

SAA88CR000-041

REV. A

APRIL 1994

SYSTEM ASSURANCE ANALYSIS  
OF THE  
20-TON MOBILE SERVICE TOWER BRIDGE CRANE  
FOR USE AT VANDENBERG AIR FORCE BASE, SLC-2  
BASELINE NO. 950.00

PMN: H88V0019

WUC: 2BFCRAB000

SS: 2B

SYSTEM: CRITICAL

00000001

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APPLICATION		PART NO.	MF	REVISIONS			
NEXT ASSY	USED ON			SYM	DESCRIPTION	DATE	APPROVAL
				A	REVISED SHTS. 1,15-25, 27-95. REV & RETYPED COVER, 2-14, 26. ADDED SHTS 96-108	4/10/94	<i>[Signature]</i>

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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	ORIGINAL DATE OF DRAWING	8-92	SYSTEM ASSURANCE ANALYSIS OF THE 20-MST BRIDGE CRANE LOCATED ON SLC-2 AT VAFB	JOHN F. KENNEDY SPACE CENTER, NASA
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MATERIAL	W. F. COURTNEY MDSSC	BASELINE 950.00	KENNEDY SPACE CENTER FLORIDA	
HEAT TREATMENT	APPROVED	DWG SIZE		SAA88CR000-041
FINAL PROTECTIVE FINISH	<i>[Signature]</i> 8/1/92 W. W. McEWEN, MDSSC	SCALE		SHEET 1 OF 108
		UNIT WT	<b>A</b>	

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## LIST OF ABBREVIATIONS AND ACRONYMS

CA	Catastrophic
CAT.	Category
CIL	Critical Items List
CN	Controlled
CR	Critical
CRIT.	Criticality
CSFP	Critical Single Failure Point
FM	Failure Mode
FMEA	Failure Modes and Effects Analysis
FPM	Feet Per Minute
GSE	Ground Support Equipment
KSC	Kennedy Space Center
LPS	Launch Processing System
MST	Mobile Service Tower
MDSSC	McDonnell Douglas Space Systems Company
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
NSTS	National Space Transportation System
OMI	Operations and Maintenance Instruction
OMRSD	Operations and Maintenance Requirements and Specifications Document
PCN	Program Control Number
PMN	Program Model Number
REF.	Reference
SAA	System Assurance Analysis
SHA	System Hazard Analysis
S/S	Station Set
STS	Space Transportation System
VAFB	Vandenberg Air Force Base
VDC	Volts, Direct Current
VAC	Volts, Alternating Current
W.O.	Work Order
WUC	Work Unit Code

## SECTION I

### SUMMARY OF FINDINGS

#### 1.1 SYSTEM CRITICALITY

The 20-Ton MST Bridge crane is assessed as critical. A failure of this crane could cause loss of life and/or flight hardware.

#### 1.2 MECHANICAL CRITICAL ITEMS

There were no mechanical Critical Items identified in the critical output functions identified in section 4.0 for this equipment. See section 5.1 for additional information.

#### 1.3 ELECTRICAL CRITICAL ITEMS

There were no electrical Critical Items identified in the critical output functions identified in section 4.0 for this equipment. See section 5.2 for additional information.

#### 1.4 CRITICAL FLEX HOSES

There are no flex hoses associated with this equipment.

#### 1.5 CRITICAL ORIFICES

There are no orifices associated with this equipment.

#### 1.6 CRITICAL FILTERS

There are no filters associated with this equipment.

#### 1.7 CRITICALITY CATEGORY 1R ITEMS

There were four (4) criticality category 1R items identified during the analysis of the critical output functions identified in section 4.0 for this equipment. See section 5.1, 5.2 and 5.10 for additional information.

#### 1.8 HAZARDS IDENTIFIED

There were no hazards identified in this analysis. See Section VI for additional information.

#### 1.9 CRITICAL CONTROL/MONITOR FUNCTIONS

There are no LPS control/monitor functions associated with this system.

#### 1.10 SNEAK CIRCUITS IDENTIFIED

There was no Sneak Circuit Analysis performed for this system.

#### 1.11 AREAS OF CONCERN AND RECOMMENDATIONS

There is one (1) areas of concern identified or recommendations to be considered for this system. See section XI for further information.

## SECTION II

### SYSTEM SUMMARY

#### 2.1 SYSTEM BASELINE

This system is baselined for STS by 79K09579, "KSC STS/Cargo Identification List for Facilities, Systems and Equipment by baseline number," dated 2/10/83. The OMD baseline number is 950.00.

#### 2.2 DOCUMENTATION LIST

The following documents were used in completing this analysis:

<u>Document/ Drawing No.</u>	<u>Rev.</u>	<u>Outstanding EOs</u>	<u>Title</u>
KHB 5310.9	BAS		Kennedy Space Center Ground Systems Safety And Reliability
Ven Drawing D2152-M01-M020			HECO-Pacific 20-Ton MST Bridge Crane drawings
NSS/GO 1740.9			NASA Safety Standard For Lifting Devices and Equipment
91-3023B Purchase Spec.			HECO Pacific Proposal and Specifications
79K32662	A		General Test Requirements for Critical Cranes located at VAFB
D2153M13	BAS		20-Ton Crane Elementary Pneumatic Diagram, HECO Pacific

#### 2.3 SYSTEM DESCRIPTION

The 20-Ton Bridge crane is located at SLC-2 within the Mobile Service Tower and is to be used to stack the Delta II stages prior to launch. The crane consists of four subsystems; the hoist, trolley, bridge and electrical control.

The crane is located on the exterior of the MST. To protect the hoist system components from the weather, they are located within the building. A series of compensating wire rope sheaves are used to maintain hook height regardless of bridge or trolley movement.

### 2.3.1 HOIST SYSTEM

The hoist system consists of a hoist motor, hoist gear reducer, wire rope drum, two electro-mechanical brakes and a wire rope drum mounted disc type emergency brake. The hoist motor is a variable speed (20 FPM max) squirrel cage type manufactured by P&H. The motor is rated at 30 HP/1800RPM. The motor torque is supplied to the gear reducer, which has a ratio of 15.63:1. The reducer is used to reduce rotational speed supplied by the motor and transfer the torque to the wire rope drum to both collect or play out wire rope during a lifting operation.

The hoist system is equipped with two forms of electro-mechanical braking: a DC shoe type brake and a DC disc type brake. Both brakes are rated to hold 150% of the cranes rated load. The disc brake is located on the end of the hoist motor frame, opposite the gear reducer. The Shoe brake is located on the opposite side of the gear reducer, downstream of the motor. Both brakes are electrically released and spring set upon loss of power to the brake coils. Should electrical power to the crane fail during an operation, both brakes will set and hold the load at the last position prior to the power failure. The drum mounted emergency brake is pneumatically operated. Compressed air is used to hold the brake pads away from the brake rotor. Should an emergency occur, the air is released and the brake will set and hold the load. The emergency brake can be set using the E-Stop button or by the overspeed switch which senses drum overspeed. The hoist is also equipped with dynamic braking, which is used to control load lowering. This form of braking is not acceptable as a primary means of braking by NSS/GO 1740.9B.

### 2.3.2 TROLLEY SYSTEM

The trolley is an underhung type and consists of a trolley motor, worm gear drive and a electro-mechanical disc type brake. The trolley motor is a variable speed motor (10 FPM max) rated at 1 1/2 HP/1800 RPM. The motor supplies rotational power to a worm gear that drives the trolley drive chain used to move the trolley along the bridge rails. The trolley brake is a electro-mechanical disc type brake, which is electrically released and spring set upon loss of electric power to the coil. Should electric power fail during an operation of the crane, the trolley will stop at its last position prior to the loss of power.

### 2.3.3 BRIDGE SYSTEM

The Bridge system is a double girder type, and is moved through its length of travel using two variable speed motors (10 FPM max) rated at 1 HP/1800 RPM. Both motors are connected to gear drive units at either end of the bridge rails. The motors are used to turn wire rope drums that pull the bridge into the required position. Both motors are equipped with electro-mechanical disc type brakes that are electrically released and spring set upon the loss of electrical power. During bridge operation one motor is used to pull the bridge; the second motor and gear drive unit are idle and paying out wire rope. When the operator commands stop both brakes engage. The idle unit acts as the braking unit for the bridge.

### 2.3.4 CRANE CONTROL PENDANT

The crane is controlled using one of two identical pendants. The pendant contains push button controls for hoist up and down, trolley right and left, bridge forward and reverse, emergency stop, and a power "on" indicator light. The pendant also contains variable pots that allow the operator to set the required speed for each subsystem. Two pendants are being supplied so as to allow operation from different locations on the MST. To prevent commands to the crane from two pendants at once, each pendant is equipped with a relay, that once energized, will electrically lock out the other pendant and prevent conflicting commands.

### 2.3.6 HOIST LIMIT SWITCHES

The hoist system is equipped with dual upper limit switches. The first is a paddle operated type, the final is a geared upper and lower limit switch. Should the hoist contact the first limit switch, a set of normally closed contacts within the hoist up circuit will open stopping hoist upward motion. If the first limit is reached all power for raising the load is removed and the brakes will set and hold the load. The load may be lowered since power will still be available for the down circuit of the hoist. Should the final upper limit be reached, all hoist system power is terminated and can only be restored using a key operated reset switch.

SECTION IV

DEFINITIONS AND GROUND RULES

3.1 DEFINITIONS

Definitions necessary for the clarification of criticality categories, hazard analysis, and "time to effect" are listed below.

a. Criticality Categories:

<u>CRITICALITY</u>	<u>POTENTIAL EFFECT OF FAILURE</u>
1	A single failure which could result in loss of life or flight hardware.
1R	Two redundant hardware items, which if both failed, could result in loss of life or vehicle (or loss of a safety or hazard monitoring system associated with flight crew emergency egress).
1S	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.
2	A single failure which could result in loss (damage) of a flight hardware system.
3	All other effects (i.e., delay, no effect).

Note: For this analysis, the term "vehicle" includes payloads.

b. Hazard Report Closure Classification

- (1) Eliminated - A hazard that has been eliminated by completely removing the hazard causal factors or by deleting the hazardous operation (e.g., modifying the system/GSE by ESR implementation).
- (2) Controlled - The likelihood of occurrence has been reduced to an acceptable level by implementing the appropriate Hazard Reduction Precedence Sequence (HRPS) to comply with program requirements (e.g., OMI controls, physical controls)
- (3) Accepted Risk - A hazard that has not been completely eliminated or controlled, and the residual risk has been accepted by project/program management on the basis of risk acceptance rationale. These risks are considered a part of doing business and necessary to continue the program phase.

c. Hazard Levels - There are three levels for which a hazard can be identified. Hazard level will be categorized as follows:

- (1) Catastrophic (CA) - Hazard 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 (applicable for accepted risk hazards only).
- (2) Critical (CR) - Hazard could result in serious injury to personnel and/or damage to flight and ground equipment which could cause mission abort or a significant program delay (applicable for accepted risk hazards only).
- (3) Controlled (CN) - Has been counteracted by appropriate design, safety devices, alarm/caution and warning devices, or special automatic/manual procedures (applicable for controlled hazards only).

d. Hazard Report Status

- (1) Closed - Corrective action/evaluation has been completed. OMRSD requirements have been identified and closed loop control is established. Governing procedural controls (e.g., OMIs, TPSSs, PMOMIs, etc...) are in place. In case of hazards which document design deficiencies, the modification has been completed, the modified system configuration has been verified, and the certification has been documented.
- (2) Open - Corrective measure/procedural hazard controls are not in place, or evaluation is pending.

e. Likelihood of Occurrence - The probability the hazard will occur, considering the in-place hazard controls. Likelihood of occurrence will be categorized as follows:

- Ao: Unlikely - Extremely remote possibility that hazard will occur in the life of the program; strong controls are in place.
- Bo: Likely - Could happen in the life of the program, but not expected; controls have minor limitations or uncertainties.
- Co: Probable - Expected to happen in the life of the program; controls have significant limitations of uncertainties. Hazard reports with this likelihood of occurrence are considered unacceptable risk.

f. Time to Effect - The analysis shall determine the time for the failure effect to occur, which will be specified as follows:

- Immediate - less than 1 second
- Seconds - 1 to 60 seconds
- Minutes - 60 seconds to 60 minutes
- Hours - 60 minutes to 24 hours
- Days - 24 hours to process completion

The description which indicates the shortest credible time or time range available to correct the situation before the effect is manifested shall be identified.

### 3.2 GROUND RULES

This analysis has been developed in accordance with KHB 5310.9, "Kennedy Space Center Ground Systems Safety and Reliability Analyses".

The following ground rules and assumptions were considered during this analysis:

- a. For this analysis it is assumed that crane operators are trained and certified to operate this crane system
- b. This analysis assumes worst case scenerio of "fail to high speed" when analyzing the hoist, trolley and bridge inverters due to the unavailability of documentation caused by manufacturers proprietary rights.
- c. This analysis assumes no lifting operations will be attempted during high wind conditions.
- d. This analysis assumes only one pendant "Power On" key will be available for use, thus eliminating the possiblity of two pendants being powered at one time.
- e. Passive components will not be analyzed in the FMEA, but are considered in the Hazard Analysis.

SECTION IV  
CRITICALITY ASSESSMENT

4.1 HARDWARE/RELIABILITY BLOCK DIAGRAM

This system input and output functions are identified from the following Hardware/Reliability Block Diagram.

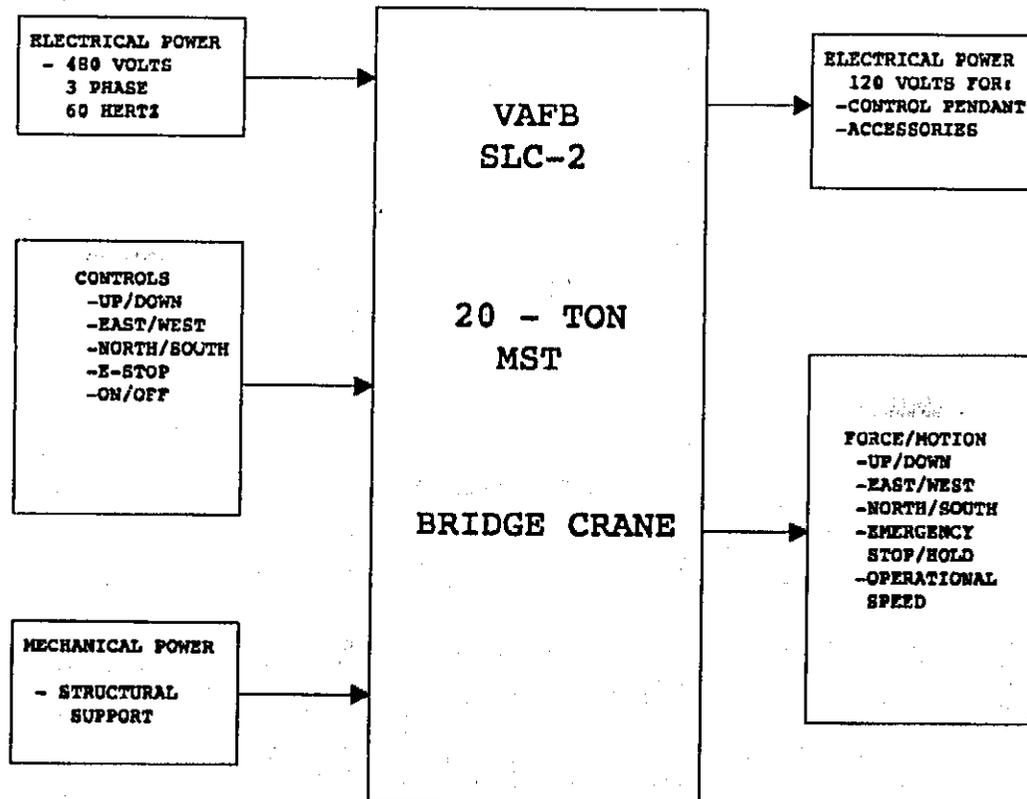


Figure 4-1. Hardware/Reliability Block Diagram

4.2 CRITICALITY ASSESSMENT WORKSHEETS

This system input and output functions are assessed on the following Criticality Assessment Summary sheet

The Criticality Assessment Worksheets are performed to determine whether the GSE or facility system is Critical or Noncritical in terms of reliability impact. If loss or improper performance of any one of the system's functions, without regard to redundancy, could result in loss of life or loss of flight hardware or damage to flight hardware, the total system is assessed as Critical. If loss or improper performance of all of the system's functions could not result in any of the aforementioned effects, the system will be considered Noncritical.

SYSTEM CRITICALITY ASSESSMENT SUMMARY WORKSHEET				SHEET 1 OF 2	
PROGRAM MODEL NO.:	SYSTEM/SUBSYSTEM:	STATION SET (NAME/NUMBER):	W.O.:	CRIT CAT	NOTE
88V0019	20-TON BRIDGE CRANE	SIC-2	NONE		
BASELINE: 950.00	LOCATION: VANDEBERG AIR FORCE BASE	PREPARED BY: J. C. WYCKOFF, MDSSC-KSC	PCN: NONE		DATE: 12-04-91
INPUT/OUTPUT	FUNCTION	TIME PERIOD	EFFECT OF LOSS/FAILURE	CRIT CAT	NOTE
60 HZ/ HOIST SYSTEM	PROVIDES ABILITY TO LIFT/LOWER LOADS UP TO 20 TONS	PRE-LAUNCH PROCESSING	FAILURE OF THE HOIST SYSTEM COULD CAUSE THE LOAD TO DROP. COULD CAUSE LOSS OF LIFE AND/OR LOSS OF FLIGHT HARDWARE.	CRIT	
60 HZ/ HOIST BRAKING SYSTEM	PROVIDES ABILITY TO HOLD A LOAD SUSPENDED ONCE ELECTRICAL POWER IS REMOVED	PRE-LAUNCH PROCESSING	FAILURE OF THE HOIST BRAKING SYSTEM WILL CAUSE THE LOAD TO DROP. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE	CRIT	
60 HZ/ TROLLEY SYSTEM	PROVIDES ABILITY TO MOVE LOAD RIGHT OR LEFT THE WIDTH OF THE BRIDGE	PRE-LAUNCH PROCESSING	FAILURE OF THE TROLLEY SYSTEM COULD CAUSE THE LOAD TO CONTACT PROCESSING FACILITY AND/OR OTHER FLIGHT HARDWARE. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.	CRIT	
60 HZ/ TROLLEY BRAKE SYSTEM	PROVIDES ABILITY TO STOP AND HOLD TROLLEY IN REQUIRED POSITION.	PRE-LAUNCH PROCESSING	FAILURE OF THE TROLLEY BRAKE COULD CAUSE IMPACT WITH FACILITY STRUCTURE AND/OR OTHER FLIGHT HARDWARE. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.	CRIT	

SYSTEM CRITICALITY ASSESSMENT SUMMARY WORKSHEET				SHEET 2 OF 2	
PROGRAM MODEL NO.:	SYSTEM/SUBSYSTEM:	STATION SET (NAME/NUMBER):	W.O.:	SCHEMATIC DWG NO.	
88V0019	20-TON MST BRIDGE CRANE	VAFB/SLC-2	NONE	D2153-M01-M10	
BASELINE:	LOCATION:	PREPARED BY:	PCI:	DATE:	
950.00	VANDENBERG AIR FORCE BASE	J. C. WYCKOFF, MDSSC-KSC	NONE	2-27-92	
INPUT/OUTPUT	FUNCTION	TIME PERIOD	EFFECT OF LOSS/FAILURE	CRIT CAT	NOTE
60 HZ/ BRIDGE SYSTEM	PROVIDES ABILITY TO TRAVERSE ENTIRE LENGTH OF THE PROCESSING FACILITY	PRE-LAUNCH PROCESSING	FAILURE OF THE BRIDGE SYSTEM COULD CAUSE FLIGHT HARDWARE TO CONTACT FACILITY STRUCTURE AND/OR OTHER FLIGHT HARDWARE. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.	CRIT	
60 HZ/ BRIDGE BRAKE SYSTEM	PROVIDES ABILITY TO STOP AND HOLD BRIDGE IN REQUIRED POSITION.	PRE-LAUNCH PROCESSING	FAILURE OF THE BRIDGE BRAKE SYSTEM COULD CAUSE FLIGHT HARDWARE TO CONTACT FACILITY STRUCTURE AND/OR OTHER FLIGHT HARDWARE. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.	CRIT	

## FAILURE MODES AND EFFECTS ANALYSIS

FOR THE

20-TON MOBILE SERVICE TOWER BRIGGE CRANE

LOCATED AT VANDENBERG AIR FORCE BASE SLC-2

PMN: 88V0019

The following components were considered passive in this analysis for this section.

<u>Nomenclature</u>	<u>Find Number</u>
1. Bridge Girders	None
2. Trolley Frame	None
3. Wire Rope	None
4. Hook	None
5. Hook Block Assembly	None
6. Bridge & Trolley Wheels	None
7. Wire Rope Sheeves & Peripheral Equipment	None

GSFC considers the above listed items as single failure points, but does not require that they be analyzed because they have been designed to a 5:1 factor of safety per NSS/GO 1740.9B

SECTION V

FAILURE MODES AND EFFECTS ANALYSIS AND CIL

5.1 MECHANICAL FMEA WORKSHEETS AND BLOCK DIAGRAMS

The mechanical components of the critical output functions identified in section 4.0 for this system were identified from documents and diagrams referenced in the Documentation List and are analyzed on the worksheets. A passive items list precedes the FMEA Worksheets and is contained on the following page.

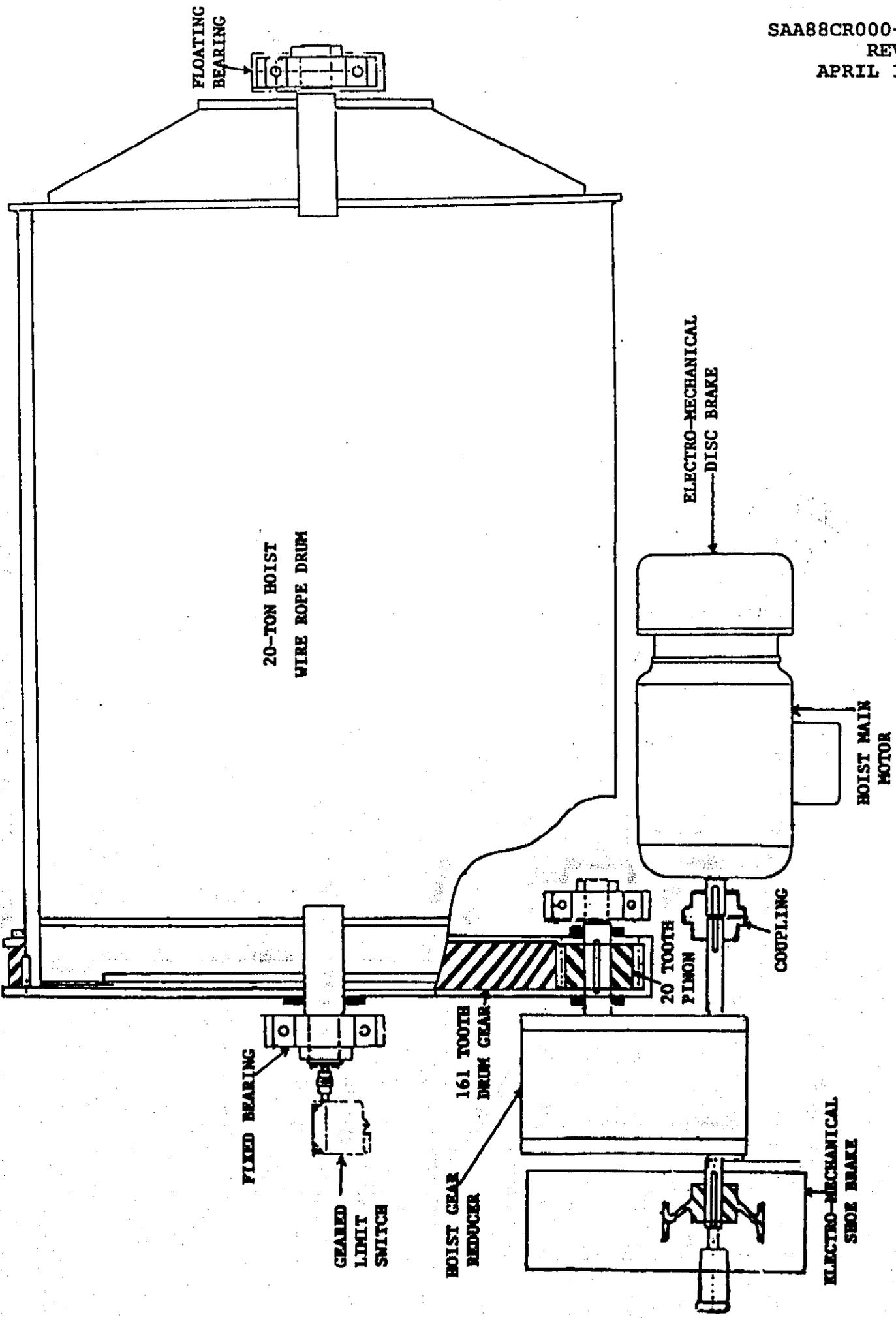


FIGURE 20-TON MST BRIDGE CRANE HOIST PHYSICAL LAYOUT

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM MECHANICAL  
 Drawing No.: D2153-M01 Sheet No.:  
 FMM: 88V0019 Baseline: 950.00  
 Program: SLC-2 Facility/Station Set: VAFB / SLC-2  
 Page 1 of 6 Date: 3/04/92  
 Prepared by: J. C. WYCKOFF

