. Shiraga
Checker: S. R. Crow

I. Objective:

The objective of this evaluation is ensure the CASTOR lifting beam meets the requirements of the Hanford Site Hoisting and Rigging Manual. The requirement is a safety factor of 3 to 1 based on yield strength.

II. References:


HNF-SD-TP-SARP-021, Safety Analysis Report for Packaging (Onsite) CASTOR GSF Cask, RFS NW Operations, Richland, WA.


D-Krantechnik, Lifting Beam Structural Calculations, Ratingen, Germany, May 7, 1996.

III. Results and Conclusions:

Results of this evaluation verifies the CASTOR Lifting Beam meets the requirements of the Hoisting and Rigging Manual (DOE, 1993). The evaluation is based on the nominal strengths of equivalent German structural steel. As shown in the evaluation the safety factors for the most critical components are equal to or greater than 3. Within this evaluation, the welds are assumed to have the same structural strength as the parent material. Since the welds are not located critical or high load areas, they are not evaluated.
IV. Evaluation:

**CASTOR LIFTING BEAM EVALUATION**

Assumed lifting weight of CASTOR w/o impact limiters (CASTOR SARP): \( W_{\text{cast}} = 41000 \text{ lbf} \)

Assumed maximum lifting weight of Lifting Beam: \( W_{\text{max}} = 44000 \text{ lbf} \)

Beam material (RS1 37-2) yield strength:

\[
\sigma_{37Y} = 225 \text{ newton/mm}^2
\]

ASTM Equivalent A-570.

Eye plate (St 52-2) yield strength:

\[
\sigma_{52Y} = 345 \text{ newton/mm}^2
\]

ASTM Equivalent A-516.

Lifting pin (St 50) yield strength:

\[
\sigma_{50Y} = 275 \text{ newton/mm}^2
\]

ASTM Equivalent A-515.

![Diagram of beam and lifting pin with dimensions in mm.](image)
Determine moment of inertia of I beam section about the axis perpendicular to the web:

Width of flange: \( w_f = 7.38 \text{ in} \)
Depth of section: \( s_d = 7.75 \text{ in} \)
Flange thickness: \( t_f = 0.88 \text{ in} \)

Thickness of web: \( t_w = 0.75 \text{ in} \)
Depth of web: \( w_s = s_d - 2t_f \)

Moment of inertia (Hudson, 1939, page 84):
\[
I_{bs} = \frac{w_f s^3_d - w_s^3}{12} = 168 \text{ in}^4
\]

Distance of center of gravity:
\[
d_{icg} = \frac{d}{2} = 3.87 \text{ in} \quad \text{Section Modulus:} \quad S_{bs} = \frac{I_{bs}}{d_{icg}}
\]

Cross sectional area:
\[
A_{bs} = 2t_f w_f + \frac{1}{2} w_s \quad A_{bs} = 17.48 \text{ in}^2
\]

Area of compression flange:
\[
A_f = t_f w_f \quad A_f = 6.49 \text{ in}^2
\]

Evaluate to AISC Design Requirements:

Width to thickness ratio: \( \frac{w_f}{2t_f} = 4.19 \)
Limiting width to thickness ratio: \( \frac{65}{37 \text{ ksi}} = 11.38 \)

Since width to thickness ratio not limiting, section is compact.

Determine value of limiting laterally unsupported length for compact section in strong axis bending:

\[
\frac{76w_f}{37 \text{ ksi}} = 8.18 \text{ ft} \quad \text{or} \quad \frac{20000}{A_f} = 42.8 \text{ ft}
\]

Unsupported length of I beam: \( L_b = 1740 \text{ mm} \quad L_b = 5.71 \text{ ft} \)

Therefore, since critical length not exceeded flexure allowable of beam is: \( s_{37k} = 0.66 \times 37 \text{ ksi} \quad s_{37k} = 21.5 \text{ ksi} \)

Loading on Main Beam:

Idealize loading as a simply supported beam with a partially distributed uniform load over center section.


