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# FAILURE MODES & EFFECTS ANALYSIS (FMEA)
# FOR CRANE NO. 226-1
# LOCATED IN BUILDING 226

Document No.

81-01-780

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PREPARED BY: _____ 10-19-12
R. Patterson, LDE Engineer, QinetiQ North America Date

APPROVED BY: _____ 10/19/12
L. Olsen, Code 660, NASA/GSFC Date

APPROVED BY: _____ 10/19/12
T. Schafer, Quality Operations Engineer, QinetiQ North America Date

APPROVED BY: _____ 18 Oct 12
S. Kowall, Supervisor, LDE Recertification Department, QinetiQ North America Date

APPROVED BY: _____ 10/31/12
Brian Montgomery, LDE Manager Code 540, NASA/GSFC Date

QinetiQ North America
Recertification Department
Goddard Space Flight Center
Greenbelt, Maryland 20771

Table of Contents

## Preface

This document includes the following:

- Critical Items List (CIL)
- Rationale for retaining the Critical Items
- Controls and verifications
- Recommendations

This document is compliant with the general methodology of NSTS 22206, "Requirements for Preparation and Approval of Failure Modes and Effects Analysis and Critical Items List".

## List of Tables



## List of Figures



## List of References

The following documents were used in completing this analysis:


1. NSTS 22206, "Requirements for Preparation and Approval of Failure Modes and Effects Analysis and Critical Items List."

2. NASA-STD-8719.9, "Standard for Lifting Devices and Equipment." Latest revision

3. NPR 8715.3. "NASA General Safety Program Requirements", latest edition.

4. GPR 8719.1. "Certification and Recertification of Lifting Devices and Equipment and Its Operators", Latest revision.

5. "Lifting Device Operator Daily Crane and Hoist Inspection and Limit Switch Test," RECERT-42-001, Latest revision.

## 1.0 Summary of Findings

### 1.1 System Criticality

Crane 226-1 is a 1/2 ton Gantry Hoist assessed as critical because failure of the crane could cause the loss of life and/or critical hardware. Crane 226-1 is compliant in all requirements as stipulated in NASA-STD-8719.9, "Standard for Lifting Devices and Equipment" for critical lifts. The crane functions are identified and assessed on the Criticality Summary Sheet (see Section 2.2).

### 1.2 Mechanical Critical Items

The Mechanical Critical Items identified in this analysis are summarized below. There are no Electrical Critical Items. The Rationale for Acceptability is documented as part of the Critical Items List (see Section 2.5)

| No. | Critical Item | Original Criticality | Downgraded Criticality | Risk |
|---|---|---|---|---|
| 1. | Sheave Gear | 1 | 3 | Controlled |
| 2. | Hoist Gearbox | 1 | 3 | Controlled |
| 3. | Hoist Mechanical Load Brake | 1R | 3 | Controlled |

The Criticality Category of the critical items was downgraded from the original 1/1R criticality to a "3" due to the implementation of defined and approved Frequent and Periodic Inspection procedures.

**GSE CRITICALITY CATEGORY DEFINITIONS**

| Criticality | Potential Effect or Failure |
|---|---|
| 1 | Single failure, which could result in loss of life or load |
| 1R | Two redundant hardware items, which if both failed, could result in loss of life or load (or loss of a safety or hazard monitoring system) |
| 1S | Single failure in a safety or hazard monitoring system that could cause the system to fail to detect, combat, or operate when needed during the existence of a hazardous condition that could result in loss of life or load. |
| 2 | Single failure, which could result in loss (damage) of a load. |
| 3 | All others. |

**TABLE 1**

1.3 Electrical Critical Items

There were no electrical critical items identified in this lifting device.

1.4 Hazards Identified

Justification for retaining the critical items listed above was based on the data elements provided in Section 2.5. This Rationale included the following information: Design, Test, Inspection, Failure History, and Operational Use. Risk assessment based on the criteria identified in NSTS 22206, "Requirements for Preparation and Approval of Failure Modes and Effects Analysis and Critical Items List," determined the risk acceptable/controlled for the retention of the above critical items.