FMS NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMM D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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<p>NONE</p> <p>HOIST GEAR REDUCER</p>	<p>PROVIDES MECHANICAL LINKAGE BETWEEN HOIST MOTOR AND WIRE ROPE DRUM AND REDUCES HOIST MOTOR ROTATIONAL SPEED</p>	<p>A1. DISENGAGES B1. BROKEN TEETH C1. FMM 88CR000-041.001 D1. UNDETECTABLE E. CORRECTING ACTION, NA F. IMMEDIATELY G. IMMEDIATELY</p>	<p>LOSS OF LOAD HOLDING ABILITY, LOAD WILL DROP.</p> <p>LOAD WILL DROP, COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.</p>	<p>1R</p>
<p>CD-SADD</p> <p>ELECTRO-MECHANICAL HOLDING BRAKE NUMBER 1 (DISC TYPE)</p>	<p>HOLDS LOAD WHEN HOIST MOTOR IS DE-ENERGIZED.</p>	<p>A1. FAILS TO ENGAGE B1. SPRING FAILURE</p>	<p>NONE, SECOND ELECTRO-MECHANICAL BRAKE AND EMERGENCY BRAKE WILL STOP AND HOLD LOAD.</p>	<p>3</p>
<p></p>	<p>A2. FAILS TO DISENGAGE B2. INTERNAL PART FAILURE</p>	<p>A2. BEARINGS FREEZE B2. LACK OF LUBRICATION</p>	<p>HOIST SYSTEM INOPERATIVE. DELAY IN OPERATIONS</p> <p>HOIST SYSTEM INOPERATIVE. DELAY FOR REPAIRS</p>	<p>3</p>

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE Program: SLC-2 Facility/Station Set: VAFB / SLC-2  
 Subsystem: CRANE SYSTEM MECHANICAL Page 2 of 6 Date: 3/04/92  
 Drawing No.: D2153-M01 Sheet No.: Prepared by: J. C. WYCKOFF  
 PNM: 88V0019 Baseline: 950.00

ITEM NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAY
TYPE 5BE	ELECTRO-MECHANICAL HOLDING BRAKE NUMBER 2. (SHOE TYPE)	HOLDS LOAD WHEN HOIST MOTOR IS DE-ENERGIZED.	A1. FAILS TO ENGAGE B1. SPRING FAILURE	NONE, FIRST ELECTRO-MECHANICAL BRAKE AND EMERGENCY BRAKE WILL STOP AND HOLD LOAD.	DELAY IN OPERATIONS. REQUIRES MULTIPLE FAILURES	3
F700T9056MHR	TROLLEY GEAR REDUCER (HELICAL GEAR/MOTOR)	PROVIDES LINKAGE AND SLOWS TROLLEY MOTOR ROTATIONAL SPEED. RATIO 177.18:1	A2. FAILS TO DISENGAGE B2. INTERNAL PART FAILURE	HOIST SYSTEM INOPERATIVE.	DELAY IN OPERATIONS	3
K98R60D7100LSB MHR	BRIDGE GEAR REDUCER (HELICAL BEVEL GEAR/MOTOR)	PROVIDES MECHANICAL LINKAGE BETWEEN BRIDGE DRIVE MOTOR AND WIRE ROPE DRUMS. SLOWS MOTOR ROTATIONAL SPEED.	A1. DISENGAGES B1. BROKEN TEETH	TROLLEY SYSTEM INOPERATIVE	DELAY IN OPERATIONS	3
			A2. BEARINGS FREEZE B2. LACK OF LUBRICATION	TROLLEY SYSTEM INOPERATIVE	DELAY IN OPERATIONS	3
			A1. DISENGAGES B1. BROKEN TEETH	BRIDGE SYSTEM INOPERATIVE	DELAY IN OPERATIONS	3
			A2. BEARINGS FREEZE B2. LACK OF LUBRICATION	BRIDGE SYSTEM INOPERATIVE	DELAY IN OPERATIONS	3
NONE	TROLLEY ELECTRO-MECHANICAL DISC TYPE BRAKE	PROVIDES ABILITY TO STOP AND HOLD TROLLEY IN REQUIRED POSITION.	A1. FAILS TO ENGAGE B1. BROKEN SPRINGS	TROLLEY SYSTEM BRAKE INOPERATIVE, TROLLEY MAY COAST A SHORT DISTANCE WHEN COMMANDED TO STOP.	DELAY IN OPERATIONS	3

**System:** 20-TON MST BRIDGE CRANE  
**Subsystem:** CRANE SYSTEM MECHANICAL  
**Drawing No.:** D2153-M01 Sheet No.:  
**Part:** 88V0019 Baseline: 950.00  
**Program:** SIC-2  
**Facility/Station Set:** VAFB / SIC-2  
**Page 3 of 6** Date: 3/04/92  
**Prepared by:** J. C. WYCKOFF

FIG NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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<p><b>WOME</b></p> <p>BRIDGE ELECTRO-MECHANICAL DISC TYPE BRANE</p>	<p>PROVIDES ABILITY TO STOP AND HOLD BRIDGE IN REQUIRED POSITION.</p>	<p>A1. FAILS TO DISENGAGE B1. OPEN/SHORTED COIL</p>	<p>TROLLEY SYSTEM INOPERATIVE</p>	<p>DELAY IN OPERATIONS</p>	<p>3</p>
<p><b>WOME</b></p> <p>BRIDGE ELECTRO-MECHANICAL DISC TYPE BRANE</p>	<p>PROVIDES ABILITY TO STOP AND HOLD BRIDGE IN REQUIRED POSITION.</p>	<p>A1. FAILS TO ENGAGE B1. BROKEN SPRINGS</p>	<p>BRIDGE SYSTEM BRAKE INOPERATIVE. BRIDGE MAY COAST A SHORT DISTANCE WHEN COMMANDED TO STOP.</p>	<p>DELAY IN OPERATIONS</p>	<p>3</p>
<p><b>SERIES F</b></p> <p>FLEXIBLE COUPLING</p>	<p>PROVIDES LINKAGE BETWEEN HOIST MOTOR AND HOIST GEAR REDUCER</p>	<p>A1. FAILS TO DISENGAGE B1. OPEN/SHORTED COIL</p>	<p>BRIDGE SYSTEM INOPERATIVE</p>	<p>DELAY IN OPERATIONS</p>	<p>3</p>
<p><b>WOME</b></p> <p>WIRE ROPE DRUM GEAR 161 TEETH</p>	<p>PROVIDES ABILITY TO TRANSFER NOTATIONAL FORCE FROM HOIST GEAR REDUCER TO WIRE ROPE DRUM.</p>	<p>A1. FAILS STRUCTURALLY B1. BROKEN TEETH C. FWN 88CR000-041.002 D. UNDETECTABLE E. CORRECTIVE ACTION, NA F. IMMEDIATELY G. IMMEDIATELY</p>	<p>NONE, ELECTRO-MECHANICAL BRAKE #2 AND EMERGENCY BRAKE WILL STOP AND HOLD LOAD.</p> <p>HOIST SYSTEM INOPERATIVE. LOAD HOLDING ABILITY, UPON THE EMERGENCY BRAKE..</p>	<p>DELAY IN OPERATIONS. REQUIRES MULTIPLE FAILURES</p> <p>NONE, IF BOTH THE GEAR AND THE EMERGENCY BRAKE FAIL, LOAD WILL DROP. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE</p>	<p>3</p> <p>1R</p>

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MSI BRIDGE CRANE  
Program: SLC-2  
Facility/Station Set: VAFB / SLC-2

Subsystem: CRANE SYSTEM MECHANICAL

Drawing No.: D2153-M01 Sheet No.:

PMS: 89V0019 Baseline: 950.00

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Prepared by: J. C. WYCKOFF

FND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FPN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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NONE WIRE ROPE DRUM PROVIDES ABILITY TO A1 FAILS STRUCTURALLY  
PINON 20 TEETH TRANSFER ROTATIONAL B1 BROKEN TEETH  
FORCE FROM HOIST C. FPN 88CR000-041.003  
GEAR REDUCER TO D. UNDETECTABLE  
WIRE ROPE DRUM E. CORRECTIVE ACTION, NA  
F. IMMEDIATELY  
G. IMMEDIATELY

GH6178-H30 AIR COMPRESSOR PROVIDES REQUIRED COMPRESSED AIR  
NEEDED TO OPERATE THE DRUM MOUNTED EMERGENCY BRAKE.  
A1. FAILS TO OPERATE DELAY FOR REPAIR 3  
B1. INTERNAL PARTS FAILURE  
EMERGENCY BRAKE TO ENGAGE. HOIST SYSTEM WILL BE INOPERATIVE.

A2. FAILS DURING OPERATION LOSS OF COMPRESSED AIR  
B2. INTERNAL PARTS FAILURE SUPPLY WILL CAUSE THE EMERGENCY BRAKE TO ENGAGE. HOIST SYSTEM WILL BE INOPERATIVE. DELAY FOR REPAIR 3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE      Program: SLC-2      Facility/Station Set: VAFB / SLC-2  
 Subsystem: CRANE SYSTEM MECHANICAL  
 Drawing No.: D2153-M01 Sheet No.:  
 FMM: 88V0019      Baseline: 950.00      Page 5 of 6      Date: 3/04/92  
 Prepared by: J. C. WYCKOFF

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FTM D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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D1024C	SELECTOR VALVE, THREE WAY, NORMALLY CLOSED (TWO UNITS)	ALLOWS FOR MANUAL OPERATION OF THE EMERGENCY BRAKE SYSTEM SO AS TO ALLOW LOWERING OF LOAD AFTER AN EMERGENCY	A1. FAILS IN AUTO POSITION B1. DEFECTIVE VALVE  A2. FAILS IN MANUAL POSITION B2. DEFECTIVE VALVE  A3. FAILS IN OFF POSITION B3. DEFECTIVE VALVE	UNABLE TO MANUALLY LOWER LOAD.  UNABLE TO CHARGE SYSTEM WITH COMPRESSED AIR. HOIST EMERGENCY BRAKE WILL REMAIN SET. HOIST SYSTEM INOPERATIVE.  UNABLE TO CHARGE SYSTEM WITH COMPRESSED AIR. HOIST EMERGENCY BRAKE WILL REMAIN SET. HOIST SYSTEM INOPERATIVE.	DELAY IN OPERATION  DELAY IN OPERATIONS  DELAY IN OPERATIONS	3  3  3
EV-30A2	EXHAUST VALVE (TWO UNITS)	PROVIDES PATH TO DISCHARGE COMPRESSED AIR THAT HOLDS THE EMERGENCY BRAKE IN THE DISENGAGED POSITION	A1. FAILS CLOSED B1. INTERNAL PARTS FAILURE  A2. FAILS OPEN B2. INTERNAL PARTS FAILURE	REDUNDANT VALVE WILL VENT NONE PRESSURE AND ALLOW SETTING THE EMERGENCY BRAKE. REQUIRES MULTIPLE FAILURES  EMERGENCY BRAKE WILL REMAIN SET. HOIST SYSTEM INOPERATIVE	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE Program: SLC-2 Facility/Station Set: VAFB / SLC-2  
 Subsystem: CRANE SYSTEM MECHANICAL Page 6 of 6 Date: 3/04/92  
 Drawing No.: D2153-M01 Sheet No.: Prepared by: J. C. WYCKOFF  
 PPM: 88V0019 Baseline: 950.00

FIND NO. PART NO.	PART NAME	PART FUNCTION	FAILURE MODE A. FAILURE MODE B. CAUSE C. FPN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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20MBA	DISC BRAKE, PROVIDES EMERGENCY STOPPING AND LOAD HOLDING ABILITY TO THE HOIST SYSTEM	MIRE ROPE DRUM MOUNTED	A1. FAILS TO ENGAGE B1. BROKEN SPRINGS C. FPN 88CR000-041.004 D. UNDETECTABLE E. CORRECTIVE ACTION, NA F. IMMEDIATELY G. IMMEDIATELY	NO EFFECT ON NORMAL OPERATIONS. FAILURE OF THE BRAKE AFTER THE FAILURE OF THE GEAR REDUCER OR DRUM GEAR/PINON SET WILL CAUSE THE LOAD TO DROP. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE. FAILS REDUNDANCY SCREEN B	DELAY OPERATIONS. REQUIRES MULTIPLE FAILURES	1R
			A2. FAILS TO DISENGAGE B2. INTERNAL PARTS FAILURE	HOIST SYSTEM INOPERATIVE	DELAY IN OPERATIONS	3

## 5.2 ELECTRICAL FMEA WORKSHEETS AND BLOCK DIAGRAMS

The electrical components of the critical output functions identified in section 4.0 for this system were identified from documents and diagrams referenced in the Documentation List and are analyzed on the worksheets.

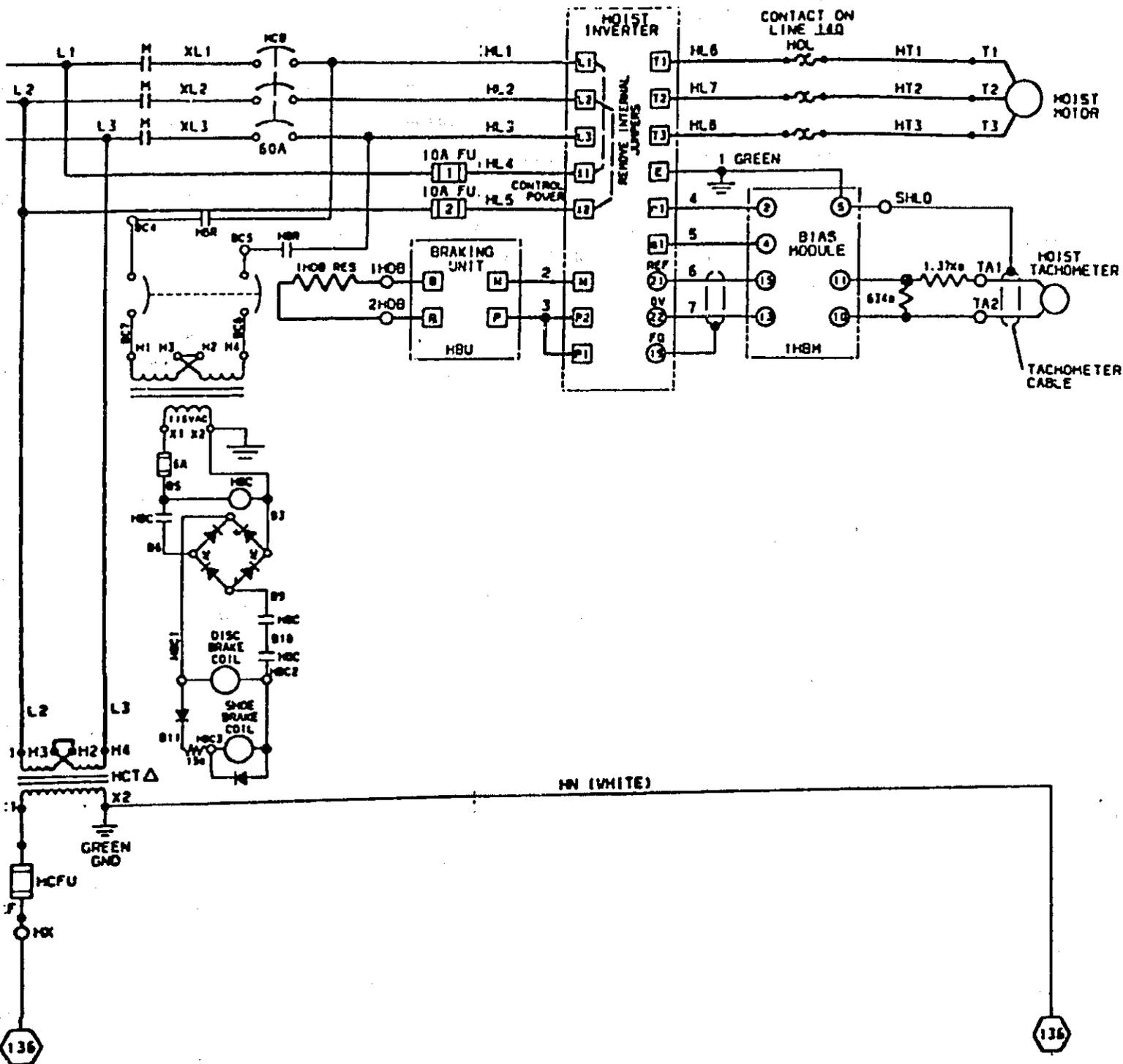


FIGURE 2. 20-TON MST CRANE HOIST ELECTRICAL SCHEMATIC  
 (TYPICAL FOR BRIDGE & TROLLEY)

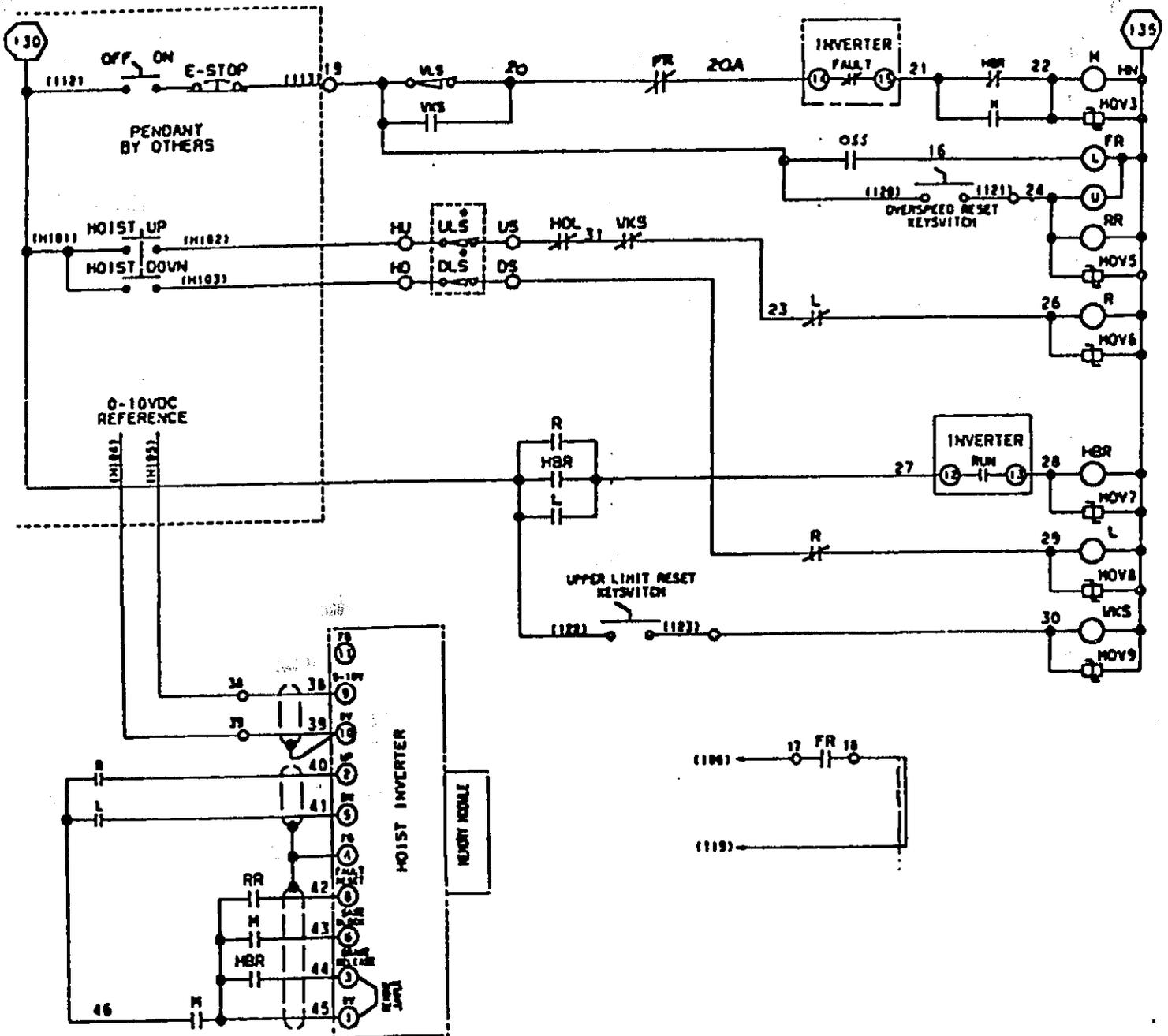


FIGURE 20-TON MST CRANE HOIST ELECTRICAL SCHEMATIC  
 (TYPICAL FOR BRIDGE & TROLLEY)

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: D2153-M01 Sheet No.:  
FAN: 88V0019 Baseline: 950.00

Program: SLC-2  
Facility/Station Set: VAFB / SLC-2  
Page 1 of 36 Date: 3-04-92  
Prepared by: J. C. WYCKOFF

FTD NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. ENDFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
NONE	HOIST DRIVE MOTOR, 30 HP/1800 RPM	PROVIDES ROTATIONAL POWER TO THE GEAR REDUCER TO MOVE THE WIRE ROPE DRUM	A1. FAILS TO OPERATE B1. OPEN/SHORTED	HOIST SYTEM INOPERATIVE, HOIST INVERTER WILL SECSE NO TORQUE FROM THE MOTOR AND MAINTAIN HOIST BRAKES IN THE SET POSITION.	DELAY IN OPERATIONS	3
NONE	TROLLEY DRIVE MOTOR, 1 HP/1200 RPM	PROVIDES ROTATIONAL POWER TO GEAR REDUCER TO MOVE THE TROLLEY TO THE REQUIRED POSITION	A1. FAILS TO OPERATE B1 OPEN/SHORTED A2. FAILS DURING OPERATION B2. OPEN/SHORTED	HOIST SYSTEM INOPERATIVE, HOIST INVERTER WILL SECSE THE LOSS OF MOTOR TORQUE AND ENGAGE BOTH HOLDING BRAKES. TROLLEY SYSTEM INOPERATIVE, TROLLEY BRAKE WILL REMAIN SET.	DELAY IN OPERATION	3
NONE	BRIDGE DRIVE MOTOR, 1.5 HP/1800 RPM	PROVIDES ROTATIONAL POWER TO GEAR REDUCER TO MOVE THE BRIDGE TO REQUIRED POSITION	A1. FAILS TO OPERATE B1. OPEN/SHORTED A2. FAILS DURING OPERATION B2. OPEN/SHORTED	TROLLEY SYSTEM INOPERATIVE, TROLLEY BRAKE WILL SET AND STOP TROLLEY MOTION. BRIDGE SYSTEM INOPERATIVE BRIDGE BRAKE WILL REMAIN SET AND HOLD BRIDGE IN LAST POSITION PRIOR TO FAILURE BRIDGE SYSTEM INOPERATIVE BRIDGE BRAKE WILL SET AND STOP BRIDGE MOTION	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON HST BRIDGE CRANE		Program: SLC-2		Facility/Station Set: VAFB / SLC-2		
Subsystem: CRANE SYSTEM ELECTRICAL		Page 2 of 36		Date: 3-04-92		
Drawing No.: D2153-M01 Sheet No.:		Prepared by: J. C. WYCKOFF				
P/N: 88V0019 Baseline: 950.00						
FILED NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT

E-STOP, SQ-D9001-SKR5R/KA41	PUSH BUTTON, NORMALLY OPEN	PROVIDES ABILITY TO DE-ENERGIZE CRANE SYSTEM BY OPENING MAIN LINE CONTACTS	A1. FAILS CLOSED B1. INTERNAL PARTS FAILURE	LOSS OF ABILITY TO DE-ENERGIZE CRANE USING E-STOP BUTTON. OPERATOR CAN STOP HOIST BY USING ON/OFF BUTTON REQUIRES MULTIPLE FAILURES.	DELAY IN OPERATIONS.	3
OEM MS4M7151 HOIST UP BUTTON	PUSH BUTTON, NORMALLY OPEN	PROVIDES ABILITY TO ENERGIZE HOIST SYSTEM IN THE "UP" MODE.	A2. FAILS OPEN B2. INTERNAL PARTS FAILURE	UNABLE TO ENERGIZE CRANE SYSTEM. CRANE SYSTEM INOPERATIVE	DELAY IN OPERATIONS	3
OEM MS4M7151 HOIST DOWN BUTTON	PUSH BUTTON, NORMALLY OPEN	PROVIDES ABILITY TO DE-ENERGIZE HOIST SYSTEM IN THE "DOWN" MODE.	A1. CONTACTS FAIL OPEN B1. INTERNAL PARTS FAILURE A2. CONTACTS FAIL CLOSED B2. INTERNAL PARTS FAILURE	UNABLE TO ENERGIZE HOIST IN "UP" MODE. HOIST WILL CONTINUE TO OPERATE WHEN COMMANDED TO STOP. HOIST IS PROTECTED BY TWO UPPER LIMIT SWITCHES. OPERATOR CAN STOP HOIST BY USING THE E-STOP BUTTON. REQUIRES MULTIPLE FAILURES.	DELAY IN OPERATIONS	3
			A1. CONTACTS FAIL CLOSED B1. INTERNAL PARTS FAILURE A2. CONTACTS FAIL OPEN B2. INTERNAL PARTS FAILURE	HOIST WILL CONTINUE TO OPERATE WHEN COMMANDED TO STOP. ABILITY TO DE-ENERGIZE HOIST DEPENDANT UPON THE E-STOP BUTTON OR ON/OFF BUTTON. REQUIRES MULTIPLE FAILURES	DELAY IN OPERATIONS.	3
			A2. CONTACTS FAIL OPEN B2. INTERNAL PARTS FAILURE	HOIST SYSTEM INOPERATIVE IN THE "UP" DIRECTION OF TRAVEL.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE		Facility/Station Set: VAFB / SLC-2				
Subsystem: CRANE SYSTEM ELECTRICAL		Page 3 of 36 Date: 3-04-92				
Drawing No.: D21-J-M01 Sheet No.:		Prepared by: J. C. WYCKOFF				
P/N: 88V0019 Baseline: 950.00						
ITEM NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. P/N D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT

OEM MS4M7151 PUSH BUTTON, MOMENTARY, NORMALLY OPEN  
TROLLEY RIGHT BUTTON

PROVIDES ABILITY TO ENERGIZE TROLLEY SYSTEM IN THE "RIGHT" DIRECTION OF TRAVEL.

