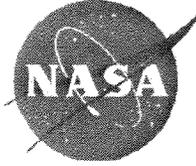


MANTECH

Document # 44-01-749



WALLOPS ISLAND FACILITY

AMERICA EQUIPMENT INC 3 TON

RADIO REMOTE CONTROL BRIDGE CRANE

HOIST SERIAL NUMBER 11524

FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

MANTECH DOCUMENT NUMBER

44-01-749

AUGUST 2004

REVIEWED BY: _____
M.J. MEIER, ENGINEER, MANTECH DATE

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Recert Function

ManTech International Corporation

Wallops Flight Facility

Wallops Island, VA 23337

Welcome to the FMEA Worksheet

This spreadsheet can be used to

1. Identify potential failure modes and their impact on product reliability.
2. Rank the potential defects to establish priority - The highest RPN value items deserve the most attention.
3. Capture owners, action plans, and status on high RPN items.

Note, FMEA's are living documents and this may be updated periodically.

Organization of Spreadsheet:

Descriptions - explains the spreadsheet cells

FMEA - the actual sheet used to enter data

Severity/Likelihood/Detectability - guidelines for the 1-10 rankings in these categories

Example - a partial example of an FMEA document

Sheet Protection:

Some sheets are protected. There is no password.

Released for review: 31-Jul-98

A. Dembski rev 1

Descriptions

Description of FMEA Worksheet

Protection: The spreadsheets are not protected or locked.

System _____
 Subsystem _____
 Component _____
 Design Lead _____
 Core Team _____

**Potential
 Failure Mode and Effects Analysis
 (Design FMEA)**

Key Date _____

FMEA Number _____
 Prepared By _____
 FMEA Date _____
 Revision Date _____
 Page _____ of _____

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	P r o b	Current Design Controls	D e t	R P N	Recommended Action(s)	Responsibility & Target Completion Date	Action Results				
											Actions Taken	New Sev	New Occ	New Det	New RPN
Coolant containment. Hose connection. Coolant fill. M	Crack/break. Burst. Side wall flex. Bad seal. Poor hose rete	Leak	8	Over pressure	8	Burst, validation pressure cycle.	1	64	Test included in prototype and production validation testing.	J.P. Aguire 11/1/95 E. Eglin 8/1/96					
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">Write down each failure mode and potential consequence(s) of that failure.</div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> Severity - On a scale of 1-10, rate the Severity of each failure (10= most severe). See Severity sheet. </div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> Likelihood - Write down the potential cause(s), and on a scale of 1-10, rate the Likelihood of each failure (10= most likely). See </div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> Detectability - Examine the current design, then, on a scale of 1-10, rate the Detectability of each failure (10 = least detectable). See Detectability sheet. </div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> Risk Priority Number - The combined weighting of Severity, Likelihood, and Detectability. RPN = Sev X Occ X Det </div> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">Response Plans and Tracking</div>															

System Design Verification Process
 Subsystem _____
 Component _____
 Design Lead Houston Mayer
 Core Team See Project III R1 Report

**Potential
 Failure Mode and Effects Analysis
 (Design FMEA)**

Key Date _____

FMEA Number Project III
 Prepared By Houston Mayer
 FMEA Date 10/22/1999
 Revision Date 8/21/2000
 Page 1 of 6

