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FAILURE MODE AND EFFECTS ANALYSIS OF THE FIVE-TON BRIDGE CRANE AT THE INSTRUMENT SYSTEMS ANALYSIS AND VERIFICATION FACILITY BUILDING 20

NSI Document

40-01-320

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Preface

The Instrument Systems Analysis and Verification Facility (ISAVF) in Building 20 was recently outfitted with a 5-ton Overhead Bridge Crane. The crane is of standard manufacture and is designed in accordance with the general guidelines of CMAA #70, "Specification for Electric Overhead Traveling Cranes." The crane is a Class C, Moderate Service rated crane.

A task was issued to the NSI Recertification Support Group to undertake certain corrective actions on the crane not performed by the installer. Additionally, the task called for the design and installation of safety platforms, certification and testing of the crane and the performance of Failure Mode and Effects Analysis (FMEA). The FMEA was to be performed because such an analysis is required by NSS/GO-1740.9, "NASA Safety Standard for Lifting Devices and Equipment."

The clean room is intended to be used for certain test and assembly operations of flight rated instruments and payloads. An immediate requirement surfaced, in the late summer of 1991, to house the HEIDI balloon launched payload for approximately a six-month period beginning in November 1991. In order to be ready for the payload, several tasks, including the crane certification, had to be completed.

This document is the product resulting from the analysis required by NASA and the Statement of Work covered by the aforementioned TAR.

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1.0 SUMMARY OF FINDINGS

1.1 System Criticality

The Five-Ton Bridge Crane is assessed as critical because failure of crane could cause the loss of life and/or critical hardware. The crane functions are identified and assessed on the Criticality Assessment Summary Sheet (see page 2).

1.2 Mechanical Critical Items

The gear reducer box is considered to be a Single Failure Point, based on ground rule 3.4.1.b.4 in Reference 1; i.e., located between the drum and nearest brake.

1.3 Electrical Critical Items

There were no Electrical Critical Items identified in this analysis which qualified as a Single Point Failure item.

1.4 Critical Control/Monitor Functions

There were no concerns identified in the Control/Monitor Functions of this equipment.

1.5 Hazards Identified

A potential source of danger has been identified in that catastrophic failure of the gearbox reducer could cause dropping the load and, in turn, possible loss of life or injury to personnel, loss of/potential damage to flight hardware, or both. No other critical hazards were identified upon application of Sections 3.4.2 through 3.4.6 of Reference 1.

1.6 Risk Assessment

Evaluation of the gear reducer box in accordance with both NHB 1700.1(V1-A), "Basic Safety Manual," and NHB 1700.1(V1-B)-Draft, determined the risk to be an acceptable one with controls in place.

System Criticality Assessment Summary Sheet

SYSTEM: 5-Ton ACCO Series 543 Bridge Crane — CRANE NO. 20-2
FLIGHT PROGRAM: HEIDI — PREPARED BY: M. Crompton
LOCATION: Building 20, Room 85A, ISAVF — DATE: November 1991

Output	Function	Effect of Loss/Failure	Crit Cat	Notes
Handling of Project Flight Hardware	Hoist: Raises/lowers and provides lateral north/south or east/west direction movement of critical equipment	Load may drop resulting in possible loss of life or injury to personnel, loss of/potential damage to Flight Hardware or both.	Critical*	See FMEA worksheets

Critical Lifting Device: A device (crane, hoist, etc.) whose potential failure or malfunction (loss of control, dropping a load, etc.) could cause loss of life, damage to flight or space hardware, damage to major facility or mission support equipment, or seriously delay the objectives of a program.

2.0 FAILURE MODE AND EFFECTS ANALYSIS

2.1 Ground Rules/Definitions/Documentation

2.1.1 Ground Rules

This analysis has been developed in accordance with the guidelines of References 1-4 (see Section 2.1.3).

The ground rules stated in Section 3.4.1 of Reference 1 were used for this analysis.

2.1.2 Definition of Criticality Categories

The criticality definitions specified in Table 5.1 of Reference 1 were used to assign the criticality rating. They are repeated below for ease of review.

- Criticality Categories. Failure criticality categories are defined as

Category	Definitions
1	A single failure that could cause loss of life or flight hardware.
1S (GSE only)	A 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 and could result in loss of life or flight hardware.
1R	Redundant hardware item(s), all of which if failed, could cause loss of life or flight hardware.
2 (GSE only)	A single failure that could cause loss (damage) of flight hardware.
3	All others (noncritical).

Critical Item - A criticality 1, 1S, or 2 Single Failure Point and redundant hardware items in loss of life/vehicle applications (Criticality 1R) where:

a. The redundant items that are not capable of being checked and verified during normal operation;

b. Loss of a redundant item not readily detectable by the operator; or

c. Redundant items can be lost by a single credible cause or event.

2.1.3 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 (FMEA) and Critical Items List (CIL)," Revision C, December 15, 1989.

2. NSS/GO-1740.9, "NASA Safety Standard for Lifting Devices and Equipment," July 1988.

3. NSS/GO-1740.9B, "NASA Safety Standard for Lifting Devices and Equipment," September 1990, Draft.

4. Assurance Requirements Office, Code 302, GSFC Document No. S-302-89-01, "Procedure for Performing a Failure Mode and Effects Analysis (FMEA)," February 1990.

5. Southern Systems, Inc., Virginia Beach, VA;

   a. Submittals
   b. Operating and Maintenance Manuals with Parts List
   c. Inverter Control.

   Twigg Corporation, Acceptance Test Report, dated November 15, 1990.

6. GMI 1710.6, "Design, Inspection, and Certification of Lifting Devices and Equipment," March 1989.

2.2 System Description

The ACCO Series 543 is a top running double girder, motor driven, dual drive crane rated at five ton capacity. Span is equal to 42'-0", lift is 65'-0". Additional pertinent dimensions are provided in Figure 1, reproduced from Reference 5.a. Standard Equipment Specifications are provided as Figure 2, likewise reproduced from Reference 5.a. Power is supplied at 208 volts, 60 Hertz, 3-phase alternating current.

The lifting device is located in the Instrument Systems Analysis and Verification Facility, Building 20, Room

85A. The intended function of the lifting device is to: a) hoist the HEIDI gondola to a vertical position, b) install the HEIDI telescope in the gondola, and c) hoist the gondola/telescope assembly to permit the performance of alignment and functional tests.