Length between load: \( l_1 = 1740 \text{ mm} - 2 \times (175 \text{ mm}) \)
Load width: \( b_1 = 550 \text{ mm} \)

Distance from load:
\[
a_1 = \frac{l_1 - b_1}{2} = 420 \text{ mm}
\]

Load on unit: \( F_t = W_{\text{max}} \)
Load per unit length:
\[
f_1 = \frac{F_t}{b_1}
\]

\[f_1 = 2032 \text{ lb} / \text{in} \]
Since symmetrical, reaction load at load points: 

\[ R_1 = \frac{f_1 b_1}{2 \alpha_1} \left( \frac{2 \alpha_1 + b_1}{2} \right) \]

\[ R_1 = 22000 \text{lb} \]

Maximum Moment: 

\[ M_{max} = R_1 \left( \frac{a_1 + R_1}{2 f_1} \right) \]

\[ M_{max} = 48287 \text{lb}\cdot\text{in} \]

Bending stress: 

\[ \sigma_b = \frac{M_{max}}{S_{bs}} \]

\[ \sigma_b = 11.17 \text{ksi} \]

Shear at Edge: 

\[ \tau_b = \frac{R_1}{A_{bs}} \]

\[ \tau_b = 1.26 \text{ksi} \]

Safety Factor based on Yield Strength: 

\[ SF_b = \frac{37}{\sigma_b} \]

\[ SF_b = 3 \]

Loading on Lift Pin: 

Assume as cantilevered circular beam that is loaded between cask lifting beam. Treat as short beam.

Pin diameter: 

\[ d_{pin} = 58 \text{mm} \]

Load on pins: 

\[ F_p = \frac{F_1}{2} \]

\[ F_p = 22000 \text{lb} \]

Cross sectional area of pin: 

\[ A_p = \pi \frac{d_{pin}^2}{4} \]

Moment of inertia of cross section: 

\[ I_p = \frac{\pi d_{pin}^4}{64} \]

Distance between pin supports: 

\[ l_{ps} = 1740 \text{mm} - 2(20 + 135 + 20) \text{mm} \]

Gap between cask and lifting beam: 

\[ l_g = \frac{l_{ps} - 1365 \text{mm}}{2} \]

\[ l_g = 0.49 \text{in} \]
Shear stress on pin: \( \tau_p = \frac{F_p (d_{pin})^2}{2 l_p} \quad \tau_p = 7.16\text{ksi} \)

Bending: \( \sigma_p = \frac{F_p l_e d_{pin}}{l_p} \) \( \sigma_p = 9.26\text{ksi} \)

Principal stress: \( \sigma_1 = \sigma_p + \sqrt{\frac{(\sigma_p)^2}{2} + (\tau_p)^2} \) \( \sigma_1 = 13.2\text{ksi} \)

Safety Factor based on Yield Strength: \( SF_p = \frac{5.50\text{ksi}}{\sigma_1} \) \( SF_p = 3 \)

Loading on lifting eye:

Thickness of plate: \( t_e = 25\text{mm} \) Length on each side of opening: \( l_e = 115\text{mm} \)

Distance to outside edge: \( d_{oe} = 125\text{mm} \)

Tensile stress on lifting eye: \( \sigma_{et} = \frac{F_t}{2 t_e l_e} \) \( \sigma_{et} = 4.94\text{ksi} \)

Safety Factor based on Yield Strength: \( SF_{et} = \frac{5.52\text{ksi}}{\sigma_{et}} \) \( SF_{et} = 10.1 \)

Shear tearout: \( \tau_{tet} = \frac{F_t}{2 t_e d_{oe}} \) \( \tau_{tet} = 4.54\text{ksi} \)

Safety Factor based on Yield Strength: \( SF_{tet} = \frac{5.52\text{ksi}}{\tau_{tet}} \) \( SF_{tet} = 11 \)
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(HNF-SD-TP-RPT-026)

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