1.5 Critical Flex hoses

There were no critical flex hoses identified in this lifting device.

1.6 Critical Orifices

There were no critical orifices identified in this lifting device.

1.7 Critical Filters

There were no critical filters identified in this lifting device.

1.8 End-to-End Areas of Concern

No areas of concern were identified which are the design responsibility of other contractors or NASA centers.

1.9 Sneak Circuits Identified

There was no Sneak Circuit Analysis performed for Crane 226-1.

2.0 Failure Mode and Effects

2.1 System Description

General

Crane 226-1 consists of a Harrington Type CB005 1/2 Ton Manual Chain Hoist, Serial No. 691240, Model No. TF2-446 supported by a Gorbel Gantry, Serial No. 336630 located in Building 226 at GSFC. Standards require that a Frequent Inspection be made every month and a Periodic Inspection be made each year. In addition, since this lifting device is used for critical lifting, a rated load test is included as part of the annual Periodic Inspection. The crane supports the loading, unloading, assembly and handling of critical payloads and space flight hardware. GPR 8719.1, "Certification and Recertification of Lifting Devices and Equipment and Its Operators" addresses the need

for a Failure Modes and Effects Analysis of the structural/mechanical load path, electrical power and control components.

Hoist & Trolley

The hoist and trolley unit is a high quality off-the-shelf Harrington Type CB manual chain hoist with manual chain powered trolley. The load chain is Grade 100 heat-treated manganese alloy load chain. The hoist function of this lifting device is controlled with a manual hand chain. The trolley function of this lifting device is controlled by manually positioning the load. The trolley is free to roll.

Main Hoist

The hoisting unit is provided with a single means of braking, capable of bringing a rated load to zero speed and holding it. This mechanical load brake is a holding brake on the gear side of the drive.

Controls

The lifting device has the following controls: Hoist: Up/Down. The Trolley is controlled with a manual hand chain. Trolley and bridge translation are controlled by manual positioning of the load, rigging and or the gantry.

Passive Components

Passive components will not be analyzed in the FMEA. The current list of passive components includes the hook, load block, load chain, and load chain sheave. However, the sheave and bearing shafts have been analyzed as to the attachment method and the bearings have been analyzed only to determine if the bearings could fail and drop the load. Their requirements are in accordance with NSTS 22206. The summary of the analysis is presented below.

| Component | Failure Effect |
|---|---|
| LH and RH Sheave Pinion Shaft Bearings | Loss of function |
| Intermediate Pinion Shaft bearings | Loss of function |
| Motor Pinion Shaft Bearings | Loss of function |
| Trolley Wheel Bearings | Impaired function |

Bearings

Bearings on sheaves and shafts were analyzed to determine if bearing failure could result in dropping the load. Impairment of the bearing mechanical integrity would be preceded by several events, each of which would provide a warning to the operator, and assist to negate dropping the load, e.g.,

- Mounting tolerances altered to cause interference with the mounting enclosure

- Obvious visible mechanical aberrations due to wear and tear of bearing hardware seen during routine inspections
- The bearing mounting would contain the shaft in the event of bearing failure. Multiple failures would be required prior to this event.

Analysis indicated the bearings to be acceptable.

2.2 System Criticality Assessment

The crane functions are identified and assessed on the following System Criticality Assessment Summary Sheet.