2.2.1 General

The five-ton Instrument Systems Analysis and Verification Facility bridge crane consists of a hoist trolley and bridge. The trolley runs east/west and the bridge runs north/south.

2.2.2 Hoist Assembly

The drive unit consists of a 5 HP, 900 RPM electric motor, ACCO Part No. 3470451, connected to an ACCO Gear Housing, Part No. 62849-11, through a keyed coupling. Two holding brakes, one located on the motor drive shaft, i.e., ACCO rectified D.C. magnetic actuated disc brake and the other, an automatic Weston-type multiple disc mechanical load brake are capable of slowing, stopping and holding the load. A geared upper and lower limit switch and redundant gravity upper limit are provided for over-travel protection.

Hoist controls include a factory adjusted, overload cutoff, to prevent the hoist from lifting excessive overloads. Cutoff reset occurs automatically when the overload, or cause of overload, has been removed.

2.2.3 Bridge and Trolley Assembly

The trolley drive unit consists of a 0.25 HP, 900 RPM electric motor integral with a fully enclosed oil splash lubricated gear reduction. The motor and the gear reduction shafts are supported by permanently lubricated precision bearings.

The bridge assembly is powered by two 0.5 HP AC electric motors, one at each end of the bridge.

The trolley drive includes an integrally mounted spring set electrically released AC disc brake.

2.2.4 AC Inverter

Speed variation of the electric motors used in the hoist, trolley motors and crane drives is provided by an E-trAC, AC inverter. Five preset speeds are programmable from the control key

pad. The E-trAC provides both an adjustable voltage and adjustable frequency to the AC motor(s), maintaining a constant torque capability throughout the motor's speed range.

2.2.5 Controls

The five-ton bridge crane is floor controlled pendant nine button, push button station, pendant mounted from the crane bridge, moveable to provide control at any distance from the point of loading.

The pendant has the following controls: Power - On/Off; Hoist - 5 speed position Up, Down, Off; Trolley - 5 speed position, Right, Left, Off; and Bridge - 5 speed position, Forward, Reverse and Off.

2.3 Mechanical FMEA Worksheets and Block Diagrams

The mechanical components of this equipment are identified from the documents listed in Section 2.1.3, "List of References" and are analyzed on the following FMEA worksheets.