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	P r o b	Current Design Controls	D e t	R P N	Recommended Action(s)	Responsibility & Target Completion Date	Action Results			
											Actions Taken	New Sev	New Occ	New Det
Customer sends in a quote request for product.	System, Software, Integration and Shipping requirements overlooked by customer	Customer needs not fully met by delivered system.	7	Human error	1	Design configuration tool.	3	21	Use configuration tool when available.	Closed 10/21/99				
Requirement entered and verified by Inside Sales in config. tool.	Data entry error	System compatability requirements not evaluated by config. tool.	3	Human error	1	Order verified by a configuration tool.	3	9	Continue order verification by configuration tool.	Closed 10/21/99				
Sales identifies need for CII or SHC	Specific packing, labeling and shipping requirements may not be fully addressed.	On time delivery and integrity of the product may be compromised if this issue is not addressed.	7	Requirements Overlooked.	3	Customer Inspection Instruction/ Special Handling Codes Process 033-001-02	3	63	Publish comprehensive procedure for the 1st Article Process.	Jun-00	Customer shipping requirements reviewed by quality assurance in 1st Article process			
	Position of the DHR in ICD label packet not identified by GE. Requirement in Purchase Specification for mousepad, but not identified on Bill of Material. ICD Card content requirements not identified in Build Procedure.	Loss of business with the customer.	1	Requirements Overlooked.	5	CII 033-001-006	1	5	Revisit contents of GE CII 033-001-006 to assure all requirements are clearly communicated to the warehouse operators and quality technicians using these documents.	Sep-00	OPEN 8/21/00			

QA and Pack and Ship Team reviews customer requirements during a 1st Article.	Specific packing labeling and shipping requirements may not be fully addressed.	Customer's full expectations may not be realized.	7	Requirements overlooked.	3	Customer requirements physically verified by quality assurance during the 1st Article process.	3	63	Continue current practices.	Closed 10/25/99					
Inside sales submits Sales Order Authorization request to TECenter.	Data entry error	Order Processing Delay	1	Human Error	1	Customer requirements verified by a TECenter engineer.	3	3	Continue current practices.	Closed 1/25/00					
TECenter Engineer reviews the design to determine if additional data is required.	Requirements overlooked by Engineer	Customer's full expectations may not be realized.	3	Requirements Overlooked.	6	Customer requirements verified by a TECenter engineer.	3	54	Continue current practices.	Closed 10/25/99					
Appropriate individuals are contacted to resolve issues.	Appropriate individuals not available.	Order Processing Delay	1	Process Failure	1	Individuals are contacted to resolve issues.	1	1	Continue current practices.	Closed 1/25/00					
Design Review is completed.	Requirements may not be complete	Customer's full expectations may not be realized.	1	Process Failure	1	Customer requirements verified by a TECenter engineer.	1	1	Continue current practices.	Closed 1/25/00					
Another engineer performs quality check of the design.	Requirements overlooked by two Engineer	Customer's full expectations may not be realized.	7	Process Failure	3	Customer requirements verified by a TECenter engineer.	3	63	Continue current practices.	Closed 10/25/99					
Completed design verification is sent to appropriate	Design verification misrouted	Order Processing Delay	1	Process Failure	1	Verification is sent to appropriate organization.	1	1	Continue current practices.	Closed 1/25/00					
Requirements are defined and capability to meet/ accept requirements.	Requirements may be missed or capability to meet overestimated	Customer's full expectations may not be realized.	1	Process Failure	1	Requirements are defined and to meet requirements.	1	1	Continue current practices.	Closed 1/25/00					

Inside Sales quotes price and availability	Wrong price and availability provided to customer	Customer's full expectations may not be realized.	3	Process Failure	1	Price provided to customer	1	3	Continue current practices.	Closed 1/25/00					
Customer sends in purchase order	Order misrouted	Order Processing Delay	1	Process Failure	1	Reprocess Order	1	1	Continue current practices.	Closed 1/27/00					
Inside sales places order on system.	Data Entry Error	Order Processing Delay	3	Human Error	1	Reprocess Order	1	3	Continue current practices.	Closed 1/27/00					
Order approved by Asset Management.	Approval not timely	Order Processing Delay	1	Process Failure	1	Expedite Process	1	1	Continue current practices.	Closed 1/27/00					
Order approved by credit.	Approval not timely	Order Processing Delay	1	Process Failure	1	Expedite Process	1	1	Continue current practices.	Closed 1/27/00					
Determination made that product is available for build.	All product required for the order may not be available at the start of the build.	(1) Product delivery date requirements may not be met. (2) Workspace occupied for an order awaiting Product is not available for integration of other orders.	5	Needed components are not available at the time of need.	3	Assure product availability before the order commitment is given to customer.	1	15	Continue current practices.	Closed 10/25/99					
Inside sales expedites with Asset to provide ship date.	Shipdates may not be accurate	Customer's full expectations may not be realized.	1	Needed components are not available at the time of need.	1	Expedite Process	1	1	Continue current practices.	Closed 1/27/00					
Order approved by Asset Mgmt. and e-mail sent to Integration.	e-mail may be misrouted	Order Processing Delay	1	Process Failure	1	Expedite Process	1	1	Continue current practices.	Closed 1/27/00					
Project Manager reviews order for special or internal instructions.	Order processing requirements may be overlooked	Customer and processing needs not identified could prevent timely processing of the order.	3	Processing requirements overlooked.	1	Project Manager order review.	1	3	Continue current practices.	Closed 10/25/99					