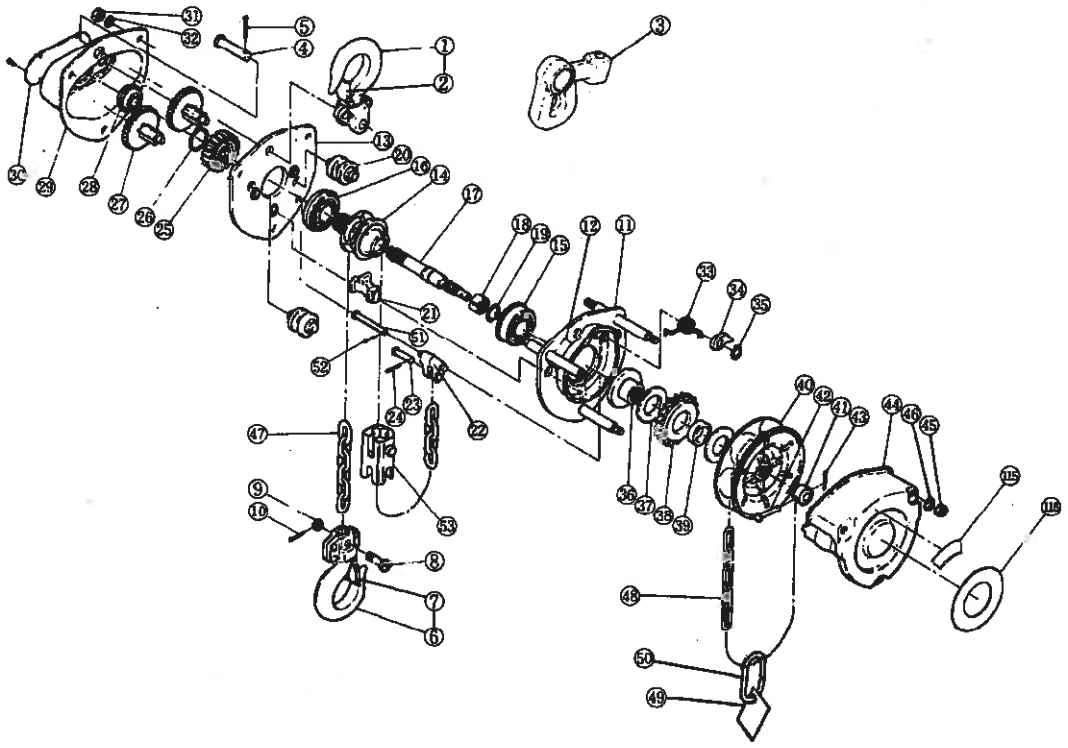
**Table 2: System Criticality Assessment Summary Sheet**

System: 1/2 Ton Jib Gantry Chain Hoist
Location: Building 226
Crane No: 226-1
Date: September 2012

| OUTPUT | FUNCTION | EFFECT OF LOSS/FAILURE | CRIT CAT | NOTES |
|---|---|---|---|---|
| Hoist System | Provides ability to lift/lower loads up to 1/2 ton. | Failure of the hoist system could cause severe injury, major damage to property or flight hardware. | CRIT | |
| Hoist Braking System | Provides ability to bring a rated load to zero speed and hold it. | Failure of the hoist braking system could cause severe injury, major damage to property or flight hardware. | CRIT | |
| Trolley System | Provides ability to move load right or left the width of the jib | Failure of the trolley system could cause the load to contact facility structure and/or other flight hardware, severe injury, major damage to property or flight hardware. | CRIT | |
| Trolley Brake System | Provides ability to stop and hold trolley in required position | Failure of the trolley brake could cause impact with facility structure and/or other flight hardware, severe injury, major damage to property or flight hardware. | CRIT | |
| Jib | Provides ability to traverse entire length of the beam | Failure of the jib could cause flight hardware to contact facility structure and/or other flight hardware, severe injury, major damage to property or flight hardware | CRIT | |