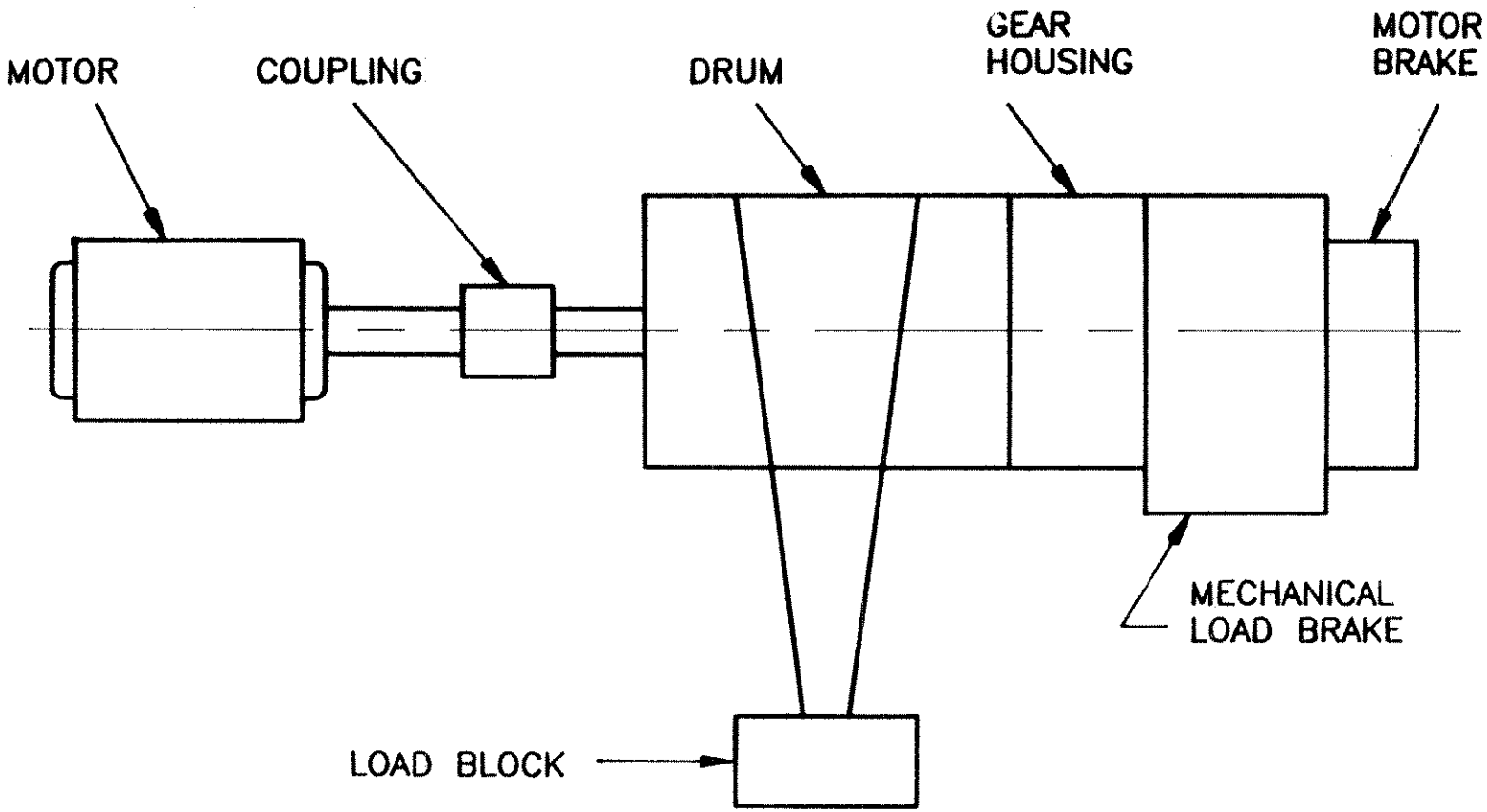


FIGURE 3: FIVE TON HOIST, INSTRUMENT SYSTEMS AND VERIFICATION FACILITY, BUILDING 20

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
ACCO Frame 284U	Electric AC Hoist Drive Motor	Prime Mover for Hoist	Loss of Electrical Power (Open/Short Windings)	Unable to operate. Brakes will set.	No effect. Delay in operation.	3
	Mechanical Load Brake	Hold load after hoisting or when de-energized	Fails to engage (structural failure of components)	Motor brake will set and hold load.	No effect. Delay in operation.	3
ACCO 60160-1	Motor Brake	Hold load after hoisting or when de-energized	Fails to engage (structural failure of components)	Mechanical load brake will set and hold load.	No effect. Delay in operation.	3
	Motor Coupling	Provides mechanical link between electric motor and drum unit	Key(s) disengagement (set screw sheared)	Mechanical load brake will set and hold load.	No effect. Delay in operation.	3
ACCO 62849-11	Gear Reducer	Transmits power and reduces rotational speed from the hoist motor to the mechanical load brake	Disengages (faulty component)	Torque for holding load will be lost. Load will drop.	Possible damage to Flight Hardware. Could cause loss of life or injury to personnel.	1

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
ACCO PA6145	Drum bearing	Support hoisting drum and allow rotation.	Bearing bind up. Failure due to overstress, corrosion, improper assembly.	Retards to stops hoisting and lowering.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley (Mechanical)
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO. FIND NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
ACCO Frame 56	Electrical AC Trolley Drive Motor, 0.25 H.P.	Provides locomotion for trolley assembly in north/south direction	Loss of electrical power (open/short windings)	Unable to operate. Trolley brake will set.	No effect. Delay in operation.	3
			Mechanical failure of motor (structural failure components)	No trolley operation.	No effect. Delay in operation.	3
None	Brake Coupling	Provides mechanical link between electric motor, brake and gear reducer	Keys disengage (set screw sheared)	No trolley operation.	No effect. Delay in operation.	3
ACCO 65893-01	Gear Reducer	Reduce motor rotation speed	Disengages (structural failure components)	Trolley stationary: No trolley operation. Trolley in motion: Loss of trolley drive and brake. Weight of trolley assembly will stop motion of trolley.	No effect. Delay in operation.	3
65659-04	Trolley Brake	Provides braking drive motor	Fails to disengage (faulty mechanism)	No trolley operation.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley (Mechanical)
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO. FIND NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fails to engage (structural failure components)	Loss of trolley braking, weight of trolley assembly will stop motion of trolley.	No effect. Delay in operation.	3
None	Trolley Assembly	Supports hoist assembly. Provides north/south movement	Wheel bearing seizure (excessive pressure or friction)	No trolley operation.	No effect. Delay in operation.	3
None	Coupling	Provide power linkage between trolley drive wheels	Keys disengagement (set screw sheared)	No trolley operation.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Bridge (Mechanical)
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO. FIND NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
None	Electric AC Bridge Drive Motor, 0.5 H.P.	Provides locomotion for bridge east/west direction	Loss of electrical power (open/short windings	Unable to operate. Brake will set.	No effect. Delay in operation.	3
			Mechanical failure of motor (structural failure components)	No bridge operation.	No effect. Delay in operation.	3
ACCO 65893-01	Bridge Gear Reducer	Reduce motor rotation speed	Disengages (structural failure components)	Bridge stationary: No bridge operation. Bridge in motion: Loss of bridge drive and brake. Weight of bridge crane will stop motion of bridge.	No effect. Delay in operation.	3
None	Bridge Assembly	Support hoist and trolley assembly, provides north/south movement	Wheel bearing (excessive pressure or friction)	No bridge operation.	No effect. Delay in operation.	3
ACCO 65659-04	Bridge Brake	Provide braking action to bridge drive motor	Fail to engage (structural failure components)	Loss of bridge braking. Weight of bridge crane will stop motion of bridge.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Bridge (Mechanical)
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO. FIND NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail to disengage (faulty mechanism)	No bridge operation. (Faulty mechanism)	No effect. Delay in operation.	3