A1. CONTACTS FAIL CLOSED  
B1. INTERNAL PARTS FAILURE

TROLLEY WILL CONTINUE TO OPERATE AFTER COMMANDED TO STOP. TROLLEY CAN BE STOPPED USING E-STOP, ON/OFF BUTTON OR TROLLEY TRAVEL LIMIT SWITCH. REQUIRES MULTIPLE FAILURES

DELAY IN OPERATIONS. 3

A2. CONTACTS FAIL OPEN  
B2. INTERNAL PARTS FAILURE

TROLLEY SYSTEM INOPERATIVE IN THE "RIGHT" DIRECTION OF TRAVEL

DELAY IN OPERATIONS. 3

OEM MS4M7151 PUSH BUTTON, MOMENTARY, NORMALLY OPEN  
TROLLEY LEFT BUTTON

PROVIDES ABILITY TO ENERGIZE TROLLEY SYSTEM IN THE "LEFT" DIRECTION OF TRAVEL

A1. CONTACTS FAIL CLOSED  
B1. INTERNAL PARTS FAILURE

TROLLEY WILL CONTINUE TO OPERATE AFTER COMMANDED TO STOP. TROLLEY CAN BE STOPPED USING E-STOP, ON/OFF BUTTON OR TROLLEY TRAVEL LIMIT SWITCH. REQUIRES MULTIPLE FAILURES

DELAY IN OPERATIONS. 3

A2. CONTACTS FAIL OPEN  
B2. INTERNAL PARTS FAILURE

TROLLEY SYSTEM INOPERATIVE IN THE "LEFT" DIRECTION OF TRAVEL.

DELAY IN OPERATIONS 3

OEM MS4M7151 PUSH BUTTON, MOMENTARY, NORMALLY OPEN  
BRIDGE FORWARD BUTTON

PROVIDES ABILITY TO ENERGIZE BRIDGE SYSTEM IN THE FORWARD DIRECTION OF TRAVEL

A1. CONTACTS FAIL CLOSED  
B1. INTERNAL PARTS FAILURE

BRIDGE WILL CONTINUE TO OPERATE AFTER COMMANDED TO STOP. BRIDGE CAN BE STOPPED USING E-STOP, ON/OFF BUTTON OR TROLLEY TRAVEL LIMIT SWITCH. REQUIRES MULTIPLE FAILURES

DELAY IN OPERATIONS. 3

A2. CONTACTS FAIL OPEN  
B2. INTERNAL PARTS FAILURE

BRIDGE SYSTEM INOPERATIVE IN FORWARD DIRECTION OF TRAVEL.

DELAY IN OPERATIONS 3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

Program: SLC-2 Facility/Station Set: VAFB / SLC-2

Page 4 of 36 Date: 3-04-92

Prepared by: J. C. WYCKOFF

System: 20-TON HSI BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: D2155-01 Sheet No.:  
PMS: 88V0019 Baseline: 950.00

FTND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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OEM MS4M7151  
BRIDGE REVERSE  
BUTTON

PUSH BUTTON,  
MOMENTARY,  
NORMALLY OPEN

PROVIDES ABILITY TO  
ENERGIZE BRIDGE  
SYSTEM IN THE  
REVERSE DIRECTION  
OF TRAVEL

A1. CONTACTS FAIL CLOSED  
B1. INTERNAL PARTS FAILURE

BRIDGE WILL CONTINUE TO  
OPERATE AFTER COMMANDED TO  
STOP. BRIDGE CAN BE  
STOPPED USING E-STOP,  
ON/OFF BUTTON OR TROLLEY  
TRAVEL LIMIT SWITCH.  
REQUIRES MULTIPLE  
FAILURES

DELAY IN OPERATIONS.

IR

A2. CONTACTS FAIL OPEN  
B2. INTERNAL PARTS FAILURE

BRIDGE SYSTEM INOPERATIVE  
IN REVERSE DIRECTION OF  
TRAVEL

3

H2POT  
HOIST SPEED  
CONTROL

VARIABLE  
RHEOSTAT

PROVIDES ABILITY  
FOR THE OPERATOR TO  
SELECT HOIST  
OPERATING SPEED IN  
BOTH "UP" AND  
"DOWN" DIRECTIONS.

A1. FAILS SHORTED  
B1. INTERNAL PARTS FAILURE

HOIST MAY TRAVEL FASTER  
OR SLOWER THAN COMMANDED  
BY OPERATOR. OPERATOR CAN  
STOP HOIST BY RELEASING  
HOIST "UP" OR "DOWN"  
BUTTON OR BY USING E-STOP  
BUTTON. REQUIRES MULTIPLE  
FAILURES.

DELAY IN OPERATIONS

3

A2. FAILS OPEN  
B2. INTERNAL PARTS FAILURE

UNABLE TO ENERGIZE HOIST  
SYSTEM. HOIST SYSTEM  
INOPERATIVE

DELAY IN OPERATIONS

3

T2POT  
TROLLEY SPEED  
CONTROL

VARIABLE  
RHEOSTAT

PROVIDES ABILITY  
FOR THE OPERATOR TO  
SELECT TROLLEY  
OPERATING SPEED IN  
BOTH "RIGHT" AND  
"LEFT" DIRECTIONS

A1. FAILS SHORTED  
B2. INTERNAL PARTS FAILURE

TROLLEY MAY TRAVEL FASTER  
OR SLOWER THAN COMMANDED  
BY OPERATOR. OPERATOR CAN  
STOP TROLLEY BY RELEASING  
TROLLEY "RIGHT" OR "LEFT"  
BUTTON OR BY USING E-STOP  
BUTTON. REQUIRES MULTIPLE  
FAILURES.

DELAY IN OPERATIONS

3

A2. FAILS OPEN  
B2. INTERNAL PARTS FAILURE

UNABLE TO ENERGIZE  
TROLLEY SYSTEM. TROLLEY  
SYSTEM INOPERATIVE.

DELAY IN OPERATIONS

3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE		Program: SLC-2		Facility/Station Set: VAFB / SLC-2		
Subsystem: CRANE SYSTEM ELECTRICAL		Page 5 of 36		Date: 3-04-92		
Drawing No.: D2153-M01 Sheet No.:		Prepared by: J. C. WYCKOFF				
P/N: 88V0019 Baseline: 950.00						
FIG NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. F/M D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT

B2POT VARIABLE RHEOSTAT CONTROL  
 PROVIDES ABILITY FOR THE OPERATOR TO SELECT BRIDGE OPERATING SPEED IN BOTH THE "FORWARD" AND "REVERSE" DIRECTION  
 A1. FAILS SHORTED  
 B1. INTERNAL PARTS FAILURE  
 BRIDGE MAY TRAVEL FASTER OR SLOWER THAN COMMANDED. OPERATO CAN STOP BRIDGE BY RELEASING BRIDGE "FORWARD" OR "REVERSE" BUTTON OR BY USING E-STOP BUTTON. REQUIRES MULTIPLE FAILURES  
 DELAY IN OPERATIONS 3

A2. FAILS OPEN  
 B2. INTERNAL PARTS FAILURE  
 UNABLE TO ENERGIZE BRIDGE SYSTEM. BRIDGE SYSTEM INOPERATIVE.  
 DELAY IN OPERATIONS 3

SQ-D UPPER PADDLE LIMIT SWITCH NORMALLY CLOSED CONTACTS  
 PROVIDES PROTECTION AGAINST HOIST OVERTRAVEL IN THE "UP" DIRECTION OF TRAVEL BY CUTTING POWER TO THE HOIST "UP" CIRCUIT.  
 A1. FAILS OPEN  
 B1. INTERNAL PARTS FAILURE  
 HOIST SYSTEM INOPERATIVE IN THE "UP" DIRECTION OF TRAVEL.  
 DELAY IN OPERATIONS 3

A2. FAILS CLOSED  
 B2. INTERNAL PARTS FAILURE  
 LOSS OF PRIMARY OVER TRAVEL PROTECTION, HOIST IS EQUIPPED WITH A FINAL GEARED UPPER LIMIT SWITCH WHICH WILL STOP HOIST TRAVEL IF THE PRIMARY LIMIT SWITCH FAILS CLOSED. REQUIRES MULTIPLE FAILURES.  
 DELAY IN OPERATIONS 3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON HST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: D2153-M01 Sheet No.:  
 Program: SLC-2 Facility/Station Set: VAFB / SLC-2  
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 Prepared by: J. C. WYCKOFF

FILED NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FTM D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAJ
GE CR115E425101	GEARED UPPER LIMIT SWITCH NORMALLY CLOSED CONTACTS	PROVIDES REDUNDANT OVER TRAVEL PROTECTION TO THE HOIST IN THE "UP" DIRECTION OF TRAVEL. UPON CONTACT THIS LIMIT SWITCH OPENS MAIN LINE CONTACTS AND TERMINATES ALL CRANE POWER.	A1. FAILS OPEN B1. INTERNAL PARTS FAILURE	UNABLE TO ENERGIZE CRANE SYSTEMS	DELAY IN OPERATIONS	3
GE CR115E425101	GEARED LOWER LIMIT SWITCH NORMALLY CLOSED CONTACTS	PROVIDES OVER TRAVEL PROTECTION IN THE "DOWN" DIRECTION OF TRAVEL. GEARED LOWER LIMIT IS INTENDED TO PROTECT THE HOIST AND WILL NOT PROTECT THE SUSPENDED LOAD.	A2. FAILS CLOSED B2. INTERNAL PARTS FAILURE	LOSS OF REDUNDANT OVER TRAVEL PROTECTION. PRIMARY LIMIT SWITCH WILL PROVIDE OVER TRAVEL PROTECTION. REQUIRES MULTIPLE FAILURES	DELAY IN OPERATIONS	3
GE CR115E425101	GEARED LOWER LIMIT SWITCH NORMALLY CLOSED CONTACTS	PROVIDES OVER TRAVEL PROTECTION IN THE "DOWN" DIRECTION OF TRAVEL. GEARED LOWER LIMIT IS INTENDED TO PROTECT THE HOIST AND WILL NOT PROTECT THE SUSPENDED LOAD.	A1. FAILS OPEN B2. INTERNAL PARTS FAILURE	UNABLE TO ENERGIZE HOIST IN THE "DOWN" DIRECTION OF TRAVEL.	DELAY IN OPERATIONS	3
GE CR115E425101	GEARED LOWER LIMIT SWITCH NORMALLY CLOSED CONTACTS	PROVIDES OVER TRAVEL PROTECTION IN THE "DOWN" DIRECTION OF TRAVEL. GEARED LOWER LIMIT IS INTENDED TO PROTECT THE HOIST AND WILL NOT PROTECT THE SUSPENDED LOAD.	A2. FAILS CLOSED B2. INTERNAL PARTS FAILURE	LOSS OF OVER TRAVEL PROTECTION IN THE "DOWN" DIRECTION OF TRAVEL. OPERATOR CAN STOP HOIST USING E-STOP BUTTON OR BY RELEASING "DOWN" BUTTON REQUIRES MULTIPLE FAILURES.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20-TON MST BRIDGE CRANE Program: SLC-2 Facility/Station Set: VAFB / SLC-2  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: D2153-M01 Sheet No.:  
 Page 7 of 36 Date: 3-04-92  
 FAN: 88V0019 Baseline: 950.00 Prepared by: J. C. WYCKOFF

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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SO-D 9001-  
KS11K2/KA41  
OVERSPEED  
RESET KEY  
SWITCH,  
NORMALLY OPEN

PROVIDES ABILITY TO  
RESET HOIST SYSTEM  
AFTER AN OVERSPEED  
CONDITION.

A1. FAILS OPEN  
B1. INTERNAL PARTS FAILURE

UNABLE TO RESET SYSTEM  
AFTER AN OVERSPEED  
CONDITION HAS OCCURRED. NO  
EFFECT ON NORMAL  
OPERATIONS

DELAY IN OPERATIONS

3

A2. FAILS CLOSED  
B2. INTERNAL PARTS FAILURE

LOSS OF HOIST OVERSPEED  
PROTECTION, NO EFFECT ON  
NORMAL OPERATIONS.  
REQUIRES MULTIPLE  
FAILURES, (E-STOP, HOIST  
MOTOR)

DELAY IN OPERATIONS

3

SO-D 9001-  
KS11K2/KA41  
UPPER LIMIT  
RESET KEY  
SWITCH

PROVIDES ABILITY TO  
RESET HOIST SYSTEM  
AFTER FINAL LIMIT  
SWITCH HAS BEEN  
CONTACTED

A1. FAILS OPEN  
B1. INTERNAL PARTS FAILURE

UNABLE TO RESET UPPER  
LIMIT SWITCH AFTER IT HAS  
BEEN OPENED.

DELAY IN OPERATIONS

3

A2. FAILS CLOSED  
B2. INTERNAL PARTS FAILURE

LOSS OF FINAL UPPER LIMIT  
OVERTRAVEL PROTECTION.  
HOIST CONTAINS TWO UPPER  
LIMIT SWITCHES. REQUIRES  
MULTIPLE FAILURES.

LOSS OF FINAL UPPER LIMIT  
DELAY IN OPERATIONS

3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
FME: 88V0019 Baseline: 950.00

Program: SLC-2  
Facility/Station Set: VAFB/SLC-2  
Page 8 of 36 Date: March 15, 1992  
Prepared by: W. D1 Mec

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FME D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CAIT CAIT
M	MAIN CONTACTOR (COIL)	PROVIDES MEANS OF APPLYING AND REMOVING 480VAC (3 PHASE) POWER TO CRANE ELECTRICAL CIRCUITRY.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	FAILURE WOULD RESULT IN INABILITY TO REMOVE PRIMARY POWER (480VAC) FROM CRANE ELECTRICAL CIRCUITS. E-STOP WOULD BE INOPERABLE.	POWER CAN BE REMOVED BY OPENING MAIN CIRCUIT BREAKER. OTHER CONTROLS STILL OPERATING.	3
M	CONTACTS (3) IN SERIES WITH 3 PHASE INPUT LINES TO HOIST INVERTER		A2. FAILS OPEN B2. INTERNAL PART FAILURE	LOSS OF 480VAC POWER TO CRANE ELECTRICAL CIRCUITRY.	DELAY IN OPERATIONS	3
M	CONTACTS AT INPUT TO HOIST INVERTER PIN 43	PREVENTS THE MOTOR DRIVE FROM FIRING ITS OUTPUT TRANSISTORS, INSURING POWER IS REMOVED FROM THE MOTOR AT THE SAME TIME THE MAINLINE CONTACTOR IS OPENED.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	FAILURE WOULD RESULT IN INABILITY TO REMOVE PRIMARY POWER (480VAC) FROM CRANE ELECTRICAL CIRCUITS. E-STOP WOULD BE INOPERABLE.	POWER CAN BE REMOVED BY OPENING MAIN CIRCUIT BREAKER. OTHER CONTROLS STILL OPERATING.	3
M			A2. FAILS CLOSED B2. INTERNAL PART FAILURE	NONE. M CONTACTS AT PIN 43 OF INVERTER WOULD ALSO HAVE TO FAIL CLOSED ALONG WITH EITHER R (RAISE) OR L (LOWER) CONTACTS	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE Program: SLC-2 Facility/Station Set: VAFB/SLC-2  
 Subsystem: CRANE SYSTEM ELECTRICAL Page 9 of 36 Date: March 15, 1992  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4 Prepared by: N. Di Neo  
 FEM: 88VCC19 Baseline: 950.00

FID NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FCM D. DETECTION METHOD E. CORRECTING ACTION F. FID TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAF
M		CONTACTS AT INPUT TO HOIST DIRECTIONAL SIGNALS WILL REACH THE DRIVE WHEN MAINLINE CONTACTOR IS OPENED.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	HOIST WILL BE INOPERATIVE.	DELAY IN OPERATIONS	3
			A2. FAILS CLOSED B2. INTERNAL PART FAILURE	NONE. M CONTACTS AT PIN 45 OF INVERTER WOULD ALSO HAVE TO FAIL CLOSED ALONG WITH EITHER R (RAISE) OR L (LOWER) CONTACTS	DELAY IN OPERATIONS	3
MOV3	METAL OXIDE VARIATOR IN PARALLEL WITH MOTOR CONTACTOR COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS MOTOR CONTACTOR COIL.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	LOSS OF 480VAC POWER TO CRANE ELECTRICAL CIRCUITRY	DELAY IN OPERATIONS	3
			A2. FAILS OPEN. B2. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF HBR RELAY COIL.	NONE	3
FU1	10 AMP FUSE IN INPUT LEG 1 OF HOIST INVERTER	PROVIDES PROTECTION TO HOIST INVERTER CIRCUITRY CAUSED BY IMPROPER INPUT VOLTAGE/CURRENT.	A1. PREMATURE OPERATION B1. INTERNAL FAILURE	LOSS OF CONTROL POWER TO HOIST INVERTER.	DELAY IN OPERATIONS	3
			A2. FAILS TO OPERATE B2. INTERNAL FAILURE	POSSIBLE DAMAGE TO HOIST INVERTER CIRCUITRY.	DELAY IN OPERATIONS	3

**FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET**

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 P/N: 88V0019 Baseline: 950.00

Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
 Page 10 of 36 Date: March 15, 1992  
 Prepared by: M. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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FU2	10 AMP FUSE IN PROVIDES PROTECTION INPUT LEG 2 OF FROM DAMAGE TO HOIST INVERTER	HOIST INVERTER CIRCUITRY CAUSED BY IMPROPER INPUT VOLTAGE/CURRENT.	A1. PREMATURE OPERATION B1. INTERNAL FAILURE	LOSS OF CONTROL POWER TO HOIST INVERTER.	DELAY IN OPERATIONS	3
MCB	MAIN CIRCUIT BREAKER	PROTECTS CRANE ELECTRICAL CIRCUITRY FROM VOLTAGE/CURRENT OVERLOAD.	A2. FAILS TO OPERATE B2. INTERNAL FAILURE A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE	POSSIBLE DAMAGE TO HOIST INVERTER CIRCUITRY. LOSS OF 480VAC POWER TO CRANE ELECTRICAL CIRCUITRY.	DELAY IN OPERATIONS	3
HBR	HOIST BRANE RELAY COIL.	PROVIDES MEANS TO CONTROL APPLICATION OF INPUT POWER (220VAC) TO HOIST BRAKE CONTROL CIRCUITRY.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	POSSIBLE DAMAGE TO CRANE ELECTRICAL CIRCUITRY/MOTORS, MOTOR OVERLOAD PROTECTION DEVICES AND OTHER CIRCUIT PROTECTIVE DEVICES ACT AS REDUNDANCY. INABILITY TO RELEASE HOIST BRAKES.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
Program: SLC-2  
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FILE NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. I/FM D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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HR	HOIST BRAKE CONTACTOR. NORMALLY OPEN CONTACTS IN PRIMARY CIRCUIT OF STEPDOWN TRANSFORMER OF HOIST BRAKE CONTROL CIRCUIT.	PROVIDES MEANS TO CONTROL APPLICATION OF INPUT POWER (220VAC) TO HOIST BRAKE CONTROL CIRCUITRY.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	NONE. THERE ARE TWO SETS OF CONTACTS, ONE IN EACH LEG OF PRIMARY CIRCUIT, BOTH SETS OF CONTACTS WOULD HAVE TO FAIL BEFORE HOIST DISC AND SHOE BRAKE CAN BE ENERGIZED (RELEASED). HOIST EMERGENCY BRAKE WOULD BE ABLE TO STOP AND HOLD THE LOAD. REQUIRES MULTIPLE FAILURES.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
HR	NORMALLY CLOSED CONTACTS IN SERIES WITH MAIN CONTACTOR COIL.	INSURES THAT INITIAL HOIST POWER UP SEQUENCE CANNOT BE COMPLETED IF MAIN CONTACTOR BRAKES ARE RELEASED.	A2. FAILS OPEN. B2. INTERNAL PART FAILURE	NONE.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
HR	NORMALLY OPEN CONTACTS IN SERIES WITH HBR COIL AND INVERTER RUN CONTACTS.	LATCHES HOIST BRAKE RELEASE CONTACTOR IN ENERGIZED CONDITION AFTER APPLICATION OF TORQUE OR LOWER BY HOIST INVERTER.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	MAIN CONTACTOR CAN BE ENERGIZED. EVEN THOUGH BRAKES ARE RELEASED. OPERATOR CAN RESET BRAKES BY RELEASING HOIST CONTROL BUTTON OR BY USING EMERGENCY BRAKE BY PUSHING THE E-STOP BUTTON.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
HR	NORMALLY OPEN CONTACTS IN SERIES WITH HBR COIL AND INVERTER RUN CONTACTS.	LATCHES HOIST BRAKE RELEASE CONTACTOR IN ENERGIZED CONDITION AFTER APPLICATION OF TORQUE OR LOWER BY HOIST INVERTER.	A2. FAILS OPEN. B2. INTERNAL PART FAILURE	MAIN CONTACTOR CAN NOT BE ENERGIZED. NO POWER TO HOIST.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
HR	NORMALLY OPEN CONTACTS IN SERIES WITH HBR COIL AND INVERTER RUN CONTACTS.	LATCHES HOIST BRAKE RELEASE CONTACTOR IN ENERGIZED CONDITION AFTER APPLICATION OF TORQUE OR LOWER BY HOIST INVERTER.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	NONE. REQUIRES MULTIPLE FAILURES (INVERTER RUN CONTACTS ARE IN SERIES WITH THESE CONTACTS). EMERGENCY BRAKE FAILURE WOULD BE REQUIRED PRIOR TO LOSS OF LOAD CONTROL.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3

**FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET**

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 FMS: 88V0019 Baseline: 950.00

Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
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 Prepared by: W. Di Meo

FIELD NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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HBR  
 NORMALLY OPEN CONTACTS IN SERIES WITH HBR COIL AND INVERTER RUN CONTACTS  
 A2. FAILS OPEN.  
 B2. INTERNAL PART FAILURE  
 INABILITY TO RELEASE HOIST BRAKES.  
 DELAY IN OPERATIONS 3

HBR  
 NORMALLY OPEN RELAY CONTACTS PROVIDES A BRAKE FEEDBACK SIGNAL TO HOIST INVERTER TO INDICATE BRAKE RELEASE CIRCUIT HAS BEEN ENERGIZED.  
 A1. FAILS CLOSED  
 B1. INTERNAL PART FAILURE  
 NONE. IF THESE CONTACTS DO NOT CHANGE STATE WHEN A STOP COMMAND IS ISSUED TO THE DRIVE THE DRIVE WILL OPEN THE MAIN CONTACTOR AND BRAKES WILL ENGAGE.  
 DELAY IN OPERATIONS 3

HBR  
 METAL OXIDE VARISTOR IN PARALLEL WITH HBR RELAY COIL.  
 A1. FAILS CLOSED  
 B1. INTERNAL PART FAILURE  
 A2. FAILS OPEN.  
 B2. INTERNAL PART FAILURE  
 NONE. IF THESE CONTACTS DO NOT CHANGE STATE WHEN A STOP COMMAND IS ISSUED TO THE DRIVE THE DRIVE WILL OPEN THE MAIN CONTACTOR AND BRAKES WILL ENGAGE.  
 DELAY IN OPERATIONS 3

MOV 7  
 PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS HBR RELAY COIL.  
 A1. FAILS CLOSED  
 B1. INTERNAL PART FAILURE  
 A2. FAILS OPEN.  
 B2. INTERNAL PART FAILURE  
 INABILITY TO RELEASE HOIST BRAKES.  
 SHORTENED LIFE EXPECTANCY OF HBR RELAY COIL.  
 NONE  
 DELAY IN OPERATIONS 3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 FMS: 86V0019 Baseline: 950.00

Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
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 Prepared by: W. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
NONE	INVERTER RUN CONTACTS (NORMALLY OPEN) IN SERIES WITH HOIST BRAKE RELEASE CONTACTOR.	PREVENTS RELEASE OF HOIST BRAKES WHEN THERE IS INSUFFICIENT TORQUE TO HOLD LOAD.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	BRAKES WILL BE RELEASED IMMEDIATELY UPON PUSHING HOIST UP OR DOWN PUSHBUTTON BEFORE SUFFICIENT TORQUE IS APPLIED TO HOLD LOAD. OPERATOR CAN RESET BRAKES BY RELEASING CONTROL BUTTON. ALSO EMERGENCY BRAKE WILL STOP AND HOLD LOAD.	DELAY IN OPERATIONS	3
NONE	BREAKER IN PRIMARY CIRCUIT OF TRANSFORMER POWERING HOIST BRAKE CIRCUIT.	PROTECTS TRANSFORMER FROM CURRENT/VOLTAGE OVERLOAD.	A1. PREMATURE TRIP B1. INTERNAL PART FAILURE	LOSS OF BRAKE CONTROL CIRCUITRY POWER. UNABLE TO RELEASE BRAKE.	DELAY IN OPERATIONS	3
NONE	STEP DOWN TRANSFORMER IN HOIST BRAKE CONTROL CIRCUIT.	STEPS DOWN 220VAC TO 115VAC FOR USE BY BRAKE CONTROL CIRCUIT.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	NONE. THERE IS ONE SET OF CONTACTS IN EACH TRANSFORMER INPUT LEG.	DELAY IN OPERATIONS	3
HBC	HOIST BRAKE CONTACTOR COIL	USED TO ACTIVATE HOIST DISC AND SHOE BRAKE.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	THE BREAKER IN THE PRIMARY CIRCUIT WOULD OPEN AND CAUSE THE BRAKES TO ENGAGE AND COULD NOT BE RELEASED. BRAKES WOULD ENGAGE AND COULD NOT BE RELEASED.	DELAY IN OPERATIONS	3
			A2. FAILS OPEN. B1. INTERNAL PART FAILURE	INABILITY TO RELEASE HOIST BRAKES.	DELAY IN OPERATIONS	3
			A2. FAILS CLOSED. B2. INTERNAL PART FAILURE	LOSS OF BRAKE CONTROL CIRCUITRY POWER. UNABLE TO RELEASE BRAKE.	DELAY IN OPERATIONS	3
			A1. FAILS CLOSED B1. INTERNAL PART FAILURE	NONE. THERE IS ONE SET OF CONTACTS IN EACH TRANSFORMER INPUT LEG.	DELAY IN OPERATIONS	3
			A2. FAILS OPEN. B2. INTERNAL PART FAILURE	THE BREAKER IN THE PRIMARY CIRCUIT WOULD OPEN AND CAUSE THE BRAKES TO ENGAGE AND COULD NOT BE RELEASED. BRAKES WOULD ENGAGE AND COULD NOT BE RELEASED.	DELAY IN OPERATIONS	3
			A1. FAILS OPEN B1. INTERNAL PART FAILURE	INABILITY TO RELEASE HOIST BRAKES.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON HST BRIDGE CRANE		Program: SLC-2		Facility/Station Set: VAFB/SLC-2		
Subsystem: CRANE SYSTEM ELECTRICAL		Page 14 of 36		Date: March 15, 1992		
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PMS: 88V0019 Baseline: 950.00						
FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FPN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT

HBC	HOIST BRAKE CONTACTS IN SERIES WITH BRIDGE RECTIFIER.	APPLIES POWER TO HOIST BRAKE RECTIFIER CIRCUIT.	A1. FAILS CLOSED B1. INTERNAL PART FAILURE	NONE. TWO OTHER SETS OF CONTACTS IN SERIES WITH BRIDGE RECTIFIER WOULD ALSO HAVE TO FAIL CLOSED TO CAUSE BRAKE TO RELEASE.	DELAY IN OPERATIONS	3
W0M2	BRIDGE RECTIFIER IN BRAKE RELEASE CIRCUIT.	USED TO RECTIFY INCOMING 115V.A.C. TO D.C. FOR OPERATION OF HOIST DISC AND SHOE BRAKE COILS.	A2. FAILS OPEN B2. INTERNAL PART FAILURE	INABILITY TO RELEASE HOIST BRAKES.	DELAY IN OPERATIONS	3
W0M2	BRIDGE RECTIFIER IN BRAKE RELEASE CIRCUIT.	USED TO RECTIFY INCOMING 115V.A.C. TO D.C. FOR OPERATION OF HOIST DISC AND SHOE BRAKE COILS.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	CURRENT WILL BE APPLIED TO THE BRAKE COILS ON ALTERNATE CYCLES OF THE INCOMING A.C. POWER, RESULTING IN BRAKE CHATTER.	DELAY IN OPERATIONS	3
W0M2	BRIDGE RECTIFIER IN BRAKE RELEASE CIRCUIT.	BRIDGE RECTIFIER IN BRAKE RELEASE CIRCUIT.	A2. FAILS SHORT B2. INTERNAL PART FAILURE	6AMP FUSE IN SERIES WITH THE BRIDGE RECTIFIER WILL OPEN CAUSING APPLICATION OF BRAKES.	DELAY IN OPERATIONS	3
W0M2	DISC BRAKE COIL	WHEN ENERGIZED THE DISC BRAKE WILL BE RELEASED.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	INABILITY TO RELEASE HOIST DISC BRAKE.	DELAY IN OPERATIONS	3
W0M2	SHOE BRAKE COIL	RELEASES SHOE BRAKE WHEN ENERGIZED.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	INABILITY TO RELEASE HOIST SHOE BRAKE.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Program: SLC-2  
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YIELD NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FME D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. EDGEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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NONE DIODE IN SERIES WITH SHOE BRAKE COIL INSURES CURRENT WILL FLOW IN ONLY ONE DIRECTION THROUGH BRAKE CIRCUIT.