**Crane 226-1 Fig. 1**

**Exploded View**



**Hoist Gearbox Fig. 2:**

## 9.1 1/2 to 20 Ton Parts

| Fig. No. | Part Name | Qty per Hoist | Capacity (T) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1/2 | 1 | 1½ & 3 | 2 | 2½ - 5 - 8 | 10 - 15 - 20 |
| *1 | Top Hook Set | 1 | CF001005 | CF001010 | *CF001015 | M3001A020 | *M3001A025 | |
| *2 | Latch Assembly | 1 | CF071005 | CF071010 | *CF071015 | CF071020 | CF071050 | |
| *3 | Suspender G | 1 | M3003010 | | | | | |
| | Suspender | 1 | | M3004015 | | M3004020 | M3004025 | |
| 4 | Top Pin | 1 | M3163005 | M3163010 | M3163015 | M3163020 | M3163025 | |
| 5 | Split Pin | 1 | 9009423 | | | 9009424 | | |
| *6 | Bottom Hook Set | 1 | M3021A005 | M3021A010 | *M3021A015 | M3021A020 | *M3021A025 | |
| *7 | Latch Assembly | 1 | CF071005 | CF071010 | *CF071015 | CF071020 | *CF071030 | |
| *8 | Chain Pin | 1 | M3041005 | M3041010 | *M3041015 | M3041020 | *M3041025 | |
| *9 | Slotted Nut | 1 | M3049005 | M2049010 | *M2049010 | *M2049020 | | |
| *10 | Split Pin | 1 | 9009402 | *9009411 | | *9009412 | | |
| 11 | Side Plate A Assy | 1 | M3101005 | M3101010 | M3101015 | M3101020 | M3101025 | |
| | Side Plate A Assy (M3B Model) | 1 | | | | | M3B101025 | |
| 12 | Nameplate F | 1 | C3BA0056B05 | | | | | |
| 13 | Side Plate B Assy | 1 | M3102005 | M3102010 | M3102015 | M3102020 | M3102025 | |
| | Side Plate B Assy (M3B Model) | 1 | | | | | M3B102025 | |
| 14 | Load Sheave | 1 | M3116005 | M3116010 | M3116015 | M3116020 | M3116025 | |
| 15 | Ball Bearing | 1 | M3140005 | | | M3140020 | | |
| 16 | Ball Bearing | 1 | M3145005 | | M3140005 | | M3140020 | |
| 17 | Pinion | 1 | M3111005 | M3111010 | M3111015 | M3111020 | M3111025 | |
| | Pinion (M3B Model) | 1 | | | | | M3B111025 | |
| 18 | Roller Bearing | 1 | M3130005 | | | M3130020 | | |
| 19 | Snap Ring | 1 | M3118005 | | | M3118020 | | |
| 20 | Guide Roller | 2 | M3161005 | M3161010 | M3161015 | M3161020 | M3161025 | |
| 21 | Stripper | 1 | M3162005 | M3162010 | M3162015 | M3162020 | M3162025 | |
| 22 | Anchorage | 1 | M3176005 | M3176010 | M3176015 | M3176020 | M3176025 | |
| 23 | Stopper Pin | 1 | M3177005 | M3177010 | M3177015 | M3177020 | M3177025 | |
| 24 | Split Pin | 1 | 9009412 | 9009415-5 | | | | |
| 25 | Load Gear | 1 | M3114005 | M3114010 | M3114015 | M3114020 | M3114025 | |
| 26 | Snap Ring | 1 | 9047123 | | 9047128 | | 9047132 | |
| 27 | Gear No. 2 Assy | 1 | M3112005 | | | | | |
| | Gear No. 2 Assy | 2 | | M3112010 | M3112015 | M3112020 | M3112025 | |
| | Gear No. 2 Assy (M3B Model) | 2 | | | | | M3B112025 | |
| 28 | Ball Bearing | 1 | M3135005 | | | M3135020 | | |
| 29 | Gear Case Assy | 1 | M3103005 | M3103010 | M3103015 | M3103020 | M3103025 | |
| 30 | Nameplate B w/ Rivets | 1 | M3600005 | M3600010 | *M3600015 | M3600020 | | |
| | Nameplate B w/ Rivets (M3B Model) | 1 | | | | | *M3600025 | |
| 31 | Nut | 3 | 9093424 | | | 9093427 | 9093433 | |

*Part number applies to 1½ or 2½ Ton capacities only. See additional parts list for 3, 5, and 8 Ton capacities.