2.4 Electrical FMEA Worksheets and Block Diagrams

The electrical components of this equipment are identified from the documents and diagrams listed in Section 2.1.3, "List of References" and are analyzed on the following FMEA worksheets.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Main Line Bridge Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
Device 610-31	30 Amp Main Disconnect at floor level	Energize and de-energize crane feeder	Fail to close. Mechanical linkage broken.	No power to crane.	No effect. Delay in operation.	3
			Fail to open. Mechanical linkage broken.	Crane stays energized. Main contactor will de-energize crane.	No effect.	3
Device 610-32	30 Amp Crane Disconnect	Energize and de-energize crane	Fail to close. Mechanical linkage broken.	No power to crane.	No effect. Delay in operation.	3
			Fail to open. Mechanical linkage broken.	Crane stays energized. Main contactor will de-energize crane.	No effect.	3
M	Main Contactor	Energize and de-energize crane.	Fail to close. Open coil	No power to crane.	No effect. Delay in operation.	3
			Fail to open. Contacts fused together.	Crane stays energized. Device 610-31 or Device 610-32 will de-energize crane.	No effect.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Main Line Bridge Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
MCX	Main Control Transformer	Provides 120V. control power for main contactor of bridge panel.	Fails open. Excessive current.	No control power to crane.	No effect. Delay in operation.	3
			Fails shorted. Vibration.	No control power to crane.	No effect. Delay in operation.	3
BFU	Bridge Fuses (3)	Protects bridge 208V. system from overload and short.	Fuses blow. Excessive current.	Crane will not bridge.	No effect. Delay in operation.	3
MCFU	Main Control Fuse (1)	Protects main and bridge 120V. system from overload and short.	Blown fuse. Excessive current.	M contactor will drop out.	No effect. Delay in operation.	3
OLR	Bridge Overload Relays (3)	Protects bridge motors from excessive current.	Fail open. Overcurrent.	Loss of 1 phase to motor.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Loss or overload protection. Requires double failure.	No effect.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Main Line Bridge Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
1M and 2M	Bridge Motor (2)	Bridge drive motors.	Open motor. Excessive heat or current.	Crane will bridge with one motor in operation. Requires double failure.	No effect.	3
			Shorted motor. Excessive heat or current.	Will cause operation of overloads.	No effect. Delay in operation.	3
None	Bridge Brake (2)	Stops bridge motion.	Open winding. Excessive heat or current.	Brake will engage and cause overloads to operate.	No effect. Delay in operation.	3
			Shorted winding. Excessive heat or current.	Excessive current will cause overloads to operate. Brake will engage.	No effect. Delay in operation.	3
R1/R2/R3	Bridge Starting Resistors (6)	Limits starting current surge, for bridge motors.	Fail open. Overcurrent	Loss of 1 phase to motor when starting.	No effect. Delay in operation.	3
			Fail short. Vibration.	Downstream overloads protect circuit.	No effect. Delay in operation.	3
None	Power On Push Button	Energizes M contactor for crane power.	Fail open. Vibration.	No power to crane.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Main Line Bridge Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused.	Power stays on crane. Crane can be de-energized with Device 610-31 at floor level.	No effect. Delay in operation.	3
None	Power Off Push Button	De-energizes M contactor.	Fail open. Vibration.	No power to crane.	No effect. Delay in operation.	3
			Fail closed. Contacts fused.	Power stays on crane. Crane can be de-energized with Device 610-31 at floor level.	No effect. Delay in operation.	3
None	Push Button Operator, Bridge	Operates bridge Forward, Reverse, and Acceleration contactors.	Fail open. Vibration.	Forward, reverse, or acceleration relays will not energize. Bridge will not operate or operate slowly.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Forward, reverse, or acceleration relays will stay energized. Bridge will continue to operate. Can be stopped with power Off push button or main disconnect. Requires double failure.	No effect. Delay in operation.	3
LS#4	Bridge Travel Limit switch (2)	Inhibits bridge movement,	Fail open. Vibration.	Crane will not bridge.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Main Line Bridge Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused together.	Crane will continue to bridge until push button is released.	No effect. Delay in operation.	3
F	Forward contactor	Provides 208V. to bridge motor in forward direction.	Fail open. Vibration.	Crane will not bridge in forward direction.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Crane will continue to bridge when push button is released. Crane can be stopped with power Off button. Requires double failure.	No effect. Delay in operation.	3
R	Reverse contactor	Provides 208V. to bridge motor in reverse direction.	Fail open. Vibration.	Crane will not bridge in reverse direction.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Crane will continue to bridge when push button is released. Crane can be stopped with power Off button. Requires double failure.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Main Line Bridge Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
A	Acceleration contactor (4)	Shorts out starting resistors for bridge motors.	Fail open. Vibration.	Crane will not accelerate.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Crane will run at a faster speed. Can be stopped by releasing push button.	No effect. Delay in operation.	3
None	Normally closed interlock on reverse contactor	Inhibits forward contactor from energizing.	Fail open. Vibration.	Crane will not bridge in forward direction.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Forward and reverse mechanical interlock will prevent simultaneous operation of directional contactors. Requires double failure.	No effect. Delay in operation.	3
None	Normally closed interlock on forward contactor	Inhibits reverse contactor from energizing.	Fail open. Vibration	Crane will not bridge in reverse direction.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Main Line Bridge Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused together.	Forward and reverse mechanical interlock will prevent simultaneous operation of directional contactors. Requires double failure.	No effect. Delay in operation.	3
None	Normally closed interlock on overload relay	De-energizes all bridge contactors when overloads operate.	Fail open. Vibration.	Crane will not bridge.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Bridge will continue to operate when overloads trip. BFU fuses will blow to stop bridge. Requires double failure.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
TFU	Trolley Fuses (3)	Protects trolley 208V. system from overload and short.	Fuses blow. Excessive current.	Crane will not trolley.	No effect. Delay in operation.	3
TOL	Trolley Overload Relays (3)	Protects trolley motor from excessive current.	Fail open. Overcurrent.	Loss of 1 phase to motor.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Loss of overload protection. Requires double failure.	No effect. Delay in operation.	3
None	Trolley Motor	Trolley drive motor.	Open motor. Excessive heat or current.	Crane will not trolley.	No effect. Delay in operation.	3
			Shorted motor. Excessive heat or current.	Will cause operation of overloads.	No effect. Delay in operation.	3
None	Trolley Brake	Stops trolley motion.	Open winding. Excessive heat or current.	Brake will engage and cause fuses to blow.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Shorted winding. Excessive heat or current.	Excessive current will cause fuses to blow.	No effect. Delay in operation.	3
R1/R2/R3	Trolley Starting Resistors (3)	Limits starting current surge for trolley motor.	Fail open. Overcurrent.	Loss of 1 phase to motor when starting.	No effect. Delay in operation.	3
			Fail short. Vibration.	Downstream overloads protect circuit.	No effect. Delay in operation.	3
None	Push Button Operator, Trolley	Operates trolley forward, reverse and acceleration contactors.	Fail open. Vibration.	Forward, reverse, or acceleration relays will not energize. Trolley will not operate or operate slowly.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Forward, reverse or acceleration relays will stay energized. Trolley will continue to operate. Can be stopped with power Off push button or main disconnect. Requires double failure.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
LS#4	Trolley Travel Limit Switch (2)	Inhibits trolley movement.	Fail open. Vibration.	Crane will not trolley.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Crane will continue to trolley until push button is released.	No effect. Delay in operation.	3
F	Forward Contactor	Provides 208V. to trolley motor in forward direction.	Fail open. Vibration.	Crane will not trolley in forward direction.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Crane will continue to trolley when push button is released. Crane can be stopped with power Off button. Requires double failure.	No effect. Delay in operation.	3
R	Reverse Contactor	Provides 208V. to trolley motor in reverse direction.	Fail open. Vibration.	Crane will not trolley in reverse direction.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused together.	Crane will continue to trolley when push button is released. Crane can be stopped with power Off button. Requires double failure.	No effect. Delay in operation.	3
A	Acceleration Contactor (4)	Shorts out starting resistors for trolley motor.	Fail open. Vibration.	Trolley will not accelerate.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Trolley will run at a faster speed. Can be stopped by releasing push button.	No effect. Delay in operation.	3
None	Normally closed interlock on reverse contactor	Inhibits forward contactor from energizing.	Fail open. Vibration.	Crane will not trolley in forward direction.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused together.	Forward and reverse mechanical interlock will prevent simultaneous operation of directional contactors. Requires double failure.	No effect. Delay in operation.	3
None	Normally closed interlock on forward contactor	Inhibits reverse contactor from energizing.	Fail open. Vibration.	Crane will not trolley in reverse direction.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Forward and reverse mechanical interlock will prevent simultaneous operation of directional contactors. Requires double failure.	No effect. Delay in operation.	3
None	Normally closed interlock on overload relay	De-energizes all trolley contactors when overloads operate.	Fail open. Vibration.	Crane will not trolley.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Trolley Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused together.	Trolley will continue to operate when overloads trip. TFU fuses will blow to stop trolley. Requires double failure.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
HFU	Hoist Fuses (3)	Protects hoist 208V. system from overload and short.	Fuses blow. Excessive current.	Crane hoist will not operate.	No effect. Delay in operation.	3
VFI	A.C. Inverter	Provides variable frequency power and fault monitor for hoist drive.	Fail no output. Excessive heat or vibration.	Crane hoist will not operate.	No effect. Delay in operation.	3
			Fail continuous output. Excessive heat or vibration.	Crane hoist will continue to operate. Can be stopped with power Off push button or main disconnect. Requires double failure.	No effect. Delay in operation.	3
None	Hoist Motor	Hoist drive motor.	Open motor. Excessive heat or current.	Crane will not hoist.	No effect. Delay in operation.	3
			Shorted motor. Excessive heat or current.	Crane will not hoist. Will cause operation of inverter fault circuit.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
HCX	Hoist Control Transformer	Provides 120V. control power for hoist and trolley panels.	Fails open. Excessive current.	No control power to hoist and trolley.	No effect. Delay in operation.	3
			Fails shorted. Vibration.	No control power to hoist and trolley.	No effect. Delay in operation.	3
HCFU	Hoist Control Fuse (1)	Protects hoist and trolley 120V. control circuits.	Fuse blown. Excessive current.	Crane hoist and trolley will not operate.	No effect. Delay in operation.	3
None	Hoist Brake, Diode Bridge	Provides D.C. power for hoist brake release.	Fail open. Excessive voltage.	Brake will not release.	No effect. Delay in operation.	3
			Fail short. Excessive current.	Brake will not release.	No effect. Delay in operation.	3
None	Hoist Brake	Stops hoist motion.	Fails open. Excessive heat or current.	Brake will engage.	No effect. Delay in operation.	3
			Fails shorted. Excessive heat or current.	Brake will engage.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
BC	Brake Contactor	Applies D.C. power to release hoist brake.	Fail open. Vibration.	Brake will engage.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Brake will release. Mechanical load brake will engage. Requires double failure.	No effect. Delay in operation.	3
None	Normally closed interlock on fault relay	Allows brake contactor to function unless a fault exists in the monitor circuit.	Fail open. Vibration.	Brake will engage.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Loss of fault monitor brake set. Brake will engage when hoist push button is released. Requires double failure.	No effect. Delay in operation.	3
BR	Brake Reduced Voltage Contactor	Reduces D.C. voltage to brake coil after brake releases.	Fail open. Vibration.	Brake will not release.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused together.	Brake will operate normally but at full voltage.	No effect.	3
None	Brake Switch	Energizes brake reduced voltage contactor.	Fail open. Vibration.	Brake will operate normally but at full voltage.	No effect.	3
			Fail closed. Contacts fused together.	Brake will not release.	No effect. Delay in operation.	3
None	Push Button Operator, Hoist	Provides forward, reverse, and acceleration commands to A.C. Inverter.	Fail open. Vibration.	Hoist will not operate or operate slowly.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Hoist will continue to operate. Can be stopped with power Off push button or main disconnect.	No effect. Delay in operation.	3
None	Overload Cutoff	Prevents the hoist from lifting excessive overloads.	Fail open. Vibration.	Hoist forward will not operate.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
			Fail closed. Contacts fused together.	Hoist will be allowed to operate with an excessive overload. Monitor circuit will identify overload and stop operation. Requires double failure.	No effect. Delay in operation.	3
None	Gravity Limit Switch	Prevents hoist overtravel in the forward direction.	Fail open. Vibration.	Hoist will not operate in forward direction.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	Two-blocking will occur. Requires double failure.	No effect.	3
None	Geared Limit Switch	Prevents hoist overtravel in both forward and reverse directions.	Fail open. Vibration.	Hoist will not operate in direction of failure.	No effect. Delay in operation.	3
			Fail closed. Contacts fused together.	In forward direction, the gravity limit switch will prevent overtravel. Requires double failure.	No effect. Delay in operation.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SYSTEM: 5-Ton Bridge Crane/ISAVF
SUBSYSTEM: Hoist Circuit
PROGRAM: HEIDI