- A1. FAILS OPEN.
- B1. INTERNAL PART FAILURE

CURRENT WILL BE APPLIED TO THE BRAKE COILS ON ALTERNATE CYCLES OF THE INCOMING A.C. POWER, RESULTING IN BRAKE CHATTER.

3

NONE

DIODE ACROSS SHOE BRAKE COIL PREVENTS EARLY BURNOUT OF SHOE BRAKE COIL.

- A1. FAILS OPEN.
- B1. INTERNAL PART FAILURE

SHORTENED LIFE EXPECTANCY OF SHOE BRAKE COIL.

3

NONE

6AMP FUSE IN BRAKE RELEASE CIRCUIT PROTECTS BRAKE RELEASE ELECTRONIC CIRCUITRY FROM CURRENT OVERLOAD.

- A1. PREMATURE FAILURE
- B1. INTERNAL PART FAILURE.

SHOE BRAKE OR DISC BRAKE WILL NOT RELEASE.

3

NONE

STEP DOWN TRANSFORMER IN HOIST CONTROL CIRCUIT STEPS DOWN INCOMING 480VAC TO 115VAC FOR USE IN HOIST CONTROL CIRCUIT

- A1. FAILS OPEN.
- B1. INTERNAL PART FAILURE

LOSS OF 120VAC TO HOIST PENDANT

3

A2. FAILS SHORT  
B2. INTERNAL PART FAILURE  
MAIN BREAKER OR FUSE HCFU WILL OPEN CAUSING LOSS OF HOIST FUNCTIONS

3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON HST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
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Program: SLC-2  
Facility/Station Set: VAFB/SLC-2  
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FIG NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FME D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. FIDELITY	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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HCFU	FUSE IN SECONDARY CIRCUIT OF HOIST CONTROL STEPDOWN TRANSFORMER	PROTECTS TRANSFORMER AND ASSOCIATED CIRCUITRY FROM CURRENT OVERLOAD.	A1. PREMATURE FAILURE B1. INTERNAL PART FAILURE	LOSS OF 120VAC TO HOIST PENDANT	DELAY IN OPERATIONS	3
R	RAISE RELAY COIL	PROVIDES RAISE INPUT SIGNAL TO HOIST MOTOR CONTROLLER	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	UNABLE TO RAISE LOAD.	DELAY IN OPERATIONS	3
R	RAISE RELAY NORMALLY OPEN CONTACTS IN SERIES WITH HOIST BRAKE CONTACTOR COIL	ENABLE HOIST BRAKE CIRCUIT WITH ACTIVATION OF HOIST RAISE CIRCUIT.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	HOIST BRAKES WILL NOT RELEASE WITH RAISE SIGNAL.	DELAY IN OPERATIONS	3
R	RAISE RELAY NORMALLY CLOSED CONTACTS IN SERIES WITH HOIST LOWER RELAY COIL.	LOCKS OUT HOIST LOWER FUNCTION WHEN RAISE FUNCTION IS SELECTED.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	HOIST BRAKE CONTACTOR WILL BE ENERGIZED EVEN AFTER RELEASE OF HOIST UP PENDANT BUTTON. INVERTER RUN CONTACTS (IN SERIES WITH HBR) WILL OPEN. IF INPUT TO INVERTER WILL CAUSE MAIN CONTACTOR TO OPEN, IN TURN CAUSING BRAKES TO ENGAGE.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON HST BRIDGE CRANE  
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FWD NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FWD D. DETECTION METHOD E. CONNECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
R	RAISE RELAY NORMALLY OPEN CONTACTS CONNECTED TO PIN 2 OF HOIST MOTOR CONTROLLER INVERTER.	ENABLES HOIST INVERTER TO ENTER RAISE MODE.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	HOIST RAISE FUNCTION WILL DELAY IN OPERATIONS NOT OPERATE.		3
MOV 6	METAL OXIDE VARISTOR IN PARALLEL WITH RAISE RELAY COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RAISE RELAY COIL.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	CONSTANT RAISE SIGNAL TO HOIST MOTOR CONTROLLER INVERTER. IF HOIST LOWER PUSHBUTTON ON PENDANT IS DEPRESSED AN INVERTER FAULT SHOULD OCCUR, OPENING MAIN CONTACTOR.	DELAY IN OPERATIONS	3
L	LOWER RELAY COIL	PROVIDES LOWER INPUT SIGNAL TO HOIST MOTOR CONTROLLER	A1. FAILS OPEN. B1. INTERNAL PART FAILURE A2. FAILS CLOSED B2. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF RAISE RELAY COIL. LOSS OF RAISE FUNCTION OF HOIST.	DELAY IN OPERATIONS	3
L	LOWER RELAY NORMALLY OPEN CONTACTS IN SERIES WITH HOIST BRAKE CONTACTOR COIL	ENERGIZES HOIST BRAKE RELEASE CIRCUIT WHEN LOWER FUNCTION IS SELECTED.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	HOIST BRAKES WILL NOT RELEASE WITH LOWER SIGNAL.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE		Program: SLC-2		Facility/Station Set: VAFB/SLC-2		
Subsystem: CRANE SYSTEM ELECTRICAL		Page 18 of 36		Date: March 15, 1992		
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Item: 88V0019 Baseline: 950.00						
ITEM NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TOLERANCE	FAILURE EFFECT OF SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT

L CONTINUED

A2. FAILS CLOSED  
B2. INTERNAL PART FAILURE

HOIST BRAKE CONTACTOR WILL BE ENERGIZED EVEN AFTER RELEASE OF HOIST LOWER PENDANT BUTTON. INVERTER RUN CONTACTS (IN SERIES WITH HBR) WILL OPEN. IF NOT HBR CONTACTS AT INPUT TO INVERTER WILL CAUSE MAIN CONTACTOR TO OPEN, IN TURN CAUSING BRAKES TO ENGAGE.

DELAY IN OPERATIONS 3

L LOWER RELAY NORMALLY OPEN CONTACTS IN SERIES WITH HOIST RAISE RELAY COIL.

LOCKS OUT RAISE HOIST FUNCTION WHEN LOWER FUNCTION IS SELECTED.

A1. FAILS OPEN.  
B1. INTERNAL PART FAILURE

IF HOIST RAISE BUTTON ON PENDANT IS DEPRESSED HOIST WILL NOT RAISE.

DELAY IN OPERATIONS 3

A2. FAILS SHORT  
B2. INTERNAL PART FAILURE

IF HOIST RAISE BUTTON ON PENDANT IS DEPRESSED BOTH THE RAISE AND LOWER SIGNAL WILL BE INPUT TO THE HOIST MOTOR CONTROLLER. THE INVERTER SHOULD OUTPUT AN INVERTER FAULT SIGNAL, OPENING MAIN CONTACTOR..

DELAY IN OPERATIONS 3

L LOWER RELAY NORMALLY OPEN CONTACTS CONNECTED TO PIN 5 OF HOIST MOTOR CONTROLLER INVERTER.

ENABLES INVERTER TO ENTER LOWER HOIST MODE.

A1. FAILS OPEN.  
B1. INTERNAL PART FAILURE

HOIST RAISE FUNCTION WILL DELAY IN OPERATIONS NOT OPERATE.

DELAY IN OPERATIONS 3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON HST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
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Prepared by: W. Di Noc

FIG NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FWH D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
L			A2. FAILS CLOSED B2. INTERNAL PART FAILURE	CONSTANT LOWER SIGNAL TO HOIST MOTOR CONTROLLER INVERTER. IF HOIST RAISE PUSHBUTTON ON PENDANT IS DEPRESSED AN INVERTER FAULT WILL OCCUR, OPENING MAIN CONTACTOR.	DELAY IN OPERATIONS	3
NOV 8	METAL OXIDE VARISTOR IN PARALLEL WITH LOWER RELAY COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RAISE RELAY COIL.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY NONE OF LOWER RELAY COIL.		3
FR (L)	FAULT LATCHING RELAY LATCH COIL	PROVIDES FAULT INDICATION TO OPERATOR BY OPERATING INDICATOR LAMP.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	AN OVERSPEED CONDITION WOULD CAUSE MAIN CONTACTOR TO OPEN WITHOUT ILLUMINATING INDICATOR LAMP FOR OPERATOR.	DELAY IN OPERATIONS	3
FR (U)	FAULT LATCHING RELAY UNLATCH COIL	EXTINGUISHES FAULT INDICATOR LAMP UPON CLOSING OF OVERSPEED RESET KEYSWITCH.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	FAULT INDICATOR LAMP WILL REMAIN ILLUMINATED EVEN AFTER ACTUAL FAULT HAS BEEN CLEARED.	DELAY IN OPERATIONS	3
FR	FAULT LATCHING RELAY FR CONTACTS	ILLUMINATES FAULT INDICATOR LAMP UPON DETECTION OF INVERTER FAULT.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	FAULT INDICATOR LAMP WILL REMAIN ILLUMINATED EVEN AFTER ACTUAL FAULT HAS BEEN CLEARED.	DELAY IN OPERATIONS	3

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CONTINUED

NOV 8

FR (L)

FR (U)

FR

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 FMS: 89V0019 Baseline: 950.00

Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
 Page 20 of 36 Date: March 15, 1992  
 Prepared by: W. Di Meo

FIG NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMING	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
FR			A2. FAILS SHORT B2. INTERNAL PART FAILURE	CONTINUOUS FAULT INDICATION.	DELAY IN OPERATIONS	3
CONTINUED						
RR	RESET RELAY COIL	PROVIDES RESET FAULT SIGNAL TO HOIST INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	UNABLE TO CLEAR HOIST INVERTER FAULT CONDITION. HOIST INOPERABLE.	DELAY IN OPERATIONS	3
		NORMALLY OPEN CONTACTS AT PIN 8 OF HOIST INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	UNABLE TO CLEAR HOIST INVERTER FAULT CONDITION. HOIST INOPERABLE.	DELAY IN OPERATIONS	3
			A2. FAILS CLOSED B2. INTERNAL PART FAILURE	CONSTANT CLEAR FAULT INPUT TO HOIST INVERTER. ALSO REQUIRES FAILURE CAUSING INITIAL FAULT CONDITION. OPERATOR CAN STOP LOAD MOTION BY USING HOIST EMERGENCY BRAKE.	DELAY FOR REPAIRS. REQUIRE MULTIPLE FAILURES	3
MOV 5	METAL OXIDE VARISTOR IN PARALLEL WITH RESET RELAY COIL.	PROVIDES SHORT CIRCUIT TO REVERSE EMF ACROSS RAISE RELAY COIL.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF RESET RELAY COIL.	NONE	3
			A2. FAILS SHORT B2. INTERNAL PART FAILURE	LOSS OF RESET FUNCTION OF HOIST.	DELAY IN OPERATIONS	3
NONE	INVERTER FAULT (NORMALLY CLOSED) CONTACT	OPENS MAIN CONTACTOR, REMOVING POWER TO HOIST.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	HOIST WILL NOT OPERATE.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 PMS: 88V0019 Baseline: 950.00

Program: SIC-2  
 Facility/Station Set: VAFB/SIC-2  
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 Prepared by: W. Di Meo

ITEM NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FCM D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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NONE	INVERTER FAULT (NORMALLY CLOSED) CONTACT		A2. FAILS CLOSED B2. INTERNAL PART FAILURE	UPON DETECTION OF INVERTER FAULT MAIN CONTACTOR WILL NOT OPEN. BEFORE LOAD DROP COULD OCCUR THE INVERTER RUN NORMALLY OPEN CONTACTS WOULD ALSO HAVE TO FAIL CLOSED. OPERATOR CAN RESET SYSTEM BRAKES BY RELEASING HOIST CONTROL BUTTON, ALSO OPERATOR CAN STOP LOAD USING EMERGENCY BY PRESSING E-STOP BUTTON	DELAY FOR REPAIRS. REQUIRE MULTIPLE FAILURES	3
NONE	INVERTER FAULT (NORMALLY OPEN) CONTACTS	OPERATES LATCHING FAULT RELAY CAUSING FAULT CONDITION TO ILLUMINATE FAULT LIGHT.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	FAULT INDICATOR LAMP WILL NOT ILLUMINATE UPON FAULT DETECTION.	DELAY IN OPERATIONS	3
WKS	WEIGHT KEYSWITCH RELAY COIL	RESETS SYSTEM BY APPLYING POWER TO MAIN CONTACTOR AFTER A WEIGHT LIMIT VIOLATION HAS OCCURRED.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE A1. FAILS OPEN. B1. INTERNAL PART FAILURE	CRANE HOIST INOPERATIVE. INABILITY TO APPLY POWER TO HOIST AFTER A WEIGHT LIMIT VIOLATION HAS BEEN SENSED.	DELAY IN OPERATIONS DELAY IN OPERATIONS	3 3
WKS	NORMALLY OPEN CONTACTS IN SERIES WITH MAIN CONTACTOR COIL.	ALLOWS SYSTEM TO BE RESET BY APPLYING POWER TO MAIN CONTACTOR AFTER A WEIGHT LIMIT (UPPER LIMIT SWITCH) VIOLATION HAS OCCURRED.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	INABILITY TO APPLY POWER TO HOIST AFTER A WEIGHT LIMIT VIOLATION HAS BEEN SENSED.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 PPM: 88V0019 Baseline: 950.00

Program: SIC-2  
 Facility/Station Set: VAFB/SIC-2  
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 Prepared by: W. DI Meo

FTMD NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FM D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
WKS	NORMALLY OPEN CONTACTS IN SERIES WITH MAIN CONTACTOR COIL.		A2. FAILS CLOSED B2. INTERNAL PART FAILURE	MAIN CONTACTOR NOT LOCKED OUT EVEN AFTER UPPER LIMIT VIOLATION OCCURRED. RAISE RELAY WILL BE LOCKED OUT BY THE NORMALLY CLOSED CONTACTS OF THE WEIGHT KEYSWITCH RELAY.	DELAY IN OPERATIONS	3
WKS	NORMALLY CLOSED CONTACTS IN SERIES WITH RAISE RELAY COIL.	PREVENTS HOIST RAISE FUNCTION FROM OPERATING UPON WEIGHT (UPPER) LIMIT BEING REACHED.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	RAISE FUNCTION OF HOIST WILL NOT OPERATE.	DELAY IN OPERATIONS	3
HBU	HOIST BRAKING UNIT	SENSES INVERTER BUS VOLTAGE. IF BUS VOLTAGE EXCEEDS A PRESET LEVEL (AS WHEN MOTOR IS DYNAMICALLY BRAKING) THE HBU SHUNTS THE GENERATED ENERGY.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	LOSS OF ONE OF TWO OVERTRAVEL PROTECTION FEATURES. REQUIRES MULTIPLE FAILURES.	DELAY FOR REPAIR. REQUIRES MULTIPLE FAILURES.	3
			A1. NO OUTPUT B1. INTERNAL PART FAILURE	INVERTER FAULT SIGNAL WILL OCCUR	DELAY IN OPERATIONS	3
			A2. IMPROPER OUTPUT B2. INTERNAL PART FAILURE	HOIST IMPOERATIVE.	DELAY IN OPERATIONS	3
			A3. FAILS SHORTED B3. INTERNAL PART FAILURE	POSSIBLE DAMAGE TO DYNAMIC BRAKE RESISTORS.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
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 Prepared by: W. Di Meo

YMD NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. EDGEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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1HDB RES	RESISTOR ACROSS TERMINALS 1HDB AND 2HDB OF BRAKING UNIT	ABSORBS CURRENT DIVERTED FROM HOIST INVERTER BUS VIA BRAKING UNIT.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	INVERTER BUS VOLTAGE WILL RISE ABOVE NORMAL THRESHOLD AND CAUSE INVERTER FAULT CAUSING MAIN CONTACTOR TO OPEN AND ENGAGE BRAKES.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
WOME	1.37 OHM RESISTOR IN SERIES WITH HOIST TACHOMETER AND PIN 11 OF BIAS MODULE.	ALONG WITH 634 OHM RESISTOR, FORMS VOLTAGE DIVIDER FOR BIAS MODULE INPUT.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	INVERTER BUS VOLTAGE WILL DROP BELOW NORMAL THRESHOLD AND CAUSE INVERTER FAULT CAUSING MAIN CONTACTOR TO OPEN AND ENGAGE BRAKES.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
WOME	HOIST INVERTER CONTROLS HOIST MOTOR FUNCTIONS		A1. FAILS SHORTED B1. INTERNAL PART FAILURE	INCORRECT VOLTAGE PRESENTED TO BIAS MODULE. A SPEED ERROR WILL OCCUR CAUSING INVERTER FAULT TO OPEN MAIN CONTACTOR, ENGAGING BRAKES.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
WOME	HOIST INVERTER CONTROLS HOIST MOTOR FUNCTIONS		A1. NO OUTPUT B1. INTERNAL PART FAILURE	INCORRECT VOLTAGE PRESENTED TO BIAS MODULE. A SPEED ERROR WILL OCCUR CAUSING INVERTER FAULT TO OPEN MAIN CONTACTOR, ENGAGING BRAKES.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
WOME	HOIST INVERTER CONTROLS HOIST MOTOR FUNCTIONS		A1. NO OUTPUT B1. INTERNAL PART FAILURE	HOIST MOTOR WILL NOT OPERATE.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3
WOME	HOIST INVERTER CONTROLS HOIST MOTOR FUNCTIONS		A1. IMPROPER OUTPUT B1. INTERNAL PART FAILURE	OVERSPEED/UNDERSPEED OF HOIST. WOULD REQUIRE FAILURE OF INVERTER, RAISE OR LOWER SWITCH AND E-STOP.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Program: SLC-2  
 Facility/Station Set: VAEB/SLC-2  
 Subsystem: CRANE SYSTEM ELECTRICAL  
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 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 Prepared by: W. DI Meo  
 FMS: 88V0019 Baseline: 950.00

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
NONE	634 OHM RESISTOR IN PARALLEL WITH PINS 11 AND 10 OF BIAS MODULE.	ALONG WITH 1.37K OHM RESISTOR, FORMS VOLTAGE DIVIDER FOR BIAS MODULE INPUT.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	INCORRECT VOLTAGE PRESENTED TO BIAS MODULE. A SPEED ERROR WILL OCCUR CAUSING INVERTER FAULT TO OPEN MAIN CONTACTOR, ENGAGING BRAKES.	DELAY IN OPERATIONS	3
NONE	BRIDGE CONTROL CIRCUIT BREAKER	PROTECTS BRIDGE ELECTRICAL CIRCUITRY FROM OVERLOAD.	A2. FAILS SHORTED B2. INTERNAL PART FAILURE	INCORRECT VOLTAGE PRESENTED TO BIAS MODULE. A SPEED ERROR WILL OCCUR CAUSING INVERTER FAULT TO OPEN MAIN CONTACTOR, ENGAGING BRAKES.	DELAY IN OPERATIONS	3
BCB	BRIDGE CIRCUIT BREAKER	PROTECTS BRIDGE ELECTRICAL CIRCUITRY FROM OVERLOAD.	A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE	LOSS OF 480VAC POWER TO BRIDGE ELECTRICAL CIRCUITRY.	DELAY IN OPERATIONS	3
BRIDGE DRIVE INVERTER	BRIDGE INVERTER	CONTROLS BRIDGE MOTOR FUNCTIONS	A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE	POSSIBLE DAMAGE TO BRIDGE ELECTRICAL CIRCUITRY/MOTORS. MOTOR OVERLOAD PROTECTION DEVICES AND OTHER CIRCUIT PROTECTIVE DEVICES ACT AS REDUNDANCY.	DELAY IN OPERATIONS	3
SMARTORQUE INVERTER	BRIDGE INVERTER	CONTROLS BRIDGE MOTOR FUNCTIONS	A1. NO OUTPUT B1. INTERNAL PART FAILURE A2. IMPROPER OUTPUT B2. INTERNAL PART FAILURE	BRIDGE MOTOR WILL NOT OPERATE. OVERSPEED/UNDERSPEED OF BRIDGE. IF THIS SHOULD OCCUR BRIDGE CAN BE STOPPED BY RELEASING DIRECTION PUSHBUTTON OR DEPRESSING E-STOP.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A1564 Sheet No.: 1 TO 4  
 PPM: 8BV0019 Baseline: 950.00  
 Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
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 Prepared by: W. D1 Meo

FTMD NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMI D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
R	BRIDGE RIGHT RELAY	WHEN CLOSED CAUSES BRIDGE RIGHT COMMAND TO BE PRESENTED TO BRIDGE DRIVE INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	BRIDGE WILL NOT MOVE TO THE RIGHT WHEN COMMANDED TO DO SO.	DELAY IN OPERATIONS	3
R	BRIDGE RIGHT RELAY	WHEN OPEN (INDICATING BRIDGE RIGHT SELECTED) THESE CONTACTS OPEN CIRCUIT TO BRIDGE LEFT RELAY COIL, PREVENTING CONFLICTING COMMANDS TO BE PRESENTED TO INVERTER.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	CONTINUOUS BRIDGE RIGHT COMMAND GIVEN TO BRIDGE INVERTER. OPERATOR CAN STOP BRIDGE BY USING THE E-STOP SWITCH.	DELAY IN OPERATIONS. REQUIRES MULTIPLE FAILURES. (BRIDGE LIMIT SWITCH, E-STOP AND CRANE ON-OFF SWITCH)	3
L	BRIDGE LEFT RELAY	WHEN CLOSED CAUSES BRIDGE LEFT COMMAND TO BE PRESENTED TO BRIDGE DRIVE INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	BRIDGE WILL NOT MOVE TO THE LEFT WHEN COMMANDED TO DO SO.	DELAY IN OPERATIONS	3
L	BRIDGE LEFT RELAY	NORMALLY OPEN CONTACTS IN SERIES WITH BRIDGE LEFT RELAY COIL.	A2. FAILS SHORTED B2. INTERNAL PART FAILURE	BOTH BRIDGE RIGHT AND LEFT COMMANDS	DELAY IN OPERATIONS	3
L	BRIDGE LEFT RELAY	NORMALLY OPEN CONTACTS AT INPUT OF INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	BRIDGE WILL NOT MOVE TO THE LEFT WHEN COMMANDED TO DO SO.	DELAY IN OPERATIONS	3
L	BRIDGE LEFT RELAY	NORMALLY OPEN CONTACTS AT INPUT OF INVERTER.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	CONTINUOUS BRIDGE LEFT COMMAND GIVEN TO BRIDGE INVERTER.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
FME: 89VD019 Baseline: 950.00