## 9.1 1/2 to 20 Ton Parts

| Fig. No. | Part Name | Qty per Hoist | Capacity (T) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1/2 | 1 | 1½ & 3 | 2 | 2½ - 5 - 8 | 10 - 15 - 20 |
| 32 | Spring Washer | 3 | 9012711 | | | 9012712 | 9012713 | |
| 33 | Pawl Springs Assembly | 1 | C3SA0055179 | | | | | |
| 34 | Pawl | 1 | M3155005 | | | | | |
| 35 | Snap Ring | 1 | 9047110 | | | | | |
| 36 | Friction Disc | 1 | M3153005 | | | M3153020 | | |
| | Friction Disc (M3B Model) | | | | | | M3B153025 | |
| 37 | Friction Plate | 2 | M3151005 | | | M3151020 | | |
| | Friction Plate (M3B Model) | | | | | | M3B151025 | |
| 38 | Ratchet Disc | 1 | M3152005 | | | M3152020 | | |
| | Ratchet Disc (M3B Model) | | | | | | M3B152025 | |
| 39 | Bushing | 1 | M3154005 | | | M3154020 | | |
| | Bushing (M3B Model) | | | | | | M3B154025 | |
| 40 | Hand Wheel | 1 | M3115005 | | M3115015 | M3115020 | M3115025 | |
| | Hand Wheel (M3B Model) | | | | | | M3B115025 | |
| 41 | Wheel Stopper | 1 | CF159005 | | | CF159010 | | |
| 42 | Wheel Stopper Pin | 1 | M2187005 | | | | | |
| 43 | Split Pin | 1 | 9009410 | | | | | |
| 44 | Wheel Cover Assy | 1 | M3171005 | | M3171015 | M3171020 | M3171025 | |
| 45 | Nut | 3 | 9093424 | | | | | |
| 46 | Spring Washer | 3 | 9012711 | | | | | |
| 47 | Load Chain | 1@ ft. | LCCF005 | LCCF010 | LCCF015 | LCC3020 | LCC3025 | |
| 48 | Hand Chain | 1@ ft. | HCCF005 | | | | | |
| 49 | Warning Tag | 1 | WTAG9 | | | | | |
| 50 | Chain Stopper Link | 1 | L4045030 | | | | | |
| 115 | Slip Clutch Label | 1 | C3YU0059802 | | | C3YU0209802 | | |
| 116 | Harrington Label | 1 | M3700005 | | M3700015 | M3700020 | M3700025 | |
| 117 | Hand Chain Masterlink | 1** | HCCF005ML | | | | | |

*Part number applies to 1½ or 2½ Ton capacities only. See additional parts list for 3, 5, and 8 Ton capacities.
**20 Ton capacity requires Quantities of 2.

2.3 Failure Modes And Effects Analysis And Critical Items List

Mechanical FMEA Worksheets
The mechanical components of this equipment are identified and are analyzed on the following FMEA worksheet.

**TABLE 3: FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET**

System: 1/2 Ton Gantry Chain Hoist — Crane No, 226-1
Subsystem: Sheave Assembly/Hoist Gearbox — Date: September 2012

| PART NAME | PART FUNCTION | FAILURE MODE AND CAUSE | FAILURE EFFECT ON SYSTEM PERFORMANCE | FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY | CRIT CAT |
|---|---|---|---|---|---|
| Sheave Gear | Transmits lifting torque, gear reduction | Disengages/ Excessive load | Torque for holding load will be lost. Load will drop. | Severe injury, major damage to property and flight hardware. | 1 |
| Hoist Gearbox | Transmits power from hand chain to sheave. | Structural failure of components. | Load will drop. | Severe injury, major damage to property and flight hardware. | 1 |
| Primary Brake (Mechanical Load Brake) | Stops and holds hoist movement when hoist is not in use | Premature deactivation (structural failure of components) | Inadvertent braking, inability to raise and lower crane cargo | No effect. Delay in operation | 1R |

2.4 Critical Items List (CIL)

| No. | Critical Item |
|---|---|
| 1 | Sheave Gear |
| 2 | Hoist Gearbox |
| 3 | Hoist Mechanical Load Brake |

2.5 Critical Items Acceptance Rationale

The justification for retaining the identified critical items is presented here. The rationale is comprised of the following elements as defined in the critical item sheets which follow:

## Critical Item 1- Sheave Gear

| No. | Contents |
|---|---|
| 1 | Item Identification: Sheave Gear |
| 2 | Critical Category: 1 |
| 3 | Function: Transmits lifting torque and provides gear reduction |
| 4 | Failure Mode: Gear disengages |
| 5 | Cause: Exceeding hoist capacity, wear, excessive torque, poor lubrication |
| 6 | Failure Mode Number: N/A |
| 7 | Failure Effect: Torque for holding load will be lost. Load will drop. Loss of critical hardware/personnel safety |
| 8 | Rationale for acceptance includes the following items: |

A. Design

The hoist is designed to meet all OSHA requirements cited in OSHA29 CFR 1910.179 applicable to a manual chain hoist. The sheave gear meets the requirements for Class C, "moderate service" and is manufactured to AGMA quality class 5 or better. Gears are smooth running, heat treated, alloy steel, straight line, spur type. The hoist complies with the requirements of ASME B30.16, Overhead Hoists (Underhung), and ASME HST-2, Performance Standard for Manually Operated Chain Hoists.

B. Test

Specific tests to detect failure modes and causes during acceptance test and certification tests were performed, i.e.:

- Factory tests before shipment
- Crane acceptance test procedures

C. Inspections

Inspections are performed to a) detect whether or not critical failure modes have occurred and b) to minimize the probability of occurrence of the failure mode and cause. The following inspections are pertinent to the sheave gear.

A daily test is performed by the certified crane operator prior to first use, each day the crane is used. See RECERT 42-001, latest revision.

Functional operating and control mechanisms are checked for maladjustments that could interfere with normal operations.

Frequent and Periodic Inspections are performed in accordance with NASA-STD-8719.9. Periodic inspections are performed annually to identify wear in sheave gear parts that are readily accessible without major disassembly beyond an acceptable limit.

D. Failure History

Severe injury, major damage to property and flight hardware resulting from the loss of the hoist sheave gear has not been experienced since the inception of the LDE Program.

E. Operational Use

Critical lift operators are trained not to exceed lifting the capacity of the crane and in the specific hazards and special procedures associated with the crane. Emergency procedures are addressed for contingency actions or other emergencies.

## Critical Item 2 – Hoist Gearbox

| No. | Contents |
|---|---|
| 1 | Item Identification: Hoist Gearbox |
| 2 | Criticality Category: 1 |
| 3 | Function: Transmits power from hand chain to sheave. |
| 4 | Failure Mode: Gear disengagement |
| 5 | Cause: Structural failure of components, excessive wear. |
| 6 | Failure Mode Number: N/A |
| 7 | Failure Effect: Torque for holding load will be lost. Load will drop. |
| 8 | Rationale for acceptance includes the following items: |

A. Design

The design features which minimize the probability of occurrence of the critical failure mode and causes are listed here.

- Gear/shaft attachment methods are approved by hoisting standards.
- Gearing is designed/manufactured in accordance with AGMA standards.

B. Test

The following identify specific tests to detect failure modes and causes during acceptance and certifications tests.

Factory Tests Before Shipment:

The manufacturing date of the hoist gearbox is unknown. However, the crane was installed as new at GSFC in September 2012. Factory tests are standard procedures for this type of equipment. See Attachment 1 for a copy of Harrington's Load Test Certificate

Examination

The equipment was examined for compliance with the requirements of the specification. This element of inspection encompassed all visual examinations and dimensional measurements.

Tests After Erection

After the crane was installed, it was adjusted, lubricated, and otherwise made ready for operation and was tested by the LDE Certification Group in accordance with GPR 8719.1.

C. Inspection

Inspections are performed to a) detect whether or not critical failure modes have occurred and b) to minimize the probability of occurrence of the failure mode and cause. The following inspections are pertinent to the hoist gearbox.

Daily, functional, operational test and inspection is performed by the certified crane operator prior to first use, each day the crane is used. See RECERT 42-001, latest revision.

Functional operating and control mechanisms are checked for maladjustments that could interfere with normal operations.