DATE: September 1991
PREPARED BY: M. Crompton

PART NO.	PART NAME	PART FUNCTION	FAILURE MODE AND CAUSE	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON CRITICAL HARDWARE AND/OR PERSONNEL SAFETY	CRIT CAT
				In reverse direction, releasing the push button operator will prevent overtravel. Requires double failure.	No effect. Delay in operation.	3

3.0 CRITICAL ITEMS LIST (CIL)

3.1 Item Identification

Item: Gear Reducer, ACCO, Wright, Part No. 62849-11.

System: ACCO Series 543 Top Running Double Girder Motorized Dual Drive Crane located at the Instrument Systems and Verification Facility, Building 20, Room 85A.

Flight Program: HEIDI

Reference Documentation: Wright Parts Manual 58979-09, Rev. 4-21-89.

3.2 Criticality Category

3.2.1 Hardware Criticality 1: The gear reducer box is considered to be a Single Failure Point, based on ground rule 3.4.1.b.4 in Reference 1; i.e., located between the drum and nearest brake.

3.2.2 Potential Effect of Failure: Could cause loss of life or injury to personnel. Possible loss of/damage to Flight Hardware.

3.3 Function

Transmits power and reduces rotational speed from the hoist motor to the mechanical load brake.

3.4 Failure Mode

Disengages.

3.5 Cause(s)

3.5.1 Faulty Component; e.g., improper heat treatment of gears.

3.5.2 Lack of Maintenance

Inadequate lubrication resulting in excessive wear.

3.5.3 Improper Gear Clearances

- Temperature rise resulting in loss of hardness.
- Excessive wear.

3.5.4 Excessive loading

Shock loading at lift - imposing excessive "G" forces resulting in exceeding the rated capacity of the crane.

3.6 Failure Mode Number

Reference ACCO Part Number 62849-11, ACCO Operation and Maintenance Manual with Parts List.