Program: SLC-2  
Facility/Station Set: VAFB/SLC-2  
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Prepared by: N. Di Mec

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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L	BRIDGE LEFT RELAY	WHEN OPEN (INDICATING BRIDGE RIGHT SELECTED) THESE CONTACTS OPEN CIRCUIT TO BRIDGE RIGHT RELAY COIL, PREVENTING CONFLICTING COMMANDS TO BE PRESENTED TO INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	BRIDGE WILL NOT MOVE TO THE RIGHT WHEN COMMANDED TO DO SO.	DELAY IN OPERATIONS	3
MOV	METAL OXIDE VARISTOR IN PARALLEL WITH BRIDGE LEFT RELAY COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RELAY COIL.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF RELAY COIL.	DELAY IN OPERATIONS	3
MOV	METAL OXIDE VARISTOR IN PARALLEL WITH BRIDGE RIGHT RELAY COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RELAY COIL.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	LOSS OF BRIDGE LEFT FUNCTION OF CRANE..	DELAY IN OPERATIONS	3
MOV	METAL OXIDE VARISTOR IN PARALLEL WITH BRIDGE RIGHT RELAY COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RELAY COIL.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF RELAY COIL.	DELAY IN OPERATIONS	3
MOV	BRIDGE LEFT TRAVEL LIMIT SWITCH	PREVENTS OVER TRAVEL OF BRIDGE IN LEFT DIRECTION.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	LOSS OF BRIDGE RIGHT FUNCTION OF CRANE.	DELAY IN OPERATIONS	3
MOV	BRIDGE RIGHT TRAVEL LIMIT SWITCH	PREVENTS OVER TRAVEL OF BRIDGE IN RIGHT DIRECTION.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	LOSS OF BRIDGE RIGHT FUNCTION OF CRANE.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Page 27 of 36 Date: March 15, 1992  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 Prepared by: W. Di Meo  
 P/N: 88V0019 Baseline: 950.00

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FCM D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CAIT CAF
BBC	BRIDGE RIGHT TRAVEL LIMIT SWITCH CONTINUED		A2. FAILS CLOSED B2. INTERNAL PART FAILURE	OVER TRAVEL OF BRIDGE IN RIGHT DIRECTION	DELAY IN OPERATIONS	3
BBC	BRIDGE BRAKE CONTACTOR COIL	CONTROLS POWER TO BRIDGE BRAKE	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	INABILITY TO RELEASE BRIDGE BRAKES.	DELAY IN OPERATIONS	3
BBC	BRIDGE BRAKE CONTACTOR	CONTROLS POWER TO BRIDGE BRAKE	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	INABILITY TO RELEASE BRIDGE BRAKES.	DELAY IN OPERATIONS	3
MOV	METAL OXIDE VARISTOR IN PARALLEL WITH BRIDGE BRAKE CONTACTOR COIL COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RELAY CONTACTOR COIL COIL.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF CONTACTOR COIL.	DELAY IN OPERATIONS	3
NONE	STEADOWN TRANSFORMER IN BRIDGE CONTROL CIRCUIT.	STEPS DOWN 480VAC TO 120VAC SINGLE PHASE POWER FOR CONTROL CIRCUITRY.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL BRIDGE FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
P/N: 88V0019 Baseline: 950.00

Program: SLC-2  
Facility/Station Set: VAFB/SLC-2  
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Prepared by: W. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	STEPDOWN TRANSFORMER IN BRIDGE CONTROL CIRCUIT.		A2. FAILS SHORTED B2. INTERNAL PART FAILURE	FUSE BFU WILL OPEN CAUSING LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL BRIDGE FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
BFU	FUSE	PROTECTS BRIDGE CIRCUITRY FROM ELECTRICAL OVERLOAD.	A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE	LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL BRIDGE FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
NONE	CLOSE AT RUN CONTACTS IN SERIES WITH BRIDGE BRAKE CONTACTOR COIL.	INSURES THAT BRIDGE INVERTER IS SUPPLYING RUN CURRENT TO BRIDGE MOTOR BEFORE BRIDGE BRAKES ARE RELEASED.	A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE	DAMAGE TO BRIDGE CONTROL CIRCUIT COMPONENTS.	DELAY IN OPERATIONS	3
BOB RES	84 OHM RESISTOR ACROSS TERMINALS B1 AND B2 OF BRIDGE INVERTER.	DISSIPATES THE ENERGY GENERATED BY THE MOTOR DURING DYNAMIC BRAKING.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	BRIDGE BRAKE MAY RELEASE BEFORE BRIDGE MOTOR HAS POWER APPLIED. BRIDGE MAY DRIFT LEFT OR RIGHT SLIGHTLY.	DELAY IN OPERATIONS	3
			A2. FAILS SHORTED B2. INTERNAL PART FAILURE	OVERHEATING OF MOTOR WOULD RESULT IN OPENING OF MOTOR THERMAL RELAY CONTACTS AND OPENING OF MAIN CONTACTOR.	DELAY IN OPERATIONS	3
			A2. FAILS SHORTED B2. INTERNAL PART FAILURE	FUSE BFU WILL OPEN CAUSING LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL BRIDGE FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 PMS: 88V0019 Baseline: 950.00

Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
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 Prepared by: W. Di Neo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMS D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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BOL	BRIDGE MOTOR OVERLOAD RELAY	PROTECTS BRIDGE MOTOR FROM OVERLOAD.	A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE	LOSS OF ALL BRIDGE FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
BOL	NORMALLY CLOSED CONTACTS IN SERIES WITH CONTROL SUPPLY VOLTAGE	WHEN BRIDGE MOTOR OVERLOAD IS SENSED THESE CONTACTS WILL OPEN PREVENTING ANY BRIDGE COMMANDS FROM CAUSING BRIDGE MOVEMENT.	A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE	DAMAGE TO BRIDGE MOTOR. LOSS OF ALL BRIDGE FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
BCB	BRIDGE CIRCUIT BREAKER	PROVIDES MEANS TO APPLY AND REMOVE POWER TO BRIDGE MOTOR CONTROLLER AND BRAKE CIRCUITS.	A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE	NONE. BRIDGE MOTOR OVERLOAD COILS WOULD OPEN CIRCUIT TO BRIDGE MOTOR PREVENTING BRIDGE MOVEMENT. BRIDGE BRAKE WILL ENGAGE AND BRIDGE CONTROLS INOPERATIVE.	DELAY IN OPERATIONS	3
NONE	CLOSE AT FAULT CONTACTS ACROSS TERMINALS 20 AND 18 OF BRIDGE INVERTER	PROVIDE AUTOMATIC RESET FOR BRIDGE DRIVE AFTER THE DRIVE HAS FAULTED..	A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE A1. FAILS OPEN. B1. INTERNAL PART FAILURE	DAMAGE TO BRIDGE MOTOR CONTROLLER. BRIDGE DRIVE WILL NOT BE AUTOMATICALLY RESET UPON DRIVE FAULT DETECTION.	DELAY IN OPERATIONS	3

**FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET**

System: 20 TON HST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 FMS: 88V0019 Baseline: 950.00

Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
 Page 30 of 36 Date: March 15, 1992  
 Prepared by: W. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FWH D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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NONE	CLOSE AT FAULT CONTACTS ACROSS TERMINALS 20 AND 18 OF BRIDGE INVERTER	CONTROLS BRIDGE MOTOR FUNCTIONS	A2. FAILS SHORTED B2. INTERNAL PART FAILURE	CONTINUOUS RESET SIGNAL TO BRIDGE INVERTER.	DELAY IN OPERATIONS	3
NONE	BRIDGE INVERTER	CONTROLS BRIDGE MOTOR FUNCTIONS	A1. NO OUTPUT B1. INTERNAL PART FAILURE	BRIDGE MOTOR WILL NOT OPERATE.	DELAY IN OPERATIONS	3
NONE	TROLLEY INVERTER	CONTROLS TROLLEY MOTOR FUNCTIONS	A2. IMPROPER OUTPUT B2. INTERNAL PART FAILURE	OVERSPEED/UNDERSPEED OF BRIDGE. WOULD REQUIRE FAILURE OF INVERTER, LEFT OR RIGHT SWITCH AND E- STOP.	DELAY IN OPERATIONS	3
TOL	TROLLEY MOTOR OVERLOAD RELAY	PROTECTS TROLLEY MOTOR FROM OVERLOAD.	A1. NO OUTPUT B1. INTERNAL PART FAILURE	TROLLEY MOTOR WILL NOT OPERATE.	DELAY IN OPERATIONS	3
TOL	NORMALLY CLOSED CONTACTS IN SERIES WITH CONTROL SUPPLY	WHEN TROLLEY MOTOR OVERLOAD IS SENSED THESE CONTACTS WILL OPEN PREVENTING ANY TROLLEY COMMANDS FROM CAUSING BRIDGE MOVEMENT.	A2. IMPROPER OUTPUT B2. INTERNAL PART FAILURE	OVERSPEED/UNDERSPEED OF TROLLEY. WOULD REQUIRE FAILURE OF INVERTER, RAISE OR LOWER SWITCH AND E-STOP.	DELAY IN OPERATIONS	3
TOL	TROLLEY MOTOR OVERLOAD RELAY	PROTECTS TROLLEY MOTOR FROM OVERLOAD.	A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE	LOSS OF ALL TROLLEY FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
TOL	NORMALLY CLOSED CONTACTS IN SERIES WITH CONTROL SUPPLY	WHEN TROLLEY MOTOR OVERLOAD IS SENSED THESE CONTACTS WILL OPEN PREVENTING ANY TROLLEY COMMANDS FROM CAUSING BRIDGE MOVEMENT.	A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE	DAMAGE TO TROLLEY MOTOR. DELAY IN OPERATIONS	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON HST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
 Page 31 of 36 Date: March 15, 1992  
 Prepared by: W. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FAN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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NONE			A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE	NONE. TROLLEY MOTOR OVERLOAD COILS WOULD OPEN CIRCUIT TO TROLLEY MOTOR PREVENTING BRIDGE MOVEMENT.	DELAY IN OPERATIONS	3
			A1. FAILS OPEN. B1. INTERNAL PART FAILURE	TROLLEY DRIVE WILL NOT BE RESET UPON DRIVE FAULT DETECTION.	DELAY IN OPERATIONS	3
TBC	CLOSE AT FAULT CONTACTS ACROSS TERMINALS 20 AND 18 OF TROLLEY INVERTER	PROVIDE AUTOMATIC RESET FOR TROLLEY DRIVE AFTER THE DRIVE HAS FAULTED..	A2. FAILS SHORTED B2. INTERNAL PART FAILURE	CONTINUOUS RESET SIGNAL TO TROLLEY INVERTER.	DELAY IN OPERATIONS	3
TBC	TROLLEY BRAKE CONTACTOR	CONTROLS POWER TO TROLLEY BRAKE.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	INABILITY TO RELEASE TROLLEY BRAKES.	DELAY IN OPERATIONS	3
TBC	COIL		A1. FAILS OPEN. B1. INTERNAL PART FAILURE	INABILITY TO RELEASE TROLLEY BRAKES.	DELAY IN OPERATIONS	3
			A2. FAILS CLOSED B2. INTERNAL PART FAILURE	NONE. REQUIRES AT LEAST TWO SETS OF CONTACTS TO FAIL.	DELAY IN OPERATIONS	3
MOV	METAL OXIDE VARISTOR IN PARALLEL WITH TROLLEY BRAKE CONTACTOR COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RELAY COIL.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF CONTACTOR COIL.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON HST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 PMN: 88V0019 Baseline: 950.00

Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
 Page 32 of 36 Date: March 15, 1992  
 Prepared by: W. D1 Moo

ITEM NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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NONE	STEPDOWN TRANSFORMER IN TROLLEY CONTROL CIRCUIT.	STEPS DOWN 480VAC TO 120VAC SINGLE PHASE POWER FOR CONTROL CIRCUITRY.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL TROLLEY FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
TFU	FUSE	PROTECTS TROLLEY CIRCUITRY FROM ELECTRICAL OVERLOAD.	A1. FAILS SHORTED B2. INTERNAL PART FAILURE	FUSE TFU WILL OPEN CAUSING LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL TROLLEY FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
NONE	CLOSE AT RUN CONTACTS IN SERIES WITH TROLLEY BRAKE CONTACTOR COIL.	INSURES THAT TROLLEY INVERTER IS SUPPLYING RUN CURRENT TO BRIDGE MOTOR BEFORE TROLLEY BRAKES ARE RELEASED.	A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE A2. FAILS TO OPERATE B2. INTERNAL PART FAILURE A1. FAILS OPEN. B1. INTERNAL PART FAILURE	LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL TROLLEY FUNCTIONS. BRAKES STAY ENGAGED. DAMAGE TO TROLLEY CONTROL CIRCUIT COMPONENTS. TROLLEY BRAKE WILL NOT RELEASE.	DELAY IN OPERATIONS	3
TDB RES	84 OHM RESISTOR ACROSS TERMINALS B1 AND B2 OF TROLLEY INVERTER.	DISSIPATES THE ENERGY GENERATED BY THE MOTOR DURING DYNAMIC BRAKING.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	TROLLEY BRAKE MAY RELEASE BEFORE TROLLEY MOTOR HAS POWER APPLIED. TROLLEY MAY DRIFT LEFT OR RIGHT SLIGHTLY. OVERHEATING OF MOTOR WOULD RESULT IN OPENING OF MOTOR THERMAL RELAY CONTACTS	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
P/M: 88V0019 Baseline: 950.00

Program: SLC-2  
Facility/Station Set: VAEB/SLC-2  
Page 33 of 36 Date: March 15, 1992  
Prepared by: M. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMA D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIME/DAY	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
R	TROLLEY RIGHT RELAY NORMALLY OPEN CONTACTS AT INPUT OF INVERTER	WHEN CLOSED CAUSES TROLLEY RIGHT COMMAND TO BE PRESENTED TO BRIDGE DRIVE INVERTER.	A2. FAILS SHORTED B2. INTERNAL PART FAILURE	FUSE TFU WILL OPEN CAUSING LOSS OF CONTROL CIRCUITRY POWER. LOSS OF ALL TROLLEY FUNCTIONS. BRAKES STAY ENGAGED.	DELAY IN OPERATIONS	3
R	TROLLEY RIGHT RELAY NORMALLY CLOSED CONTACTS IN SERIES WITH BRIDGE LEFT RELAY COIL.	WHEN OPEN (INDICATING TROLLEY RIGHT SELECTED) THESE CONTACTS OPEN CIRCUIT TO TROLLEY LEFT RELAY COIL, PREVENTING CONFLICTING COMMANDS TO BE PRESENTED TO INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	TROLLEY WILL NOT MOVE TO THE RIGHT WHEN COMMANDED TO DO SO.	DELAY IN OPERATIONS	3
R	TROLLEY LEFT RELAY NORMALLY OPEN CONTACTS AT INPUT OF INVERTER	WHEN CLOSED CAUSES TROLLEY LEFT COMMAND TO BE PRESENTED TO TROLLEY DRIVE INVERTER.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	CONTINUOUS TROLLEY RIGHT COMMAND GIVEN TO BRIDGE INVERTER.	DELAY IN OPERATIONS	3
L	TROLLEY LEFT RELAY NORMALLY OPEN CONTACTS AT INPUT OF INVERTER	WHEN CLOSED CAUSES TROLLEY LEFT COMMAND TO BE PRESENTED TO TROLLEY DRIVE INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	TROLLEY WILL NOT MOVE TO THE LEFT WHEN COMMANDED TO DO SO.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
PMN: 88V0019 Baseline: 950.00

Program: SLC-2  
Facility/Station Set: VAFB/SIC-2  
Page 34 of 36 Date: October 8, 1993  
Prepared by: W. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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L	TROLLEY LEFT RELAY NORMALLY OPEN CONTACTS AT INPUT OF INVERTER CONTINUED	WHEN OPEN (INDICATING TROLLEY RIGHT SELECTED) THESE CONTACTS OPEN CIRCUIT TO TROLLEY RIGHT RELAY COIL, PREVENTING CONFLICTING COMMANDS TO BE PRESENTED TO INVERTER.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	CONTINUOUS TROLLEY LEFT COMMAND GIVEN TO BRIDGE INVERTER. OPERATOR CAN STOP TROLLEY BY USING THE E-STOP SWITCH OR THE CRANE POWER ON-OFF SWITCH. REQUIRES MULTIPLE FAILURES.	DELAY IN OPERATIONS	3
L	TROLLEY LEFT RELAY NORMALLY CLOSED CONTACTS IN SERIES WITH TROLLEY RIGHT RELAY COIL.	WHEN OPEN (INDICATING TROLLEY RIGHT SELECTED) THESE CONTACTS OPEN CIRCUIT TO TROLLEY RIGHT RELAY COIL, PREVENTING CONFLICTING COMMANDS TO BE PRESENTED TO INVERTER.	A1. FAILS OPEN B1. INTERNAL PART FAILURE	TROLLEY WILL NOT MOVE TO THE RIGHT WHEN COMMANDED TO DO SO.	DELAY IN OPERATIONS	3
MOV	METAL OXIDE VARISTOR IN PARALLEL WITH TROLLEY LEFT RELAY COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RELAY COIL.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF RELAY COIL.	DELAY IN OPERATIONS	3
MOV	METAL OXIDE VARISTOR IN PARALLEL WITH TROLLEY RIGHT RELAY COIL.	PROVIDES SHORT CIRCUIT TO PREVENT BUILD UP OF REVERSE EMF ACROSS RELAY COIL.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	LOSS OF TROLLEY LEFT FUNCTION OF CRANE...	DELAY IN OPERATIONS	3
			A1. FAILS OPEN. B1. INTERNAL PART FAILURE	SHORTENED LIFE EXPECTANCY OF RELAY COIL.	DELAY IN OPERATIONS	3
			A2. FAILS CLOSED B2. INTERNAL PART FAILURE	LOSS OF TROLLEY RIGHT FUNCTION OF CRANE.	DELAY IN OPERATIONS	3

FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System: 20 TON MST BRIDGE CRANE  
Subsystem: CRANE SYSTEM ELECTRICAL  
Drawing No.: 101A15654 Sheet No.: 1 TO 4  
FME: 88V0019 Baseline: 950.00

Program: SLC-2  
Facility/Station Set: VAFB/SLC-2  
Page 35 of 36 Date: March 15, 1992  
Prepared by: W. Di Meo

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FME D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
NONE	TROLLEY LEFT TRAVEL LIMIT SWITCH	PREVENTS OVER TRAVEL OF TROLLEY IN LEFT DIRECTION.	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	LOSS OF TROLLEY LEFT FUNCTION OF CRANE.	DELAY IN OPERATIONS	3
NONE	TROLLEY RIGHT TRAVEL LIMIT SWITCH	PREVENTS OVER TRAVEL OF TROLLEY IN RIGHT DIRECTION.	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	OVER TRAVEL OF TROLLEY IN LEFT DIRECTION	DELAY IN OPERATIONS	3
NONE	TROLLEY RIGHT TRAVEL LIMIT SWITCH	CONTINUED	A1. FAILS OPEN. B1. INTERNAL PART FAILURE	LOSS OF TROLLEY RIGHT FUNCTION OF CRANE.	DELAY IN OPERATIONS	3
NONE	TROLLEY RIGHT TRAVEL LIMIT SWITCH	CONTINUED	A2. FAILS CLOSED B2. INTERNAL PART FAILURE	OVER TRAVEL OF TROLLEY IN RIGHT DIRECTION	DELAY IN OPERATIONS	3
TCB	TROLLEY CIRCUIT BREAKER	PROVIDES MEANS TO APPLY AND REMOVE POWER TO TROLLEY MOTOR CONTROLLER AND BRAKE CIRCUITS.	A1. PREMATURE OPERATION B1. INTERNAL PART FAILURE	TROLLEY BRAKE WILL ENGAGE AND TROLLEY CONTROLS INOPERATIVE.	DELAY IN OPERATIONS	3
ITE EF3A010	EMERGENCY BRAKE CIRCUIT BREAKER	PROVIDES CIRCUIT PROTECTION TO THE EMERGENCY BRAKE AIR COMPRESSOR.	A1. FAILS CLOSED B1. INTERNAL PARTS FAILURE	LOSS OF CIRCUIT PROTECTION. PROTECTED UPSTREAM BY MAIN CIRCUIT BREAKER. NO EFFECT ON NORMAL OPERATIONS	NONE. REQUIRES MULTIPLE FAILURES.	3
			A2. FAILS PREMATURELY B2. INTERNAL PARTS FAILURE	LOSS OF AIR COMPRESSOR. HOIST EMERGENCY BRAKE WILL ENGAGE AND STOP HOIST. HOIST SYSTEM INOPERATIVE.	DELAY IN OPERATIONS	3

**FAILURE MODES AND EFFECTS ANALYSIS (FMEA) WORKSHEET**

System: 20 TON MST BRIDGE CRANE  
 Subsystem: CRANE SYSTEM ELECTRICAL  
 Drawing No.: 101A15654 Sheet No.: 1 TO 4  
 Program: SLC-2  
 Facility/Station Set: VAFB/SLC-2  
 Page 36 of 36 Date: March 15, 1992  
 Prepared by: W. Di Leo  
 PM#: 88V0019 Baseline: 950.00

FLND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FPN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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<p>OSS MCI SRS-1A</p>	<p>OVER-SPEED SWITCH</p>	<p>PROVIDES PROTECTION AGAINST HOIST OVER-SPEED. IF AN OVER-SPEED IS SENSED, SWITCH CLOSES AND ENGAGES THE HOIST EMERGENCY BRAKE.</p>	<p>A1. FAILS CLOSED B2. INTERNAL PARTS FAILURE</p>	<p>LOSS OF AUTOMATIC OVER-SPEED PROTECTION. OPERATOR CAN ENGAGE EMERGENCY BRAKE BY PUSHING THE E-STOP BUTTON. REQUIRE MULTIPLE FAILURES</p>	<p>DELAY IN OPERATIONS</p>	<p>3</p>
<p>HEBS</p>	<p>LIMIT SWITCH, HOIST EMERGENCY BRAKE</p>	<p>PREVENTS HOIST FROM POWERING UP IF THE EMERGENCY BRAKE IS ENGAGED.</p>	<p>A2. FAILS OPEN B2. INTERNAL PARTS FAILURE</p>	<p>HOIST EMERGENCY BRAKE WILL REMAIN ENGAGED. HOIST SYSTEM INOPERATIVE.</p>	<p>DELAY FOR OPERATIONS</p>	<p>3</p>
<p>HEBS</p>	<p>LIMIT SWITCH, HOIST EMERGENCY BRAKE</p>	<p>PREVENTS HOIST FROM POWERING UP IF THE EMERGENCY BRAKE IS ENGAGED.</p>	<p>A1. FAILS CLOSED B1. INTERNAL PARTS FAILURE</p>	<p>LOSS OF PROTECTION FROM POWER UP AFTER EMERGENCY BRAKE HAS ENGAGED. POSSIBLE DAMAGE TO HOIST MOTOR IF OPERATOR COMMANDS MOTION WHILE BRAKE IS ENGAGED.</p>	<p>DELAY IN OPERATIONS</p>	<p>3</p>
<p>HEBS</p>	<p>LIMIT SWITCH, HOIST EMERGENCY BRAKE</p>	<p>PREVENTS HOIST FROM POWERING UP IF THE EMERGENCY BRAKE IS ENGAGED.</p>	<p>A2. FAILS OPEN B2. INTERNAL PARTS FAILURE</p>	<p>UNABLE TO POWER UP HOIST SYSTEM. HOIST SYSTEM INOPERATIVE.</p>	<p>DELAY IN OPERATIONS</p>	<p>3</p>

#### 5.2 HOSE FMEA WORKSHEETS

There are no Flexhoses associated with this system.

#### 5.4 ORIFICE FMEA WORKSHEETS

There are no Orifices associated with this system.

#### 5.5 FILTER FMEA WORKSHEETS

There are no Filters associated with this system.

#### 5.6 CRITICAL ITEMS LIST

There were no Critical Items identified during this analysis which are summarized on the following Critical Items List.

#### 5.7 CRITICAL FLEXHOSES

Not applicable

#### 5.8 CRITICAL ORIFICES

Not applicable

#### 5.9 CRITICAL FILTERS

Not applicable

#### 5.10 CRITICALITY CATEGORY 1R ITEMS

There were four (4) Category 1R items identified during the analysis of the critical output functions identified in section 4.0 for this system. The 1R items are summarized on the following Criticality Category 1R Items Worksheets.