Frequent and Periodic Inspections are performed in accordance with NASA-STD-8719.9. Periodic Inspections are performed annually to identify wear in brake system parts that are readily accessible without major disassembly beyond an acceptable limit.

D. Failure History

Severe injury, major damage to property and flight hardware resulting from loss of the hoist gearbox has never been experienced since the inception of the RECERT Program.

E. Operational Use

Gear teeth would have to be lost to effectively impair the mechanical integrity of the load path. The certified crane inspector would notice such an abnormal condition during scheduled periodic inspection. Critical lift operators are trained not to exceed the lifting capacity of the crane and in the specific hazards and special procedures to mitigate the effects of a failure once it has occurred.

## Critical Item 3 – Hoist Mechanical Load Brake

| No. | Contents |
|---|---|
| 1 | Item Identification: Hoist Mechanical Load Brake, Weston type lowering brake which is actuated by a roller ratchet and serves to limit the speed of descent and hold the load. |
| 2 | Criticality Category: 1R |
| 3 | Function: Hold load after hoisting |
| 4 | Failure Mode: a. Fails to engage<br>b. Possible over-speeding of cargo while lowering |
| 5 | Cause: a. Structural failure of components<br>b. Wear, Contamination |
| 6 | Failure Mode Number: N/A |
| 7 | Failure Effect: a. Brake will set<br>b. Load will hold |
| 8 | Critical Items List Acceptance Rationale includes the following items: |

A. Design

The mechanical load brake controls the lowering speed of the load and prevents the load from dropping. The mechanical load brake consists of an ACME threaded shaft with a fixed flange, a drive gear with an ACME threaded bore, a ratchet with friction linings riveted to each side, and a spring controlled pawl mounted in the gear case. During the raising cycle, the drive gear is driven counterclockwise and the ACME thread causes the drive gear to compress the ratchet between itself and the fixed flange on the shaft. The spring loaded pawl is thrown away from the ratchet and therefore no braking action takes place. During the lowering cycle, the hand chain shaft is driven clockwise. The load on the hook tends to keep the brake closed. The pawl engages the ratchet and forces the ratchet to slip between the driven gear and flange thereby creating the braking torque.

B. Test

Periodic testing is performed annually for recertification of Crane 226-1. Testing is performed in accordance with Section 6.3 of NASA-STD-8719.9. The Operational Test includes a demonstration of the brake's ability to stop and hold a load.

C. Inspections

Inspections are performed to a) detect whether or not critical failure modes have occurred and b) to minimize the probability of occurrence of the failure mode and cause.

Frequent and Periodic Inspections are performed in accordance with NASA-STD-8719.9.

D. Failure History

Severe injury, major damage to property and flight hardware resulting from disc brake failure has not been experienced since the inception of the LDE program.

E. Operational Use

Critical Lift Operators are trained not to exceed the lifting capacity of the crane and in the specific hazards and special procedures associated with the lift. Emergency procedures are addressed for contingency actions in lift specific procedures required for critical lifts.

## 3.0 Risk Assessment

The following risk assessment evaluation was performed using the risk assessment Matrix. The Severity, Probability, Estimates and Risk Assessment Code (RAC) Number for each of the Critical Items is documented. The Controls are considered to be in place to achieve minimum residual risk. Definitions for risk Severity Class and Probability Estimate follow.

Risk Severity Class:

Severity is an assessment of the worst potential consequence, defined by degree of injury or property damage, which would occur. The severity classifications are defined as follows:

Class I – Catastrophic – A condition that may cause death or permanently disabling injury, facility destruction on the ground, or loss of crew, major systems, or vehicle during the mission.

Class II – Critical – A condition that may cause severe injury or occupational illness, or major property damage to facilities, systems, equipment, or flight hardware.

Class III – Moderate – A condition that may cause minor injury or occupational illness, or minor property damage to facilities, systems, equipment or flight hardware.

Class IV – Negligible – A condition that could cause the need for minor first aid treatment though would not adversely affect personal safety or health. A condition that subjects facilities, equipment, or flight hardware to more than normal wear and tear.