3.7 Failure Effect

Potential effect of failure: Dropping the load could cause loss of life or injury to personnel. Possible loss of/damage to Flight Hardware.

Detectability: Impending gearbox failure may be detectable by the following means:

Measurement of the baseline gearbox vibration signature and subsequent periodic monitoring at regular intervals as part of the RECERT Program;

A significant change in the noise level emanating from the gearbox;

An extremely elevated temperature of the oil in the gearbox; and

Gearbox disassembly to allow more detailed inspection if external conditions indicate the need.

3.8 Rationale for Acceptability

Rationale for acceptance includes the following items.

3.8.1 Design

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

Communications with both the crane manufacturer and installer confirm that the subject crane gearbox was designed and built in accordance with CMAA Specification #70, "Specification for Electric Overhead Traveling Cranes," Class C (Moderate Service). Structural and mechanical parts are designed in accordance with Chapter Nos. 70-3 and 70-4, respectively.

The gearbox components were designed so that the calculated static stress in the material, based

on the rated load, does not exceed 20% of the published average ultimate strength of the material.

The gears are attached to the shaft by means of a hardened key and splines in accordance with industry standard design practices.

Gear design is in accordance with American Gear Manufacturers Association (AGMA) standards.

Additionally, the ACCO hoist is equipped with an overload limiting device designed to permit hoist operation within its rated load and to limit the amount of overload that can be lifted by a properly maintained hoist under normal operating conditions. The overload cutoff is factory set and tested for loads between 110/125% capacity. Overloading, including that dynamically induced, results in securing of power.

Design modification to install a holding brake between the motor and drum unit, was discussed with the manufacturer. Whereas the modification was considered to be technically feasible, the modification would be extremely expensive to accomplish and difficult to maintain. Also, such modifications may compromise the proven reliability of off-the-shelf, OEM equipment.

3.8.2 Test

ACCO tests include crane tests to assure satisfactory operation, load tests - including tests to set the overload cutoff device and dielectric tests. The subject tests may be witnessed by the customer, in accordance with Contract requirements.

Specific tests performed at NASA/GSFC have been performed as follows.

Acceptance Tests performed by Southern Crane, Inc., and witnessed by representatives of Code 271.3, Design and Construction Section C, and NSI Technology Services Corporation, Recertification Support (NSI). These tests included hoisting and holding 125% of rated load.

Certification Tests were performed by NSI in accordance with NSI Document No. 40-02-736, "Certification Test Procedure." These procedures included hoisting, lowering and

traveling with rated load. A thorough inspection, including lubricant level, was also performed prior to the tests.

Additionally, Rated Load and Operational Tests, as defined in NSS/GO-1740.9, "NASA Safety Standard for Lifting Devices and Equipment," and OSHA 1910.179 will be performed annually and monthly as part of the on-going Lifting Device and Equipment Recertification Program.

Item	Condition
Crane	Certification current, including
	Tests: Proof/Rated Load Operational

Vibration - A baseline gearbox noise signature will be obtained and monitored as a function of crane use and criteria established by MIL-STD 167-1 and typical industry standards.

3.8.3 Inspections

ACCO performs standard in-process manufacturing inspections and batch tests utilizing statistical methods. Lubricant levels are verified prior to the gearboxes leaving the plant and AFTER crane erection.

Inspections performed at NASA/GSFC minimize the probability of failure because they are also combined with preventative maintenance.

Daily inspections will be performed by a certified crane operator prior to first use each day. Inspections will be performed in accordance with the requirements of NSS/GO-1740.9 and OSHA 1910.179. While primarily intended to assure limit switch operation, any change in gearbox noise level from day-to-day would easily be discernible and suspect.

Frequent inspections are performed monthly by NSI Recertification Support inspectors. Inspections are performed in accordance with the requirements of OSHA 29 CFR 1910.179 and ANSI/ASME B.30 Series, as applicable and a detailed "Inspection and Preventative Maintenance Procedure" for each crane. These inspections require both visual and hands-on testing of all crane operations and load line. The inspection technician will be alert for any unusual sounds which may indicate trouble.

Periodic inspections will be performed annually by NSI Recertification Support inspectors. Inspections are performed in accordance with the above listed standards and procedures.

The Periodic inspections will include all of the requirements of Frequent inspections plus boarding the bridge to conduct cleaning, adjustments, measurements, lubrication, and any repair necessary.

3.8.4 Failure History

Two gearbox failures were reported by the manufacturer; each having occurred more than ten years ago. The failures resulted in dropping the load.

The first failure was caused by lack of proper user maintenance - inadequate lubricant level.

The second failure reported was caused by nonheat-treated gearing resultant in soft gears. The failure cause of the "softgear" problem was attributed to a fault in the inspection process at ACCO. Appropriate action to rectify the cause was immediately taken by the manufacturer to forestall any future problems.

The Crane Manufacturers Association of America, Inc., (CMAA) was contacted pertinent to acquiring statistical data to establish the numerical probability of failure for a typical gearbox. Failure history data was not available from this source. The CMAA recommended that their membership be polled to obtain the required data. This activity is presently in process. The statistical failure history data, thus obtained, will be utilized to establish a quantitative method to complement the qualitative risk assessment method presently utilized. The failure history data resultant from the poll will be provided, at a later date, as an attachment to this FMEA.

3.8.5 Operational Use

On-site crane operator training is presently in place which includes emphasis on the following items. Operator observance of these items will additionally mitigate the effect of the critical item.

- Adherence to safety standards.

- Under no condition shall the crane be loaded beyond its rated capacity.
- Operator shall not, at any time, jerk the load during lifting.
- All lift personnel to be excluded from beneath the load and lift personnel to be located in the immediate vicinity of the load only in accordance with specific, documented and strictly enforced lift procedures.
- Traffic control tape, limited access signs/flashing lights are in place and the lift area is secured from nonessential personnel.
- All lift personnel are wearing the required safety equipment.

4.0 RISK ASSESSMENT

The following evaluation of risk acceptance was performed in accordance with the criteria of Reference #2, Section 2.1.3.

Severity and probability indices were assigned in this assessment, as follows:

Severity Class I: Catastrophic - may cause death or major system destruction

Probability Estimate D - Unlikely to occur.

These indices yield a Risk Assessment Code (RAC) equal to a RAC 3. All RACs 3-6 are considered nonserious, however, they establish a scheme for prioritizing for corrective action.