SYSTEM: 20-TON MST BRIDGE CRANE		PROGRAM: VAFB SLC-2		FACILITY/STATION SET: VAFB/SLC-2			
BASELINE: 950.00		PAGE 1 OF 2		DATE 3-04-92			
PMN No. H88V0019		PREPARED BY: J. C. WYCKOFF					
FIND NO. NASA NO. MFG. NO.	PART NAME PMN NUMBER DRAWING NO. FMN NUMBER	FAILURE MODE CAUSE(S)	FAILURE EFFECT	REDUNDANCY SCREENS		TEST AND INSPECTION REQUIREMENT(S)	TEAR DOWN ANALYSIS REQUIRED
				PASS	FAIL		
NONE	HOIST GEAR REDUCER	DISENGAGES	LOAD HOLDING ABILITY DEPENDANT ON EMERGENCY DRUM BRAKE. IF BOTH THE GEAR REDUCER AND THE EMERGENCY BRAKE FAIL, LOAD WILL DROP. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.	A	B	PER 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, THE HOIST IS PREOPERATIONALLY LOAD TESTED TO 110% OF THE WEIGHT OF LOAD TO BE LIFTED, NOT TO EXCEED RATED LOAD AND WITHIN 30 DAYS OF LIFTING CRITICAL ITEMS.	NO
NONE	PMN 88V0019 D2153-M01	BROKEN TEETH		C			
NONE	FMN 88CR000- 041.001						
NONE	WIRE ROPE DRUM GEAR 161 TEETH	DISENGAGES	LOAD HOLDING ABILITY DEPENDANT ON EMERGENCY BRAKE. IF E-BRAKE FAILS ALSO, LOAD WILL DROP, COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.	A	B	PER 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, THE HOIST IS PREOPERATIONALLY LOAD TESTED TO 110% OF THE WEIGHT OF LOAD TO BE LIFTED, NOT TO EXCEED RATED LOAD AND WITHIN 30 DAYS OF LIFTING CRITICAL ITEMS.	NO
NONE	PMN 88V0019 D2153-M01	SPRING FAILURE		C			
NONE	FMN 88CR000- 041.002						

SYSTEM: 20-TON MST BRIDGE CRANE  
 BASELINE: 950.00  
 PMN No. H88V0019

PROGRAM: VAFB SLC-2

FACILITY/STATION SET: VAFB/SLC-2  
 PAGE 2 OF 2 DATE 3-04-92  
 PREPARED BY: J. C. WYCKOFF

FIND NO. NASA NO. MFG. NO.	PART NAME PMN NUMBER DRAWING NO. FMN NUMBER	FAILURE MODE CAUSE(S)	FAILURE EFFECT	REDUNDANCY SCREENS		TEST AND INSPECTION REQUIREMENT(S)	TEAR DOWN ANALYSIS REQUIRED
				PASS	FAIL		
NONE	WIRE ROPE DRUM PINON PMN 88V0019	DISENGAGES	LOAD HOLDING ABILITY DEPENDANT ON EMERGENCY BRAKE IF EMERGENCY BRAKE FAILS ALSO, LOAD WILL DROP. COULD CAUSE LOSS OF LIFE AND/OR FLIGHT HARDWARE.	A	B	PER 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, THE HOIST IS PREOPERATIONALLY LOAD TESTED TO 110% OF THE WEIGHT OF LOAD TO BE LIFTED, NOT TO EXCEED CRANE RATED LOAD AND WITHIN 30 DAYS OF LIFTING CRITICAL ITEMS.	NO
NONE	D2153-M01	BROKEN TEETH		C			
NONE	FMN 88CR000- 041.003						
NONE	EMERGENCY DISC BRAKE	FAILS TO ENGAGE	FAILURE OF THE EMERGENCY BRAKE AND GEAR REDUCER OR ROPE DRUM GEAR/ PINON SET WILL CAUSE THE LOAD TO DROP. COULD CAUSE LOSS OF LIFE AND/ OR FLIGHT HARDWARE	A	B	PER 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, CRANE IS OPERATED THROUGH ITS ENTIRE RANGE PRIOR TO EACH LIFT OR ONCE A DAY IF MULTIPLE LIFTS ARE TO BE PERFORMED. HOIST IS PREOPERATIONALLY LOAD TESTED TO 110% OF LOAD TO BE LIFTED NOT TO CRANE RATED LOAD.	NO
20MBA	PMN 88V0019	BROKEN SPRINGS		C			
NONE	D2153-M12						
NONE	FMN 88CR000- 041.004						

REV. A

## SECTION VI

### HAZARD ANALYSIS

#### 6.1 OBJECTIVE

The objective of this System Hazard Analysis (SHA) on the 20-Ton Mobile Service Tower Bridge Crane for use at Vandenberg Air Force Base (VAFB), SLC-2, is to identify and document any system or equipment safety concerns that represent a risk to safe system operation or design. This SHA follows the guidelines in KHB 5310.9, Kennedy Space Center Ground Systems Safety and Reliability Analysis.

The analysis complements the reliability analysis by reporting hazards normally ground-ruled out of the FMEA, such as generic hazards, failure of passive components, or human factors. The following were assessed in the preparation of this hazard analysis:

- o Concerns that could cause death/injury to personnel, and/or loss/damage to flight hardware.
- o Design issues that affect normal operation of the system.

#### 6.2 RESULTS

The areas assessed by this SHA are depicted on the top level fault tree with the assessment rationale documented on the SHA worksheets. The [REDACTED] hazards arise from either structural failure or improper assembly of hardware, which could result in dropped flight hardware.

Trolley hardware failures must be accompanied with operator error to result in death/injury of personnel and/or loss/damage to equipment. The other system failures identified also require multiple failures to occur. Single hoist passive component failure increases the possibility of death/injury and loss/damage to flight hardware. However, these components meet required design specifications and are regularly inspected.

No Formal Hazard Reports for NASA Level III Risk Assessment Board (RAB) approval were generated.

**HAZARD IDENTIFICATION DATA**

SYSTEM/SUBSYSTEM (Title)	B/L	PMN	PCN
20-TON MOBILE SERVICE TOWER BRIDGE CRANE AT VAFB, SLC-2	950.00	H88V0019	M00000

The following hazard identification criteria were considered during the hazard analysis:

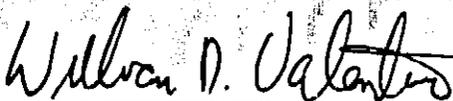
DESIGN SAFETY CHECKLIST SECTION NUMBER AND TITLE: KHB 5310.9, APPENDIX I

- |   |  |
|---|--|
| <input checked="" type="checkbox"/> 1.0 Handling and Transportation | <input checked="" type="checkbox"/> 2.0 Fluids, Gases/Pneumatics |
| <input checked="" type="checkbox"/> 3.0 Electrical/Electronic       | <input type="checkbox"/> 4.0 Facilities                          |
| <input type="checkbox"/> 5.0 Hydraulic                              | <input type="checkbox"/>   |
- HAZARD ANALYSIS ELEMENTS: KHB 5300.4 (ID-2)
  - FAILURE MODE AND EFFECTS ANALYSIS (FMEA)
  - FUNCTIONAL AND PHYSICAL INTERFACES
  - OCCUPATIONAL SAFETY AND HEALTH STANDARDS (OSHA) 29 CFR 1910
  - KHB 5310.9 KENNEDY SPACE CENTER GSE SAFETY AND RELIABILITY ANALYSES
  - SW-E-002. SPACE SHUTTLE PROGRAM GSE GENERAL DESIGN REQUIREMENTS

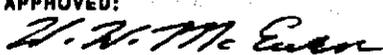
The Hazard Analysis was based on the following system documentation (list documents here):

- NSS/GO 1790.9 Rev. B    NASA Safety Standard for Lifting Devices and Equipment
- 79K32662 Rev. A        General Test Requirements for Critical Cranes Located at Vandenberg Air Force Base
- D2153-M01              HECO Pacific Proposal for Lifting Devices and Equipment
- 91-3023B                HECO Pacific Proposal and Specifications (Purchase Spec.)

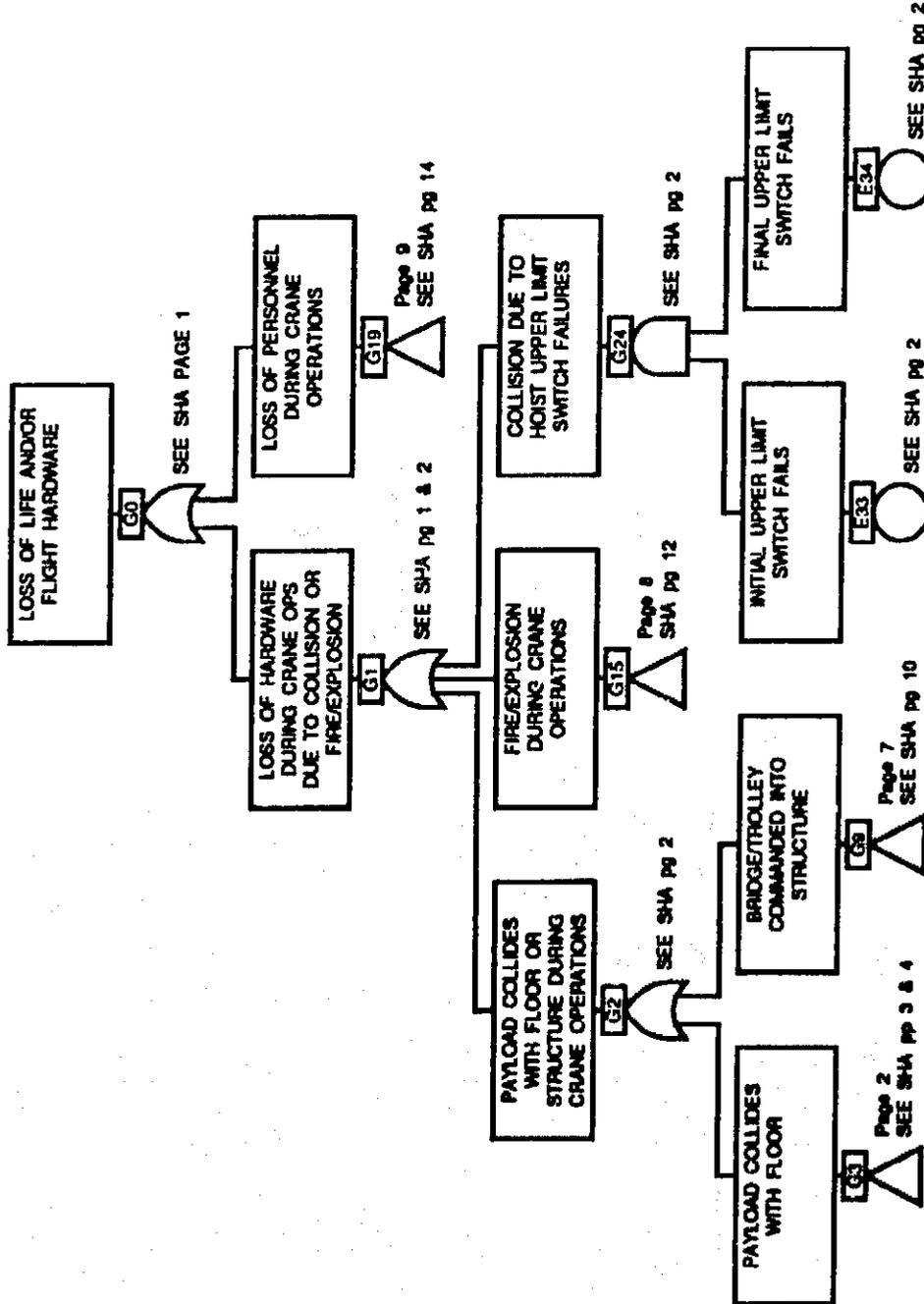
**Hazard Summary:** No Formal NASA Hazard Reports were generated by this analysis for Level III Risk Assessment Board Approval.

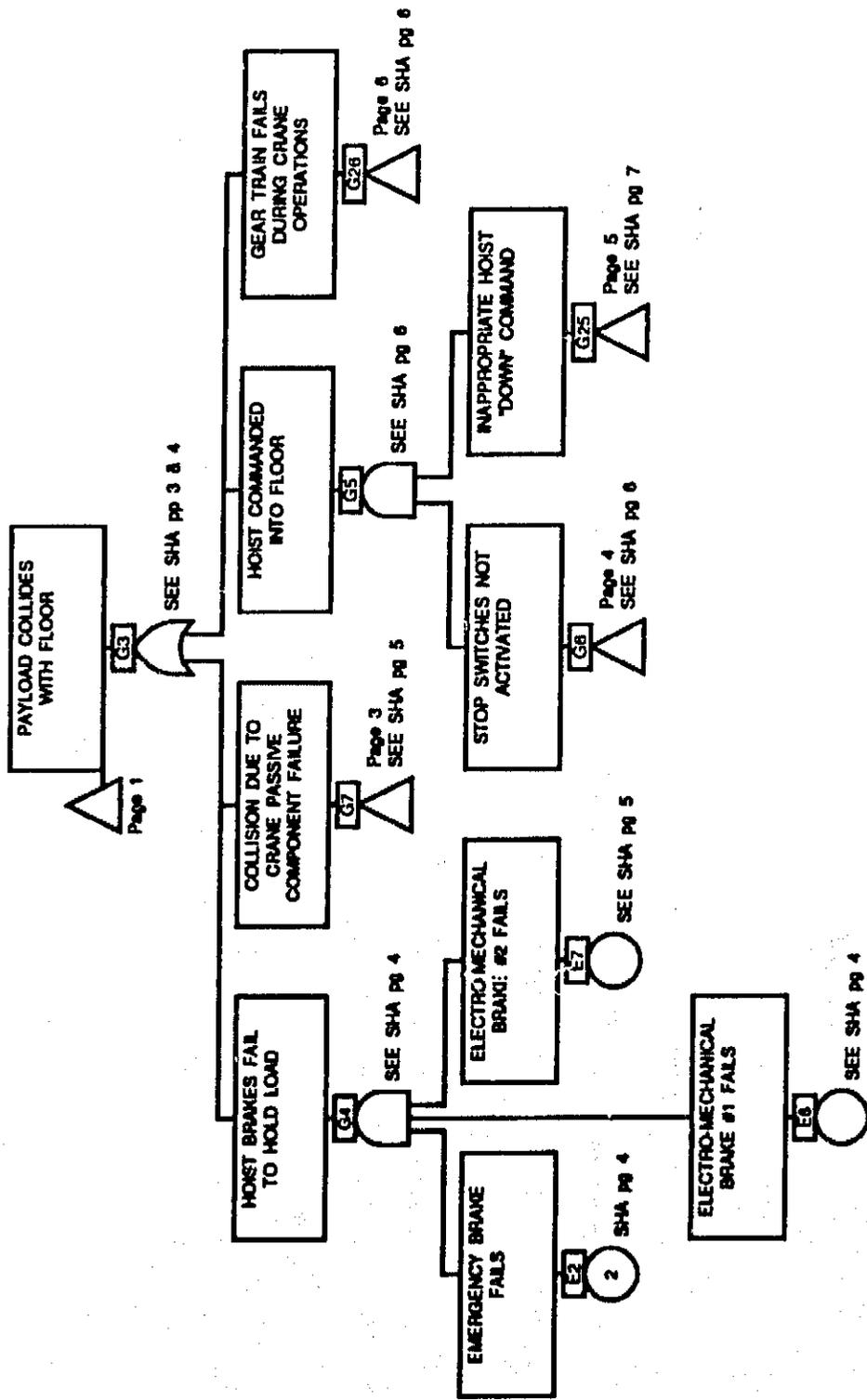


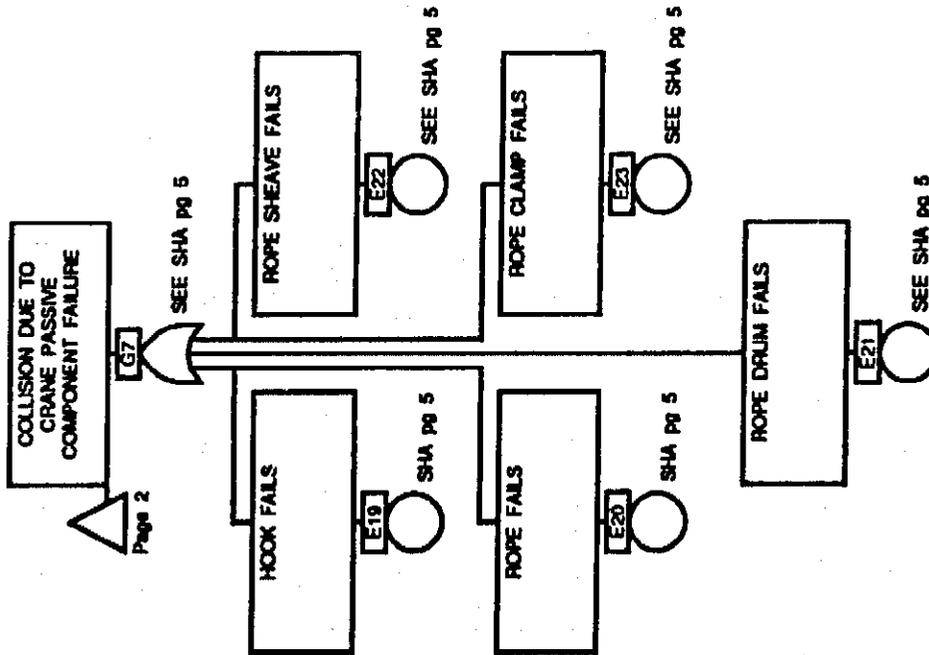
William D. Valentino, Safety Engineer,  
SRM&Q Eng. Analysis, F194

APPROVED:  
 3/10/92  
W.W. McEwen, Mgr. SRM&Q Eng. Analysis, F194

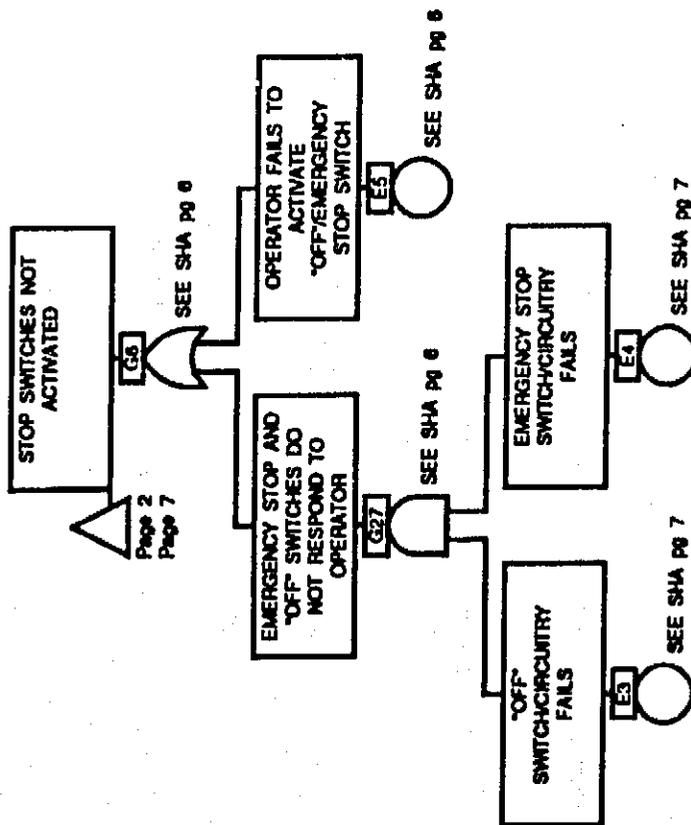
APPROVED (NASA):