Probability Estimate:

Probability is the likelihood that an identified hazard will result in a mishap, based on an assessment of such factors as location, exposure in terms of cycles or hours of operation, and affected population. The following is an example of Probability Estimation:

| | |
|---|---|
| A. | Likely to occur immediately |
| B. | Probably will occur in time |
| C. | May occur in time |
| D. | Unlikely to occur |
| E. | Improbable to occur |

The risk matrix is completed by documenting each hazard cause severity and likelihood of occurrence in the appropriate risk assessment code block.

3.1 Risk Assessment Code (RAC) and Closure

Table 4
Crane 226-1 Risk Assessment Code Matrix

| | Probability Estimate | | | | |
|---|---|---|---|---|---|
| Severity Class | A | B | C | D | E |
| I | 1 | 1 | 2 | 3 | 4 |
| II | 1 | 2 | 3 | 4 | 5 |
| III | 2 | 3 | 4 | 5 | 6 |
| IV | 3 | 4 | 5 | 6 | 7 |

A summary of the risk assessment criteria for the Critical Items List components follows.

| Critical Item | Severity Class | Probability | RAC No. |
|---|---|---|---|
| 1. Sheave Gear | Critical (II) | Improbable(E) | 5 |
| 2. Hoist Gearbox | Critical (II) | Improbable(E) | 5 |
| 3. Hoist Mechanical Load Brake | Critical (II) | Improbable(E) | 5 |

It is noted that the effectiveness of the in place controls and verifications is demonstrated by the fact that lifting device failure has not been a contributing root cause since the inception of the lifting device certification program in 1985.

4.0 Controls and Verifications

4.1 Crane Operator training to include:

- Emergency procedures/contingency actions; include specific hazards and special procedures.
- Effects of failure once it has occurred.

4.3 Test and Inspections

- Perform frequent/periodic tests and inspections
- Maintain current Test and Inspection Procedures.
- Perform daily Operational Tests and Inspections
- Maintenance of a Failure Log

4.4 Specifications for New Equipment

Include requirement for:

- Factory tests before shipment (See Attachment 1)
- Crane acceptance test procedures
- All gearing designed to AGMA standards
- Attach gears and shafts by a method approved by hoisting standards

## 5.0 End-to-End Analysis

There were no areas of concern identified which are the design responsibility of other contractors or NASA Centers.

## 6.0 Sneak Circuit Analysis

There was no sneak circuit analysis performed on this lifting device.

## 7.0 Recommendations

- Certify the lifting device to reflect operational requirements. Continue to perform maintenance of the critical items per OEM requirements.
- Mandate that only certified, trained operators shall be authorized to operate lifting devices.
- Maintain current documents and approved test and inspection procedures.
- Review/update this analysis, as required, to reflect any changes in operation or facility improvements that affect the crane system.

## 8.0 Conclusion

Based on the above analysis, the risk hazard with controls and verification in place is assessed to be acceptable/controlled. With a RAC 5, it is concluded that this crane is in compliance with the requirements set forth in NASA-STD-8719.9 for performing critical lift operations.

Attachment 1: Factory Load Test Certificate

HARRINGTON
HOISTS AND CRANES

Harrington Hoists, Inc.
401 West End Avenue
Manheim, PA 17545
Phone: (717) 665-2000

Harrington Hoists, Inc.
2341 Pomona Rd #103
Corona, CA 92880
Phone: (951) 279-7100

www.harringtonhoists.com

## Certificate of Inspection and Test

***Overhead Hoist***

This certifies that the following Harrington product:

- Conforms to the latest version of ASME B30.16.
- Was thoroughly inspected.
- Was subjected to a load test in accordance with the latest version of ASME B30.16.

lb

HARRINGTON
HOISTS AND CRANES

**CB005**

**1/2 TON CHAIN HOIST**

Product Code
M3CB005-SC

M3134452126

10 FT. LIFT
8 FT. H/C DROP

Load Applied: [X] Not less than 125 % of rated capacity

Scott Miller
Quality Manager

Chris Hess
Manager of Engineering

CIT101-ENG
EFFECTIVE JANUARY 11, 2011