A risk assessment of the subject Gearbox Failure Effect was similarly performed using the method defined in Reference 3. This assessment was performed, although the document is in the draft stage, as an exercise to compare results with the above Risk Assessment.

Severity Level: Catastrophic. A hazard that could result in a mishap causing fatal injury to personnel, and/or loss of one or more major elements of the flight vehicle or ground facility.

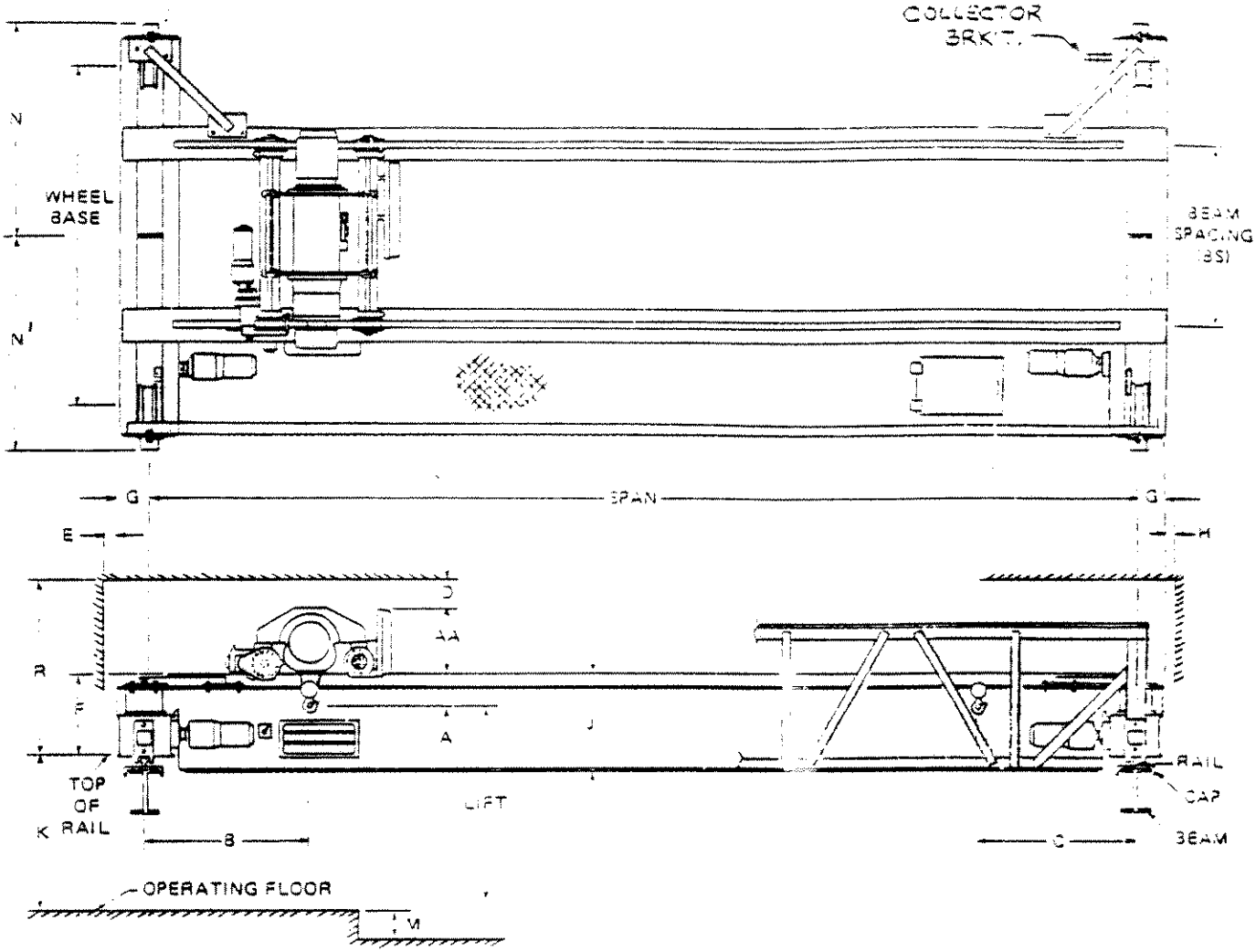
Likelihood of Occurrence: Improbable: Extremely remote possibility that it will happen in the life of the program. Strong controls in place.

These indices are plotted on the Reference 3, Risk Matrix, included herein as Figure 4. The risk, as described above, is considered to be a "Controlled Hazard." The imposition of

appropriate, readily implementable, verifiable controls will aid in the further reduction of minimal residual risk.

WORK-RATED® SERIES 343 TOP RUNNING DOUBLE GIRDER
MOTORIZED DUAL DRIVE CRANE

54-17
Issued 10-30-87



Note: Left-hand runway is standard location of runway conductors.

Minimum OSHA clearance between crane and obstruction requires 2" lateral and 3" overhead.

CUSTOMER: SOUTHERN SYSTEMS INC.

CUST. ORDER NO. T-2384
ACCO QUOTE NO.
ACCO JOB NO. 1-29-3477
DATE 9-7-89
CUSTOMER APPROVAL

DATE SIGNATURE

CRANE PROD. NO. 5430181
CAPACITY 5 TON
SPAN 42'-0"
LIFT 65'-0" AVAILABLE
HOIST PROD. NO. 3470-51
RUNWAY:
BEAM W24 x 55 #
CAP. CH. C12 x 20.7 #
RAIL 40# ASCE
WHEEL LOADING 3,400 #
POWER SUPPLY 208-3-60

A	23/8"
AA	2-1/2"
B	30"
BS	78"
C	37"
D	3" MIN
E	2" MIN
F	9 1/4"
G	8 1/2"
H	3" MIN
J	18 3/4"
K	50'-0"
M	0"
N	4'-0"
N'	4'-63/4"
NB	9'-3"
N'	7'-9"

Acco Products Division
A division of Babcock Industries Inc
1110 E. Princess Street, York, PA 17403
Telephone 717 843-1523
FAX 717 846-5387 Telex 84-0411

R.M.M.

WARNING Equipment described herein is not designed for, and should not be used for, lifting, supporting or transporting humans.

Failure to comply with any one of the limitations noted herein can result in serious bodily injury and/or property damage.