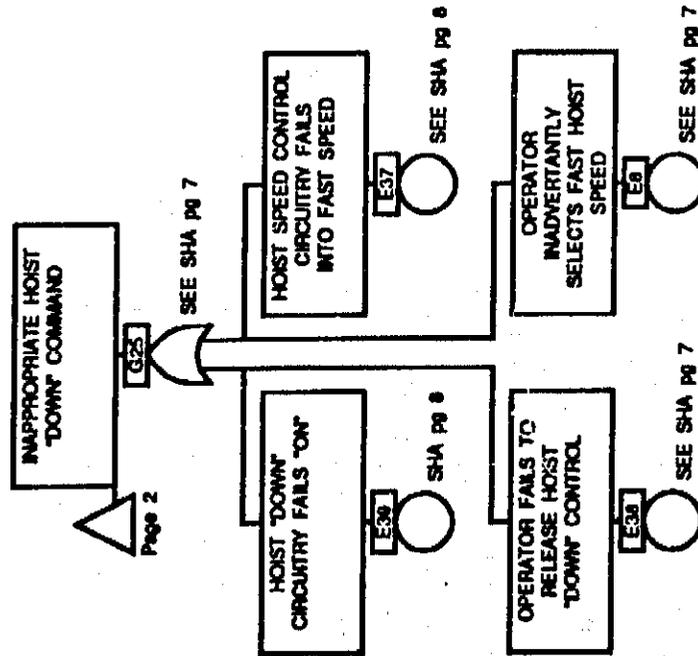




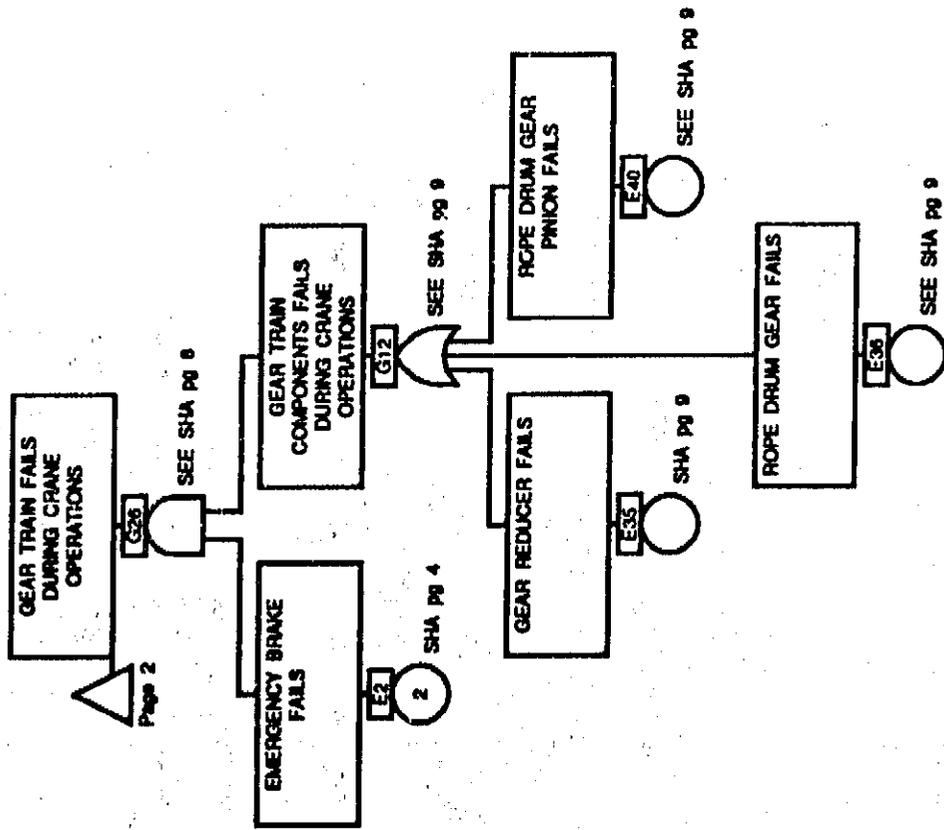
Page 2

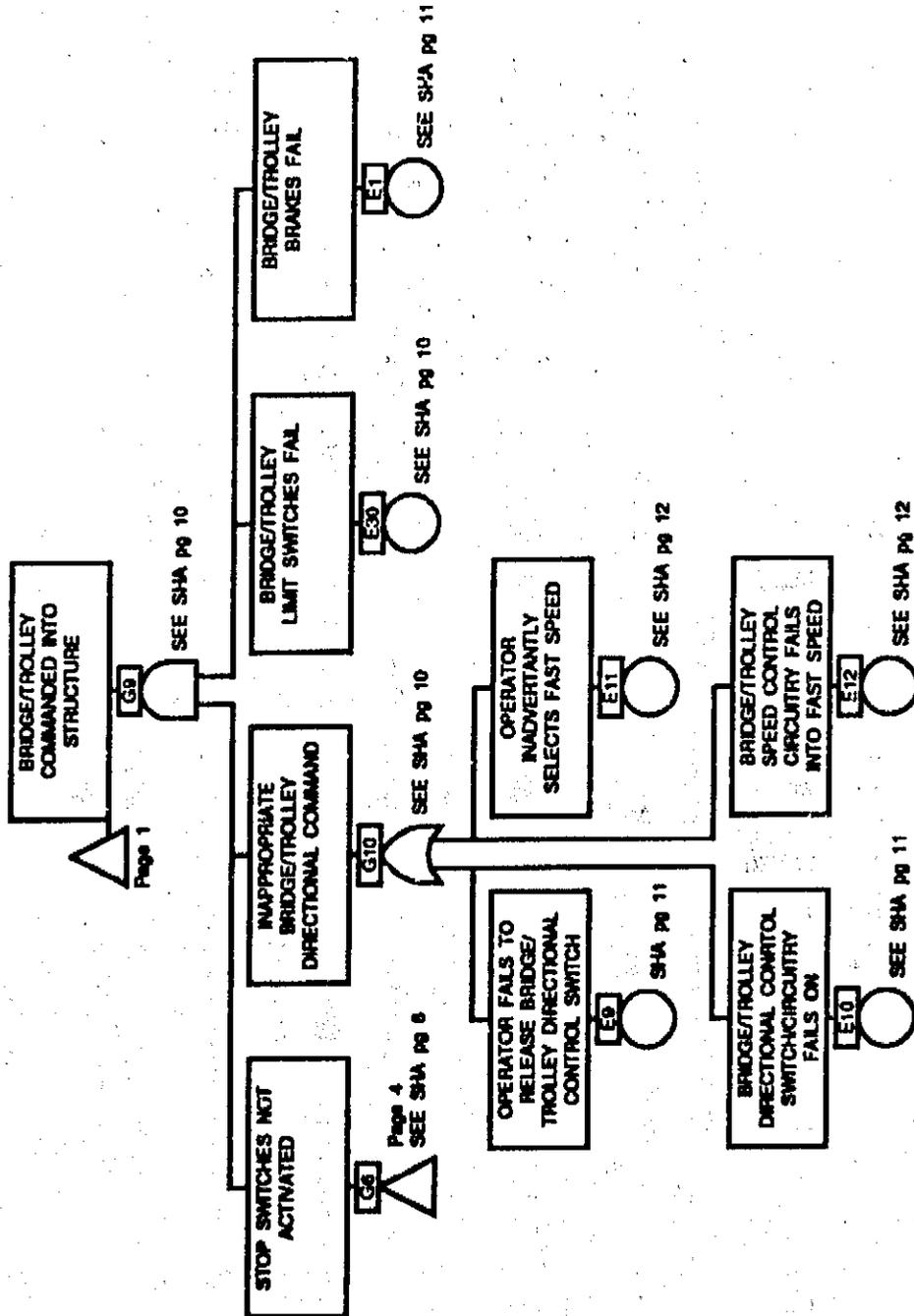


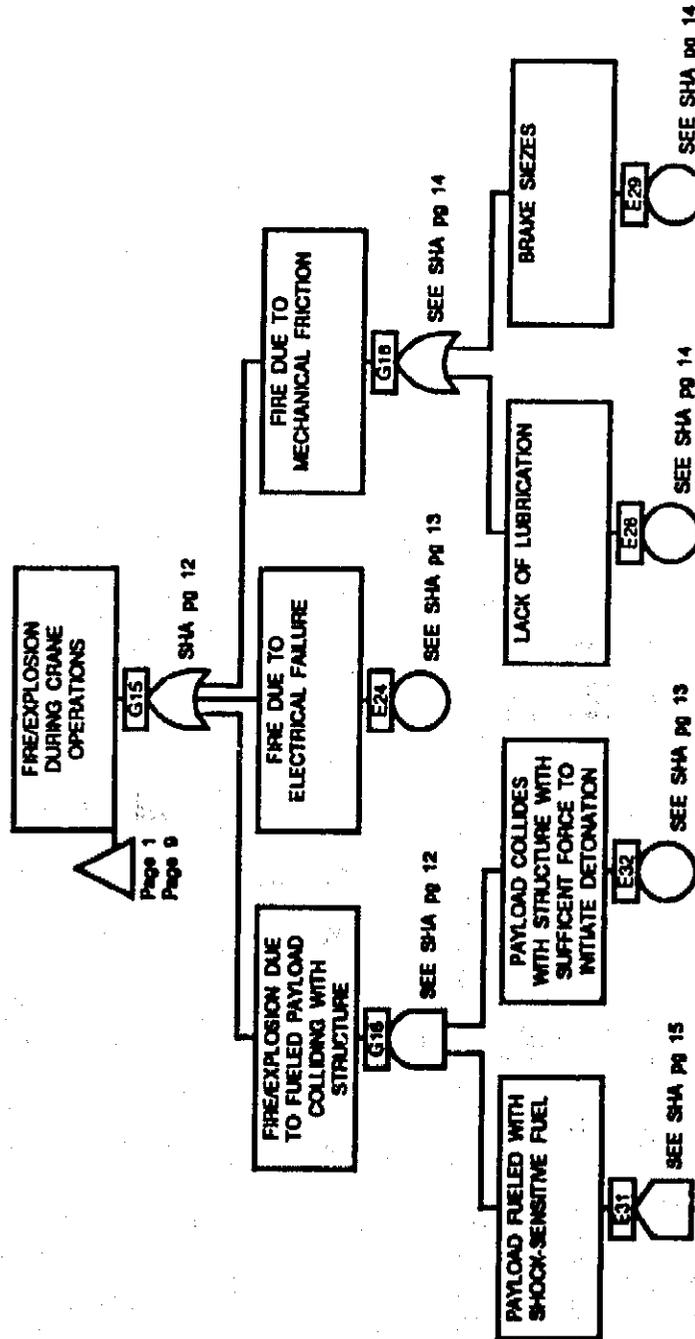
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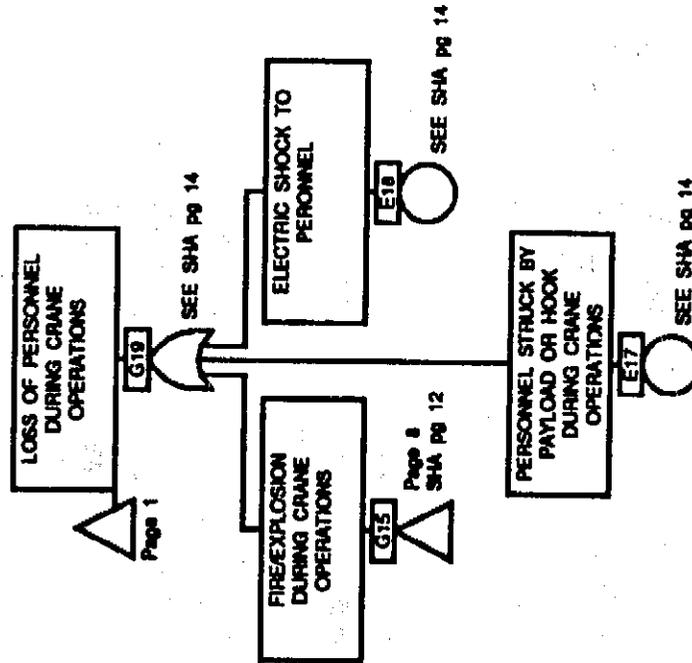
Page 2







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Page 9



<p>SAA NO: SAA88CR000-041      <b>SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET</b></p> <p>MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS      ENGINEER: W.D. Valentino</p> <p>SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB      DATE: 10 April, 1992</p> <p>EFFECTIVITY: ALL FLIGHTS      SHEET: 1 OF 15</p>						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	C# : LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G1) BELOW	DEVELOPED UNDER (G1) BELOW	A0 - UNLIKELY
(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	(G19) - LOSS OF PERSONNEL DURING CRANE OPERATIONS	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	C# : LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G19) BELOW (PAGE 14)	DEVELOPED UNDER (G19) BELOW	A0 - UNLIKELY
(G1) - LOSS OF HARDWARE DURING CRANE OPERATIONS DUE TO COLLISION OR FIRE/EXPLOSION	(G2) - PAYLOAD COLLIDES WITH FLOOR OR STRUCTURE DURING CRANE OPERATIONS	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	C# : LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G2) BELOW (PAGE 3)	DEVELOPED UNDER (G2) BELOW	A0 - UNLIKELY
(G1) - LOSS OF HARDWARE DURING CRANE OPERATIONS DUE TO COLLISION OR FIRE/EXPLOSION	(G15) - FIRE OR EXPLOSION DURING CRANE OPERATIONS	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	C# : LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G15) BELOW (PAGE 12)	DEVELOPED UNDER (G15) BELOW	A0 - UNLIKELY

SAA NO: SAA88CR000-041 MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB EFFECTIVITY: ALL FLIGHTS SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET ENGINEER: W.D. Valentino DATE: 10 April, 1992 SHEET: 2 OF 15						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G1) - LOSS OF HARDWARE DURING CRANE OPERATIONS DUE TO COLLISION OR FIRE/EXPLOSION	(G24) - HOIST UPPER LIMIT SWITCHES FAIL DURING CRANE OPERATIONS	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G24) BELOW	DEVELOPED UNDER (G24) BELOW	Ao - UNLIKELY
(G24) - HOIST UPPER LIMIT SWITCHES FAIL DURING CRANE OPERATIONS	(E33) - FIRST UPPER LIMIT SWITCH FAILS (SEE ELECTRICAL FMEA, PAGE 5)	NO EFFECT UNLESS (E34) ALSO OCCURS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 7.1.1. REQUIRES THAT CRITICAL CRANES HAVE DUAL UPPER LIMIT SWITCHES - AN INITIAL AND A FINAL, WHICH PRECLUDE ALL CRANE MOTION	PER DRAWING D2153-M01, INITIAL UPPER LIMIT SWITCH IS A GEARED LIMIT SWITCH WHICH PREVENTS THE HOIST FROM BEING RAISED. THE WEIGHTED UPPER LIMIT SWITCH WHICH TRIPS THE MAIN BREAKER	Ao - UNLIKELY
(G24) - HOIST UPPER LIMIT SWITCHES FAIL DURING CRANE OPERATIONS	(E34) - FINAL UPPER LIMIT SWITCH FAILS (SEE ELECTRICAL FMEA, PAGE 6)	NO EFFECT UNLESS (E33) ALSO OCCURS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 7.1.1. REQUIRES THAT CRITICAL CRANES HAVE DUAL UPPER LIMIT SWITCHES - AN INITIAL AND A FINAL, WHICH PRECLUDE ALL CRANE MOTION	PER DRAWING D2153-M01, INITIAL UPPER LIMIT SWITCH IS A GEARED LIMIT SWITCH WHICH PREVENTS THE HOIST FROM BEING RAISED. THE WEIGHTED UPPER LIMIT SWITCH WHICH TRIPS THE MAIN BREAKER	Ao - UNLIKELY

<p>SAA NO: SAA88CR000-041      SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET</p> <p>MISSION YEARS: DELTA PAYLOAD GROUND OPERATIONS      ENGINEER: M.D. Valentino</p> <p>SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB      DATE: 10 April, 1992</p> <p>EFFECTIVITY: ALL FLIGHTS      SHEET: 3 OF 15</p>						
HAZARD'S CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G2) - PAYLOAD COLLIDES WITH FLOOR OR STRUCTURE DURING CRANE OPERATIONS	(G3) - PAYLOAD COLLIDES WITH FLOOR/STRUCTURE	(G1) - LOSS OF HARDWARE DURING CRANE OPERATIONS DUE TO COLLISION OR FIRE/EXPLOSION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G3) BELOW	DEVELOPED UNDER (G3) BELOW (PAGE 4)	Lo - UNLIKELY
(G2) - PAYLOAD COLLIDES WITH FLOOR OR STRUCTURE DURING CRANE OPERATIONS	(G9) - BRIDGE/TROLLEY COMMANDED INTO STRUCTURE	(G1) - LOSS OF HARDWARE DURING CRANE OPERATIONS DUE TO COLLISION OR FIRE/EXPLOSION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G9) BELOW (PAGE 10)	DEVELOPED UNDER (G9) BELOW (PAGE 11)	Lo - UNLIKELY
(G3) - PAYLOAD COLLIDES WITH FLOOR/STRUCTURE	(G4) - HOIST BRAMES FAIL TO HOLD LOAD	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G4) BELOW (PAGE 4)	DEVELOPED UNDER (G4) BELOW	Lo - UNLIKELY
(G3) - PAYLOAD COLLIDES WITH FLOOR/STRUCTURE	(G5) - HOIST COMMANDED INTO FLOOR	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G5) BELOW (PAGE 6)	DEVELOPED UNDER (G5) BELOW	Lo - UNLIKELY

<b>SAA NO: SAA88CR000-041</b> <b>MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS</b> <b>SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB</b> <b>EFFECTIVITY: ALL FLIGHTS</b>						
<b>SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET</b>						
<b>ENGINEER: N.D. Valentino</b> <b>DATE: 10 April, 1992</b> <b>SHEET: 4 OF 15</b>						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G3) - PAYLOAD COLLIDES WITH FLOOR/STRUCTURE	(G7) - COLLISION DUE TO CRANE PASSIVE COMPONENT FAILURE	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G7) BELOW (PAGE 5)	DEVELOPED UNDER (G7) BELOW	Ao - UNLIKELY
(G3) - PAYLOAD COLLIDES WITH FLOOR/STRUCTURE	(G26) - GEAR TRAIN FAILS DURING CRANE OPERATIONS	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G26) BELOW (PAGE 8)	DEVELOPED UNDER (G26) BELOW	Ao - UNLIKELY
(G4) - HOIST BRANES FAIL TO HOLD LOAD	(E2) - EMERGENCY BRAKE FAILS	NO EFFECT WITHOUT OCCURRENCE OF (E6) & (E7) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 3.e. REQUIRES THAT HOISTS HAVE TWO MEANS OF BRAKING, EACH OF WHICH CAN HOLD THE RATED LOAD.	PER DRAWING D2153-M01, THE HOIST HAS TWO MAIN BRAKES, EACH OF WHICH IS CAPABLE OF STOPPING 1500 OF RATED LOAD, PLUS THE PNEUMATICALLY-OPERATED EMERGENCY BRAKE.	Ao - UNLIKELY
(G4) - HOIST BRANES FAIL TO HOLD LOAD	(E6) - ELECTRO-MECHANICAL BRAKE #1 FAILS (SEE FMEA MECHANICAL, PAGE 1)	NO EFFECT WITHOUT OCCURRENCE OF (E2) & (E7) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 3.g. REQUIRES THAT HOISTS HAVE TWO MEANS OF BRAKING, EACH OF WHICH CAN HOLD THE RATED LOAD.	PER DRAWING D2153-M01, THE HOIST HAS TWO MAIN BRAKES, EACH OF WHICH IS CAPABLE OF STOPPING 1500 OF RATED LOAD, PLUS THE PNEUMATICALLY-OPERATED EMERGENCY BRAKE.	Ao - UNLIKELY

**SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET**

ENGINEER: W.D. Valentino  
 DATE: 8 October, 1993  
 SHEET: 5 OF 15

MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS  
 SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB  
 EFFECTIVITY: ALL FLIGHTS

SAA NO: SAA88CR000-041

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G4) - HOIST BRAKES FAIL TO HOLD LOAD	(E7) - ELECTRO-MECHANICAL BRAKE #2 FAILS (SEE FMEA MECHANICAL, PAGE 2)	NO EFFECT WITHOUT OCCURRENCE OF (E2) & (E6) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 3.e. REQUIRES THAT HOISTS HAVE TWO MEANS OF BRAKING, EACH OF WHICH CAN HOLD THE RATED LOAD.	PER DRAWING D2153-M01, THE HOIST HAS TWO MAIN BRAKES, EACH OF WHICH IS CAPABLE OF STOPPING 150% OF RATED LOAD, PLUS THE PNEUMATICALLY-OPERATED EMERGENCY BRAKE.	Lo - UNLIKELY
(G7) - COLLISION DUE TO CRANE MASSIVE COMPONENT FAILURE	(E19) - HOOK FAILS; (E20) ROPE FAILS; (E21) ROPE DRUM FAILS; (E22) ROPE SHEAVE FAILS; (E23) ROPE CLAMP FAILS	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	E19 - NSS/GO 1740.9 PARA. 2.4.5.K REQUIRES MONTHLY INSPECTION OF HOOKS FOR DEFORMATION OR CRACKS, AND AN ANNUAL NONDESTRUCTIVE EVALUATION. E20 - NSS/GO 1740.9 PARA. 2.4.5.N REQUIRES MONTHLY INSPECTION OF WIRE ROPE. E21 - NSS/GO 1740.9 PARA. 2.4.5.b REQUIRES PERIODIC INSPECTION FOR CRACKED OR WORN DRUMS. E22 - NSS/GO 1740.9 PARA. 2.4.5.B REQUIRES FORMAL PERIODIC INSPECTION FOR CRACKED OR WORN SHEAVES. E23 - NSS/GO 1740.9 PARA. 2.2.6.K REQUIRES ROPE ENDS TO BE ANCHORED SECURELY BY A CLAMP AND THE DRUM HAVE NO LESS THAN TWO FULL WRAPS WHEN THE HOOK IS AT ITS LOWEST POINT.	79K32662, TEST REQUIREMENTS FOR VAFB CRANES, SPECIFIES PROPER PROOF TESTING AND MAINTENANCE SCHEDULES. VAFB LAUNCH PREPARATION DOCUMENT LPD V579 STATES THAT WIRE ROPE IS VISUALLY INSPECTED FOR DAMAGE MONTHLY.	Lo - UNLIKELY

<p>SAA NO: SAA88CR000-041      SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET</p> <p>MISSION PHASE:      DELTA PAYLOAD GROUND OPERATIONS      ENGINEER:      W.D. Valentino</p> <p>SYSTEM/SUBSYSTEM:      20-TON CRANE AT VAFB      DATE:      10 April, 1992</p> <p>EFFECTIVITY:      ALL FLIGHTS      SHEET:      6 OF 15</p>						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G5) - HOIST COMMANDED INTO FLOOR/STRUCTURE	(G6) - STOP SWITCHES NOT ACTIVATED	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G6) BELOW	DEVELOPED UNDER (G6) BELOW	Ao - UNLIKELY
(G5) - HOIST COMMANDED INTO FLOOR/STRUCTURE	(G25) - INAPPRO-PRATE HOIST "DOWN" COMMAND	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G25) BELOW (PAGE 7)	DEVELOPED UNDER (G25) BELOW	Ao - UNLIKELY
(G6) - STOP SWITCHES NOT ACTIVATED	(G27) - "OFF" SWITCH AND EMERGENCY STOP SWITCH DO NOT RESPOND TO OPERATOR	NO EFFECT WITHOUT OCCURRENCE OF (G25) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G27) BELOW (PAGE 7)	DEVELOPED UNDER (G27) BELOW	Ao - UNLIKELY
(G6) - STOP SWITCHES NOT ACTIVATED	(E5) - OPERATOR FAILS TO ACTIVATE "OFF"/EMERGENCY STOP SWITCH	NO EFFECT WITHOUT OCCURRENCE OF (G25) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 2.6 REQUIRES A PERSONNEL CERTIFICATION PROGRAM, INCLUDING TRAINING AND LICENSING	79K32662, TEST REQUIREMENTS FOR VAFB CRANES, CONTAINS PROVISIONS FOR A PERSONNEL CERTIFICATION PROGRAM.	Ao - UNLIKELY

SAA NO: SAA88CR000-041      SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB EFFECTIVITY: ALL FLIGHTS ENGINEER: W.D. Valentino DATE: 10 April, 1992 SHEET: 7 OF 15						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G27) - "OFF" SWITCH AND EMERGENCY STOP SWITCH DO NOT RESPOND TO OPERATOR	(E3) - "OFF" SWITCH/CIRCUITRY FAILS	NO EFFECT WITHOUT OCCURRENCE OF (G25) AND IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9, PARA. 7.d., REQUIRES THAT CONTROL STATIONS HAVE A STOP PUSHBUTTON THAT OPERATES MAINLINE CONTACTOR	PER DRAWING D2153-M01, THE CONTROL CONSOLE HAS A BUTTON LABELED "OFF" WHICH OPENS THE MAINLINE CONTACTOR	AO - UNLIKELY
(G27) - "OFF" SWITCH AND EMERGENCY STOP SWITCH DO NOT RESPOND TO OPERATOR	(E4) - EMERGENCY STOP SWITCH/CIRCUITRY FAILS (SEE FMEA ELEC, PAGE 2)	NO EFFECT WITHOUT OCCURRENCE OF (G25) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9, PARA. 7.d. REQUIRES A RED, EMERGENCY STOP BUTTON THAT OPERATES THE MAINLINE CONTACTOR AND/OR MAIN CIRCUIT BREAKER.	PER DRAWING D2153-M01, THE EMERGENCY STOP ACTIVATES BOTH MAIN CIRCUIT BREAKER AND MAINLINE CONTACTOR. L.	AO - UNLIKELY
(G25) - INAPPROPRIATE HOIST "DOWN" COMMAND	(E8) - OPERATOR INADVERTENTLY SELECTS HOIST FAST SPEED	NO EFFECT WITHOUT OCCURRENCE OF (G6) AND IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 2.6 REQUIRES A PERSONNEL CERTIFICATION PROGRAM, INCLUDING TRAINING AND LICENSING	79K32662, TEST REQUIREMENTS FOR VAFB CRANES, CONTAINS PROVISIONS FOR PERSONNEL CERTIFICATION	AO - UNLIKELY
(G25) - INAPPROPRIATE HOIST "DOWN" COMMAND	(E37) - HOIST SPEED CONTROL CIRCUITRY FAILS INTO FAST SPEED (SEE FMEA ELEC. PAGE 4)	NO EFFECT WITHOUT OCCURRENCE OF (G6) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 7.f. REQUIRES THAT THE ELECTRICAL SYSTEM BE FAIL-SAFE.	REQUIREMENT MET BY DESIGN - THREE INDEPENDENT FAILURES ARE NECESSARY FOR HAZARD TO OCCUR.	AO - UNLIKELY

SAA NO: SAA88CR000-041 MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB EFFECTIVITY: ALL FLIGHTS ENGINEER: M.D. Valentino DATE: 10 April, 1992 SHEET: 8 OF 15 SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G25) - INAPPROPRIATE HOIST "DOWN" COMMAND	(E38) - OPERATOR FAILS TO RELEASE HOIST "DOWN" CONTROL	NO EFFECT WITHOUT OCCURRENCE OF (G6) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 2.6 REQUIRES A PERSONNEL CERTIFICATION PROGRAM, INCLUDING TRAINING AND LICENSING	79K32662, TEST REQUIREMENTS FOR VAFB CRANES, CONTAIN SPROVISIONS FOR A PERSONNEL CERTIFICATION PROGRAM.	Ao - UNLIKELY
(G25) - INAPPROPRIATE HOIST "DOWN" COMMAND	(E39) - HOIST DOWN CIRCUITRY FAILS ON (SEE FMEA ELEC. PAGE 2)	NO EFFECT WITHOUT OCCURRENCE OF (G6) IN CONJUNCTION	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 7.f. REQUIRES THAT THE ELECTRICAL SYSTEM BE FAIL-SAFE.	REQUIREMENT MET BY DESIGN - THREE INDEPENDENT FAILURES ARE NECESSARY FOR HAZARD TO OCCUR.	Ao - UNLIKELY
(G26) - GEAR TRAIN FAILS DURING CRANE OPERATIONS	(G12) - GEAR TRAIN COMPONENT FAILS DURING CRANE OPERATIONS	NO EFFECT UNLESS (E2) ALSO OCCURS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G12) BELOW (PAGE 9)	DEVELOPED UNDER (G12) BELOW	Ao - UNLIKELY
(G26) - GEAR TRAIN FAILS DURING CRANE OPERATIONS	(E2) - EMERGENCY BRAKE FAILS	NO EFFECT UNLESS (G12) ALSO OCCURS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 3.e. REQUIRES THAT HOISTS HAVE TWO MEANS OF BRAKING, EACH OF WHICH CAN HOLD THE RATED LOAD.	PER DRAWING D2153-M01, THE HOIST HAS TWO MAIN BRAKES, EACH OF WHICH IS CAPABLE OF STOPPING 150W OF RATED LOAD, PLUS THE PNEUMATICALLY-OPERATED EMERGENCY BRAKE.	Ao - UNLIKELY

SAA NO: SAAB88CR000-041 SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET ENGINEER: W.D. Valentino DATE: 10 April, 1992 SHEET: 9 OF 15						
DELTA PAYLOAD GROUND OPERATIONS 20-TON CRANE AT VAFB ALL FLIGHTS						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G12) - GEAR TRAIN COMPONENTS FAIL DURING CRANE OPERATIONS	(E35) - GEAR REDUCER FAILS	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 3.6.b. STATES THAT GEARING SHOULD BE ENCLOSED, SUCH THAT COMPONENT FAILURE WILL INCREASE THE PROBABILITY OF MAINTAINING THE MESH BETWEEN GEARS.	PER DRAWING D2153-M01, THE GEARS ARE SHOWN TO BE ENCLOSED.	AO - UNLIKELY
(G12) - GEAR TRAIN COMPONENTS FAIL DURING CRANE OPERATIONS	(E36) - ROPE DRUM GEAR FAILS	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 3.6.b. STATES THAT GEARING SHOULD BE ENCLOSED, SUCH THAT COMPONENT FAILURE WILL INCREASE THE PROBABILITY OF MAINTAINING THE MESH BETWEEN GEARS.	PER DRAWING, THIS HAZARD IS CONTROLLED BY THE ADDITION OF THE EMERGENCY BRAKE	AO - UNLIKELY
(G12) - GEAR TRAIN COMPONENTS FAIL DURING CRANE OPERATIONS	(E40) - ROPE DRUM GEAR PINION FAILS	(G1) - LOSS OF FLIGHT HARDWARE DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 3.6.b. STATES THAT GEARING SHOULD BE ENCLOSED, SUCH THAT COMPONENT FAILURE WILL INCREASE THE PROBABILITY OF MAINTAINING THE MESH BETWEEN GEARS.	PER DRAWING, THIS HAZARD IS CONTROLLED BY THE ADDITION OF THE EMERGENCY BRAKE	AO - UNLIKELY

SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET

SAA88CR000-041

MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS

SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB

EFFECTIVITY: ALL FLIGHTS

ENGINEER: W.D. Valentino

DATE: 10 April, 1992

SHEET: 10 OF 15

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G9) - BRIDGE/TROLLEY COMMANDED INTO STRUCTURE	(G6) - STOP SWITCHES NOT ACTIVATED	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	SEE (G6) ABOVE (PAGE 6)	SEE (G6) ABOVE	Ao - UNLIKELY
(G9) - BRIDGE/TROLLEY COMMANDED INTO STRUCTURE	(G10) - INAPPROPRIATE BRIDGE/TROLLEY DIRECTIONAL COMMAND	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G10) BELOW (PAGE 11)	DEVELOPED UNDER (G10) BELOW	Ao - UNLIKELY
(G9) - BRIDGE/TROLLEY COMMANDED INTO STRUCTURE	(E30) - BRIDGE/TROLLEY LIMIT SWITCHES FAIL	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	N55/GO 1740.9 PARA. 7.f. REQUIRES THAT THE ELECTRICAL CIRCUITRY BE FAIL-SAFE, SO THAT THE FAILURE OF ANY COMPONENT WILL NOT CAUSE THE CRANE TO OPERATE IN A SPEED RANGE FASTER THAN COMMANDED. ANY OPERATION IN THE ABSENCE OF A COMMAND WOULD VIOLATE THIS.	PER DRAWING D2153-M01, THE BRIDGE/TROLLEY LIMIT SWITCHES STOPS BRIDGE/TROLLEY MOVEMENT IN THE DIRECTION OF TRAVEL. MOTION IN THE REVERSE DIRECTION IS PERMITTED.	Ao - UNLIKELY

SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET

SAA NO: SAA88CR000-041

MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS  
SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB  
EFFECTIVITY: ALL FLIGHTS