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FIGURE 1

WORK-RATED® SERIES 543 TOP RUNNING DOUBLE GIRDER MOTORIZED DUAL DRIVE CRANE

STANDARD EQUIPMENT SPECIFICATIONS

DESIGN FACTORS Standard capacity ratings shall represent the net load at the hook of any type of hoist. The crane shall be so designed that the load carrying parts, except structural members and hoisting ropes and gearing, shall be designed so that the calculated static stress in the material, based on the rated load, shall not exceed 20% of the published average ultimate strength of the material. This limitation of stress provides a margin of strength to allow for variations in the properties of materials, manufacturing and operating conditions, and design assumptions. However, under no condition shall the crane be loaded beyond its rated capacity.

BEAMS Bridge beam shall be designed in accordance with latest specifications of the Crane Manufacturers Association of America and shall be of standard structural shapes constructed in accord with AISC specifications. Under full load the beam deflection shall not exceed 1/800 of the span. Bridge beam shall be selected structural steel members provided with rails. Rails shall be securely fastened in place to maintain center distance. Provision shall be made to prevent creeping of the bridge [illegible] by means of a positive stop at the ends of the rails. The bridge beam shall be braced to maintain squareness with the trucks. Bridge beam shall have adequate lateral stiffness with a minimum lateral moment of inertia of 1/20 that of the vertical beam moment of inertia.

END TRUCKS The end truck frame shall be welded from structural shapes into a single unit as to prevent distortion and mismatch of gears under maximum rated load. End truck wheelbase shall be a minimum of 1/7 of the crane span. One wheel in each truck shall be geared and meshed with a pinion. The truck shall contain diaphragm members welded to truck frames to maintain alignment and distribute truck loads uniformly on inner and outer truck member. A wheel gear protecting guard shall be part of the end truck. The truck shall be designed so that the drop of the truck will be limited to one inch in case of axle or wheel failure. Attachment of end truck to bridge beam shall be bolted.

CRANE WHEELS Crane wheels shall be double flange steel and have tread surfaces hardened to 375 to 425 Brinell. Each wheel shall be supported on tapered roller bearings mounted on stationary axles suitable to take radial and thrust loads. The wheels shall be lubricated at the factory with a sodium base grease and provided with suitable reservoir of lubricant to eliminate the need for field lubrication. Wheel axles must have mounting nuts for bearing adjustment. Wheel mounting shall be designed so that axles and wheels can be removed without disturbing other truck elements of their alignment. Drive wheels shall be matched pairs within .001 inches per inch of diameter or a total of .010 inches on the diameter whichever is smaller.

RUNWAYS The crane runway, runway rails, and stops shall be furnished and installed by the user.

The runway rails shall be straight, parallel, level, and at the same elevation. The distance center to center and the elevation shall be within a tolerance of plus or minus 1/8". The runway rails should be standard rail sections of a proper size for the crane to be installed and must be provided with proper rail splices.

The crane runway shall be designed with sufficient strength and rigidity to prevent undue lateral or vertical deflection.

WELDING Welding shall be done by certified welders and shall be in accordance with the American Welding Society standards. All welds shall be ductile, shall have good weld penetration free of cracks and undercuts, and the welds shall manifest workmanlike appearance.

CRANE DRIVE Each end truck shall be provided with a helical gear motor reducer. The drive motor for each truck shall be fully enclosed, 30 minute duty rated Class B insulation in a NEMA frame and shall comply with NEMA performance specifications. A spring set, electrically released A.C. disc type brake shall be integrally mounted on each reducer in line with the motor. The motors shall be integral with fully enclosed oil splash lubricated gear reducers. The gear reduction shaft shall be supported by precision ball or roller bearings.

BEARING LIFE All bearings in the crane wheels, those supporting the drive shafts and the gear reduction shafts, shall be designed for 5,000 hours B-10 bearing life minimum.

BRIDGE BUMPERS The bridge shall be provided with b[illegible] capable of stopping the crane (not including [illegible]) [illegible] of deceleration not to exceed three feet per second per second traveling in either direction at 20% of rated speed. The bumpe[illegible] have sufficient energy absorbing capacity to stop the crane traveling at a speed of at least 40% of the rated load speed.

RAIL SWEEPS Bridge trucks shall be equipped with sweeps [illegible] extend below the top of the rail and project in front of the cra[illegible] wheels.

ELECTRICAL CONTROLS Electrical controls shall be single speed or multi speed as determined by speed requirements. Bridge control shall include a mainline magnetic contactor, manually operated fused mainline disconnect with lock-out provision, branch circuit fuses, reversing bridge control and transformer with fused secondary. Bridge control shall be mounted on bridge in NEMA 3R enclosure actuated from a pendant push button station suspended from either movable or fixed point on bridge or movable with trolley hoist as specifically called for in application. Single speed motors or two speed motors shall be provided with a solid state control to adjust the starting torque and acceleration.

BRIDGE CONDUCTORS AND WIRING Rigid track flatwire festoon shall be provided with the crane. All other wiring of the crane shall be in rigid or flexible conduit and in accordance with National Electric Code.

PAINTING The crane before shipment shall be painted with one coat of mustard yellow lead free chromate paint.

OPERATING AND MAINTENANCE Proper erection instructions, parts list and maintenance instructions will be furnished with the crane.

WARNING Equipment described herein is not designed for, and should not be used for, lifting, supporting or transporting humans.

Modifications to upgrade, derate, or otherwise alter this crane or hoist equipment shall be authorized only by the original equipment manufacturer or qualified professional engineer.

Failure to comply with any one of the limitations noted herein can result in serious bodily injury and/or property damage.

FIGURE 2

(HAZARD SEVERITY AND LIKELIHOOD OF OCCURRENCE WITH CONTROLS IN PLACE)

LIKELIHOOD	MARGINAL	CRITICAL	CATASTROPHIC
PROBABLE	ACCEPTED RISK	ACCEPTED RISK	UNACCEPTABLE RISKS
OCCASIONAL	ACCEPTED RISK	ACCEPTED RISK	ACCEPTED RISK
REMOTE	CONTROLLED	ACCEPTED RISK	ACCEPTED RISK
IMPROBABLE	CONTROLLED	CONTROLLED	CONTROLLED

4 HAZARD CAUSES

SEVERITY LEVELS

Risk Matrix Test for Agreement Between Closure Classification and Risk

FIGURE 4