ENGINEER: W.D. Valentino  
DATE: 20 October, 1993  
SHEET: 11 OF 15

HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G9) - BRIDGE/TROLLEY BRIDGES/COMMANDS INTO STRUCTURE	(E1) - BRIDGE/TROLLEY BRAKES FAIL (SEE FMEA MECH, PAGE 2 & 3)	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	PER CFR 29 1910.179 (f) (4) (vii), BRAKES FOR STOPPING TROLLEY OR BRIDGE SHALL BE OF SUFFICIENT SIZE TO STOP THE BRIDGE OR TROLLEY WITHIN THE DISTANCE SPECIFIED AT FULL SPEED WITH FULL LOAD.	PER 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, THE BRAKES SHOULD BE TESTED TO THIS CRITERIA.	Ad - UNLIKELY
(G10) - INAPPROPRIATE BRIDGE/TROLLEY DIRECTIONAL COMMAND	(E9) - OPERATOR FAILS TO RELEASE BRIDGE/TROLLEY DIRECTIONAL CONTROL SWITCH	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 2.6 REQUIRES A PERSONNEL CERTIFICATION PROGRAM, INCLUDING TRAINING AND LICENSING	PER 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, CONTAINS PROVISIONS FOR A PERSONNEL CERTIFICATION PROGRAM.	Ad - UNLIKELY
(G10) - INAPPROPRIATE BRIDGE/TROLLEY DIRECTIONAL COMMAND	(E10) - BRIDGE/TROLLEY CONTROL SWITCH/CIRCUITRY FAILS "ON" (ELEC FMEA, PAGE 3 & 4)	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	SEE (E30) ABOVE (PAGE 10)	PER DRAWING D2153-M01, THIS POTENTIAL HAZARD IS CONTROLLED BY THE STOP SWITCH AND THE EMERGENCY STOP SWITCHES.	Ad - UNLIKELY

SAA NO: SAA88CR000-041 MISSION PHASE: DELTA PAYLOAD GROUND OPERATIONS SYSTEM/SUBSYSTEM: 20-TON CRANE AT VAFB EFFECTIVITY: ALL FLIGHTS SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET ENGINEER: W.D. Valentino DATE: 10 April, 1992 SHEET: 12 OF 15						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G10) - INAPPROPRIATE BRIDGE/TROLLEY DIRECTIONAL COMMAND	(E11) - OPERATOR INADVERTANTLY SELECTS FAST SPEED	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 2.6 REQUIRES A PERSONNEL CERTIFICATION PROGRAM, INCLUDING TRAINING AND LICENSING	PER 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, CONTAINS PROVISIONS FOR A PERSONNEL CERTIFICATION PROGRAM.	AO - UNLIKELY
(G10) - INAPPROPRIATE BRIDGE/TROLLEY DIRECTIONAL COMMAND	(E12) - BRIDGE/TROLLEY SPEED CONTROL CIRCUITRY FAILS INTO FAST SPEED (SEE FMEA ELEC, PAGE 4 & 5)	(G8) - PAYLOAD COLLIDES WITH STRUCTURE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9 PARA. 7.4. REQUIRES THAT THE ELECTRICAL CIRCUITRY BE FAIL-SAFE, SO THAT THE FAILURE OF ANY COMPONENT WILL NOT CAUSE THE CRANE TO OPERATE IN A SPEED RANGE FASTER THAN COMMANDED. ANY OPERATION IN THE ABSENCE OF A COMMAND WOULD VIOLATE THIS.	PER DRAWING D2153-M01, THIS HAZARD IS CONTROLLED BY THE STOP SWITCH AND THE EMERGENCY STOP SWITCHES.	AO - UNLIKELY
(G15) - FIRE/EXPLOSION DURING CRANE OPERATIONS	(G16) - FIRE DUE TO FUELED PAYLOAD COLLIDING WITH STRUCTURE	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G16) BELOW (PAGE 13)	DEVELOPED UNDER (G16) BELOW	AO - UNLIKELY

SAA NO: SA88CR000-041      SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET MISSION PHASE:      DELTA PAYLOAD GROUND OPERATIONS SYSTEM/SUBSYSTEM:      20-TON CRANE AT VAFB EFFECTIVITY:      ALL FLIGHTS ENGINEER:      W.D. Valentino DATE:      10 April, 1992 SHEET:      13 OF 15						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G15) - FIRE/EXPLOSION DURING CRANE OPERATIONS	(G18) - FIRE DUE TO MECHANICAL FRICTION	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	DEVELOPED UNDER (G18) BELOW (PAGE 14)	DEVELOPED UNDER (G18) BELOW	Ac - UNLIKELY
(G15) - FIRE/EXPLOSION DURING CRANE OPERATIONS	(E24) - FIRE DUE TO ELECTRICAL FAILURE	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NSS/GO 1740.9, PARA. 7.a., b. AND c. REQUIRE COMPLIANCE WITH NFPA 70 (NATIONAL ELECTRIC CODE), NEMA EQUIPMENT ENCLOSURE SPECIFICATIONS AND NEC OVERLOAD PROTECTION. PARA 7.g. REQUIRES GROUNDING OF THE HOOK WHEN LIFTING EXPLOSIVES, FLAMMABLES, OR SOLID PROPELLANTS.	PER DRAWING D2153-M01, THE CRANE HAS OVERCURRENT PROTECTION, AND PROVISIONS FOR GROUNDING THE HOOK.	Ac - UNLIKELY
(G16) - FIRE DUE TO FUELED PAYLOAD COLLIDING WITH STRUCTURE	(E32) - PAYLOAD COLLIDES WITH STRUCTURE WITH SUFFICIENT FORCE TO INITIATE DETONATION	(G15) - FIRE/EXPLOSION DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	REFER TO (G2) ABOVE (PAGE 3)	REFER TO (G2) ABOVE	Ac - UNLIKELY

<p style="text-align: center;"><b>SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET</b></p>						
<p><b>SAA NO:</b> SAA88CR000-041</p>		<p><b>MISSION PHASE:</b> DELTA PAYLOAD GROUND OPERATIONS</p>		<p><b>ENGINEER:</b> W.D. Valentino</p>		
<p><b>SYSTEM/SUBSYSTEM:</b> 20-TON CRANE AT VAFB</p>		<p><b>ACTIVITY:</b> ALL FLIGHTS</p>		<p><b>DATE:</b> 10 April, 1992</p>		
				<p><b>SHEET:</b> 14 OF 15</p>		
<b>HAZARDOUS CONDITION</b>	<b>HAZARD CAUSE</b>	<b>HAZARD EFFECT</b>	<b>SEVERITY</b>	<b>SAFETY REQUIREMENTS</b>	<b>HAZARD ELIMINATION/CONTROL PROVISIONS</b>	<b>LIKELIHOOD OF OCCURRENCE</b>
(G18) FIRE DUE TO MECHANICAL FRICTION	(E28) - LACK OF LUBRICATION	(G15) - FIRE/EXPLOSION DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	PER CFR 29 1910.179 (f) (c) (11), DESIGN SHALL PROVIDE FOR MEANS OF LUBRICATING ALL MOVING PARTS THAT REQUIRE IT FOR OPERATION.	PER DRAWING D2153-M01, THE GEAR CASE IS DESIGNED OIL-TIGHT AND OUTFITTED FOR OIL MAINTENANCE.	Ao - UNLIKELY
(G18) FIRE DUE TO MECHANICAL FRICTION	(E29) - BRAKE SEIZES	(G15) - FIRE/EXPLOSION DURING CRANE OPERATIONS	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	PER CFR 29 1910.179 (f) (C) (11), THE BRAKES "...SHALL HAVE THE THERMAL CAPACITY FOR FREQUENCY OF OPERATION REQUIRED BY SERVICE."	PER DRAWING D2153-M01, THE CRANE IS EQUIPPED WITH TWO MAIN BRAKES, WHICH ARE EACH RATED AT 150% OF THE CRANE'S RATED LOAD	Ao - UNLIKELY
(G19) - LOSS OF PERSONNEL DURING CRANE OPERATIONS	(G15) FIRE/EXPLOSION DURING CRANE OPERATIONS	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	SEE (G15) ABOVE (PAGE 12)	SEE (G15) ABOVE	Ao - UNLIKELY
(G19) - LOSS OF PERSONNEL DURING CRANE OPERATIONS	(E17) - PERSONNEL STRUCK BY PAYLOAD OR HOOK DURING CRANE OPERATIONS	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	NES/GO 1740.9, PARA. 2.7 DEFINES REQUIREMENTS FOR CRANE OPERATIONS, INCLUDING THE ESTABLISHMENT OF SAFETY ZONES	PER, 79K32662, TEST REQUIREMENTS FOR VAFB CRANES, WILL ESTABLISH PROPER PROCEDURES FOR CRANE OPERATIONS	Ao - UNLIKELY

SPACE SHUTTLE SYSTEM HAZARD ANALYSIS (SHA) WORKSHEET						
SAA NO: SAA88CR000-041		DELTA PAYLOAD GROUND OPERATIONS				
MISSION PHASE:		20-TON CRANE AT VAYB				
SYSTEM/SUBSYSTEM:		ALL FLIGHTS				
EFFICIENCY:						
ENGINEER: W.D. Valentino						
DATE: 10 April, 1992						
SHEET: 15 OF 15						
HAZARDOUS CONDITION	HAZARD CAUSE	HAZARD EFFECT	SEVERITY	SAFETY REQUIREMENTS	HAZARD ELIMINATION/CONTROL PROVISIONS	LIKELIHOOD OF OCCURRENCE
(G19) - LOSS OF PERSONNEL DURING CRANE OPERATIONS	(E18) - ELECTRIC SHOCK TO PERSONNEL	(G0) - LOSS OF LIFE AND/OR FLIGHT HARDWARE	Cs: LOSS OF PERSONNEL, VEHICLE OR EQUIPMENT	N55/GO 1740.9, PARA. 7.4., REQUIRES THAT ELECTRICAL PORTIONS OF THE CRANE ARE DESIGNED IN ACCORDANCE WITH NFPA 70, AND CFR 29, SUBPART S, 1910.301-.399	PER DRAWING D2153-M01, ELECTRICAL PARTS ARE ENCLOSED, AND MEANS OF DISCONNECT COMPLY WITH THE STANDARDS.	As - UNLIKELY

NOTE: EVENT (E31) - "PAYLOAD FUELED WITH SHOCK-SENSITIVE FUEL" IS A "TRIGGER EVENT", ONE NORMALLY EXPECTED TO OCCUR. SINCE IT IS NOT A FAILURE, IT IS NOT ANALYZED.

## SECTION VII

### CONTROL LOGIC ANALYSIS

There are no LPS control/monitor functions associated with this system. No control logic analysis is therefore required.

## SECTION VIII

### EMERGENCY SAFING ANALYSIS

This system is not controlled by a computer control system. No emergency safing analysis is therefore required.

## SECTION IX

### SNEAK CIRCUIT ANALYSIS

Per KHB 5310.9, Appendix H, the methodology for the control of sneak circuits is not formally implemented in the design of this equipment. No sneak circuit analysis is therefore required.

SECTION X

END-TO-END ANALYSIS



Figure 10-1. End-to-End System Block Diagram

SECTION XI

AREAS OF CONCERN AND RECOMMENDATIONS

11.1 AREAS OF CONCERN

Currently the document 79K32662 Rev. A, "General Test Requirements for Critical Cranes Located At VAFB" does not contain the 20-Ton MST crane, thus no current test document exists for this crane.

11.2 RECOMMENDATIONS

Create a revision to 79K32662 which incorporates the MST 20-Ton Crane. Once this crane is incorporated into 79K32662, the Safety Hazard Analysis Worksheets will be updated to reflect the change.

ADDENDUM

At the request of GSFC, this addendum (prepared by NSI Technical Services) is being added to the completed/signed-off System Assurance Analysis covering the 20-Ton SLC-2 MST Crane. The System Assurance Analysis numbered SAA88CR000-041 is being re-released at the "A" revision level to reflect this change. The System Assurance Analysis will not be resubmitted for signature approval prior to the release.

Approved:  4/28/94  
S. Chan, NASM/GSFC Date  
Recertification Manager

ADDENDUM to SHA No. SAA88CR000-041, SYSTEM HAZARD ANALYSIS (SHA)

1

System: 20-Ton SIC-2W Crane at Vandenberg Air Force Base (VAFB)

Title: Operational Failure

Effect: Uncontrolled Movement of Load/Load Block

Severity: Catastrophic

HAZARD CAUSE:Status: Controlled

Slack in wire rope.

Requirement

- Acceptable replacement of wire rope
- NSS/GO-1740.9B, "NASA Safety Standard for Lifting Devices and Equipment," paragraph 206, "Operations,"
  - 206.a.(17) If there is a slack rope condition, it shall be determined that the rope is properly seated on the drum and in the sheaves before starting the hoist.
  - 206.a.(18) During hoisting, care shall be taken that there is no sudden acceleration or deceleration of the moving load and that the load does not contact any obstructions.
- 206.a.(1) General operating procedures describing crane operation, emergency steps, communication requirements, and special requirements including checklists and inspection requirements shall be prepared, approved, and followed for each crane. There must be a formal system for review, approval, and update to maintain valid operating procedures. Emergency procedures shall be developed for contingency actions such as power loss, brake failure, or other emergencies.
- NSS/GO-1740.9, Paragraph 203.a.
- Document technical operating procedures for the performance of daily and periodic safety inspections, including safety trip bar location/function. Inadequacies discovered during an inspection shall be documented and, if determined to be a

ADDENDUM to SHA No. SAA88CR000-041, SYSTEM HAZARD ANALYSIS (SHA)

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hazard, corrected prior to further use. Inspections shall be made by qualified designated personnel according to approved technical operating procedures.

- Perform Daily, Monthly, and Periodic Inspections in accordance with the requirements of Paragraph Nos. 203.d, 203.e.(2), and 203.e.(1), respectively of NSS/GO-1740.9B.
- OSHA 29 CFR 1910.179(j) "Inspection"

Inspect for defects in accordance with Part 1910, section (j)(2) Frequent inspection and (j)(3) Periodic inspection.

Control

- ACD DCI 468, Handling, Installation and Acceptance Test Procedure for Replacement Crane Hoist Line. Identify the appropriate procedural steps by number and provide the date of activity completion. The replacement of the crane hoist line shall be performed by certified/qualified personnel and/or the manufacturer's representative.

Handling, Installation, and Acceptance Test for Replacement Crane Hoist Line were in accordance with hoist rope manufacturer's representative's instructions and procedures have been documented.

- Locate an operator in the Drum Room during all crane operations. The operator shall be equipped with a radio to communicate with the crane operator. Provide a procedural reference and identify the appropriate steps.

The location of an E-Stop operator with a radio in the Drum Room during all crane operations is in place.

- Specific Procedure for each task, "Operating Procedure for SLC-2W 20-Ton Crane." Specify procedural steps for loaded and unloaded hook operation, including emergency procedures addressing:
  - Twisted multiple part ropes;
  - Slack rope condition, i.e., the rope is not properly seated on the drum and in the sheaves; and,
  - Sudden acceleration or deceleration of the moving load block.
- Install a safety trip bar, positioned to shut down the hoisting operation, to be activated by drum rope overlay.

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The safety trip bar has been confirmed to be positioned 1/4 to 3/8" above the rope and has been verified to activate the brakes when displaced.

Verification: Test/Inspection

- ACD DCI 468, "Handling, Installation and Acceptance Test Procedure for Replacement Crane Hoist Line."
- Organizational element responsible for crane inspection or QA verify that the safety trip bar is positioned at a specified distance to cause hoisting shut down at trip bar displacement.
- Perform technical operating procedure for Daily, Monthly, and Periodic safety inspections, including verification of safety trip bar location and operation.

Risk Assessment

Likelihood of Occurrence: Remote

Severity Level: Catastrophic

Risk Classification: Acceptable Risk (Uncertainties  
Controlled/Managed)

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HAZARD CAUSEStatus: Controlled

Loading the crane beyond its rated capacity/maintaining the minimum safety factor.

Requirement

- NSS/GO-1740.9B, Paragraph 206, "Operations"
  - 206.a.(4) A crane shall not be loaded beyond its rated load (capacity) except for required testing.
- NSS/GO-1740.9B, Paragraph 805.a.(11)

The minimum design load safety factor for wire rope, based on ultimate material strength, shall be equal to 5.
- NSS/GO-1740.9B, Paragraph 203.e
- Perform Daily, Monthly, and Periodic Inspections in accordance with the requirements of Paragraph Nos. 203.d, 203.e.(2), and 203.e.(1), respectively of NSS/GO-1740.9B.
- OSHA 29 CFR 1910.179(j) "Inspection"

Inspect for defects in accordance with Part 1910, section (j)(2) Frequent inspection and (j)(3) Periodic inspection.
- NSS/GO-1740.9B, Paragraph 203.g

Inspection Reports. After each periodic inspection, qualified, authorized personnel shall prepare written, dated, and signed inspection reports. These reports shall include procedure reference and adequacy of the crane/crane components. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and be made readily available by the organizational element responsible for crane inspection.
- OSHA 1910.179(k) - (1) Size of load. The crane shall not be loaded beyond its rated load except for test purposes as provided in paragraph (k) of this section...(Rated Load Test).
- CMAA Specification #70, Revised 1988, "Specification for Electric Overhead Traveling Cranes."

- 1.6.1 The rated capacity of a crane is specified by the manufacturer. This capacity shall be marked on each side of the crane and shall be legible from the operating floor.

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Control

- Specific Procedure for each task, "Operating Procedure for SLC-2W 20-Ton Crane." Procedural steps specify loaded and unloaded hook operation.
- New wire rope analyzed by the manufacturer to verify the adequacy of a minimum 5:1 rope safety factor was maintained.

The replacement rope manufacturer has stated that the minimum design load safety factor is greater than five.

- ACD DCI 468, Periodic Inspection Procedure for SLC-2W, 20-Ton Crane. Perform Periodic inspection.
- Specific Inspection Procedure and Criteria for All Sheaves and Hoisting Rope, Document No. ACD DCI 468, Section 1. Sheaves and hoisting rope are inspected.

The hook block counterweight is considered, by the crane manufacturer, as an integral part of the hook block. The added counterweight does not adversely impact the manufacturer's rated capacity.

Verification

Organizational element responsible for crane inspection or QA verifies the performance of Periodic test and inspection of SLC-2W, 20-Ton Crane, including written, dated, and signed inspection reports, prior to operation.

Risk Assessment

Likelihood of Occurrence: Remote  
Severity Level: Catastrophic  
Risk Classification: Acceptable Risk (Uncertainties  
Controlled/Managed)

ADDENDUM to SHA No. SAA88CR000-041, SYSTEM HAZARD ANALYSIS (SHA)

6

HAZARD CAUSE

Status: Controlled

Excessive block rotation post wire rope replacement and/or excessive reduction of nominal diameter.

Requirement

- Manufacturer's calculation of wire rope Torque Factor were based on an acceptable block rotation  $\leq 30^\circ$ .
- Manufacturer's permissible constructional stretch is equal to 0.01%.
- NSS/GO-1740.9B, Paragraph 204.c.(3),(a) through (g)
  - (3) The need to replace wire rope shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results.

Criteria for rope replacement due to reduction of nominal diameter shall be in accordance with the requirements of Paragraph 204.c.(3).(g). Note that in addition to reduction of rope diameter, other types of rope deterioration such as broken wires, severe corrosion, etc., are grounds for rope replacement.

- NSS/GO-1740.9B, Paragraph 202.a

Proof Load Test. Before first use and after installation, all new, extensively repaired, extensively modified, or altered cranes shall undergo a proof load test with a dummy load as close as possible to, but not exceeding 1.25 times the rated capacity of the crane. A proof load test also should be performed when there is a question in design or previous testing. The load shall be lifted slowly and in an area where minimal damage will occur if the crane fails. The load rating of the crane shall be clearly marked to be legible from the operator's or user's position and shall not be more than the proof test weight divided by 1.25.

- NSS/GO-1740.9B, Paragraph 203.b

All new, extensively repaired, or modified cranes shall be given a daily and a periodic inspection prior to first use. For component repair on cranes, only the inspections that apply to the repaired portion need to be performed prior to first use unless a periodic inspection interval expires during the downtime.

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- Perform Daily, Monthly, and Periodic inspections in accordance with the requirements of Paragraph Nos. 203.d, 203.e.(2), and 203.e.(1), respectively of NSS/GO-1740.9B.
- OSHA 29 CFR 1910.179 (j) Inspection  
Inspect for defects in accordance with Part 1910, section (j)(2) Frequent inspection and (j)(3) Periodic inspection.

Control

- 79K32662, Test Requirements for VAFB Cranes, specifies proper proof testing and maintenance schedules.

The rope manufacturer's representative approved and was present during handling, installation, acceptance testing, and proof testing of the replacement crane hoist line. Tag line personnel shall be required to assure that multiple part ropes are not twisted around each other.

Verification

- Organizational element responsible for crane inspection or QA verifies performance of Proof Load Test.
- Periodic inspection, to include but not be limited to the repaired portion of the crane, prior to operation. Various methods of nondestructive examination such as ultrasonics, x-ray, magnetic particle, dye penetrant, etc., shall be used as needed. A post inspection report shall be written, dated and signed. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use.

Risk Assessment

Likelihood of Occurrence: Remote  
Severity Level: Catastrophic  
Risk Classification: Acceptable Risk (Uncertainties Controlled/Managed)

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HAZARD CAUSE

Status: Controlled

Excessive friction at bearings and sheaves.

Requirement

- NSS/GO-1740.9B, Paragraph numbers 203.d, 203.e.(b)
  - d. Daily Inspections. These inspections shall be performed by the certified operator prior to first use each day the crane is used, and shall include the following:
    - (1) Check functional operating and control mechanisms for maladjustments that could interfere with normal operations.
  - e.(b) Cracked or worn sheaves and drums.

Control

- ACD DCI 468, Periodic Inspection Procedure for SLC-2W, 20-Ton Crane. Periodic inspection is performed.

Verification

Organizational element responsible for crane inspection or QA verifies the performance of Periodic test and inspection of SLC-2W, 20-Ton Crane, including written, dated and signed inspection reports. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use.

Risk Acceptance

Likelihood of Occurrence: Remote

Severity Level: Catastrophic

Risk Classification: Acceptable Risk (Uncertainties  
Controlled/Managed

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9

HAZARD CAUSE

Status: Controlled

Improper rope installation

Requirement

- OSHA 1910.179(j) Initial Inspection. Prior to initial use, all new and altered cranes shall be inspected to insure compliance with the provision of section (j).
- NSS/GO-1740.9B, Paragraph 204.C.(3)(h). If replaced, the new rope shall be proof load tested using the associated crane proof load value.
- Perform Daily, Monthly, and Periodic inspections in accordance with the requirements of Paragraph Nos. 203.d, 203.e.(2), and 203.e.(1), respectively of NSS/GO-1740.9B.
- OSHA 29 CFR 1910.179 (j) Inspection  
Inspect for defects in accordance with Part 1910, section (j)(2) Frequent inspection and (j)(3) Periodic inspection.
- ACD DCI 468, Frequent Inspection Procedure for SLC-2W, 20-Ton Crane.

Control

- ACD DCI 468, Periodic Inspection Procedure for SLC-2W, 20-Ton Crane. Periodic inspection is performed.
- ACD DCI 468, Specific Inspection Procedure and Criteria for All Sheaves and Hoisting Rope. Sheaves and hoisting rope are inspected.
- ACD DCI 468, Handling, Installation and Acceptance Test Procedure for Replacement Crane Hoist Line. Replacement and Acceptance Testing is performed.

Verification

- Organizational element responsible for crane inspection or QA verifies the performance of Periodic test and inspection of SLC-2W, 20-Ton Crane, including written, dated and signed inspection reports. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use.

The rope manufacturer's representative approved and was present during handling, installation, acceptance testing, and proof testing of the replacement crane hoist line.

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Risk Assessment

Likelihood of Occurrence: Remote

Severity Level: Catastrophic

Risk Classification: Acceptable Risk (Uncertainties  
Controlled/Managed)

ADDENDUM to SHA No. SAA88CR000-041, SYSTEM HAZARD ANALYSIS (SHA)

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HAZARD CAUSE

Status: Controlled

Wire rope corrosion, abrasion, loss of lubricant.

Requirement

- NSS/GO-1740.9B, Paragraph 204.C.(3)(f).
  - (3) The need to replace wire rope shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results. Any of the following signs of deterioration and damage are sufficient reasons for questioning continued use of the rope:
    - (f) Corrosion (internal or external) that results in reduction of rope diameter, or at end connectors.
- Perform Daily, Monthly, and Periodic inspections in accordance with the requirements of Paragraph Nos. 203.d, 203.e.(2), and 203.e.(1), respectively of NSS/GO-1740.9B.
- OSHA 29 CFR 1910.179 (j) Inspection  
Inspect for defects in accordance with Part 1910, section (j)(2) Frequent inspection and (j)(3) Periodic inspection.
- NSS/GO-1740.9B, Paragraph 203.e  
Periodic Inspections. These inspections shall be performed at varying intervals, depending on activity, severity of service, environment, and criticality.
- NSS/GO-1740.9B, Paragraph 203.g.  
Inspection Reports. After each periodic inspection, qualified, authorized personnel shall prepare written, dated, and signed inspection reports. These reports shall include procedure reference and adequacy of the crane/crane components. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and be made readily available by the organizational element responsible for crane inspection.

Control

- ACD DCI 468, Periodic Inspection Procedure for SLC-2W, 20-Ton Crane. Periodic inspection is performed.

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- Inspect rope on a monthly basis and lubricate as required to prevent corrosion.

Verification

- Organizational element responsible for crane inspection or QA verifies the performance of Periodic test and inspection of SLC-2w, 20-Ton Crane, including written, dated and signed inspection reports.

Risk Assessment

Likelihood of Occurrence: Remote

Severity Level: Catastrophic

Risk Classification: Acceptable Risk (Uncertainties  
Controlled/Managed)