Build document bill of material matched with SCN.	Documents do not match	Order Processing Delay	5	Needed components are not available at the time of need.	3	Expedite Process Integration Center Operations Manual 093-009 OPSMNL	3	45	Continue current practices.	Closed 1/27/00						
Stock availability is checked and delivery dates are acquired for non stock items	stock availability and dates may be inaccurate	Customer's full expectations may not be realized.	3	Needed components are not available at the time of need.	1	Expedite Process	1	3	Continue current practices.	Closed 1/27/00						
Order is forwarded to Production Engineer for	Order may be misrouted	Order Processing Delay	1	Process Failure	1	Expedite Process	1	1	Continue current practices.	Continue current practices.						
Determination made for a 1st Article build.	Need for 1st build may be overlooked	Customer's full expectations may not be	7	Requirements Overlooked.	3	Individuals are contacted to resolve issues.	5	105	Continue current practices.	Continue current practices.						
Build document is reviewed and verified.	Requirements may be overlooked	Customer's full expectations may not be	3	Requirements Overlooked.	3	Individuals are contacted to resolve issues.	3	27	Continue current practices.	Continue current practices.						
Project management notifies sales with status of	Sales may not receive order status	Order Processing Delay	3	Requirements Overlooked.	1	Individuals are contacted to resolve issues.	1	3	Continue current practices.	Continue current practices.						
Asset management places order for non stock items.	Items may not be ordered	Order Processing Delay	3	Needed components are not available at the time of need.	1	Expedite Process	1	3	Continue current practices.	Closed 1/27/00						
Order is scheduled for production.	Order may not be entered in schedule	Order Processing Delay	3	Requirements Overlooked.	1	Individuals are contacted to resolve issues.	1	3	Continue current practices.	Closed 1/27/00						
Whse Operator reviews parts to SOA & SCN.	Parts may not match requirement	Order Processing Delay	3	Requirements Overlooked.	3	Individuals are contacted to resolve issues.	1	9	Continue current practices.	Closed 1/27/00						
Whse. Operator Unpack, inspect & Kit order.	All parts may not reach integration	Order Processing Delay	3	All components are not available at the time of need.	3	Individuals are contacted to resolve issues. Integration Kitting and Packing 153-001-01	3	27	Continue current practices.	Closed 1/27/00						

Techs. Check product against SOW and build instructions.	Parts may not match requirement	Order Processing Delay	5	All components are not available at the time of need.	3	Individuals are contacted to resolve issues.	1	15	Continue current practices.	Closed 1/27/00					
Integration Techs. inspect parts and chassis.	Materials may not be compliant	Order Processing Delay	7	All components are not available at the time of need.	3	QA Inspection and Test Procedure 103-001-03	3	63	Continue current practices.	Closed 1/27/00					
	No NT Resource Kit Missing Video Board	Loss of business with the customer.	1	Requirements Overlooked.	1	QA Inspection and Test Procedure 103-001-03	5	5	Update Build Procedures to clearly define product requirements specific to the model being integrated.	Closed 8/21/00					
Techs. Integrate & Power-Up System	System may be integrated incorrectly	Order Processing Delay	7	Individuals are contacted to resolve issues.	7	QA Inspection and Test Procedure 103-001-03	3	147	Continue current practices.	Closed 1/27/00					
Integration Techs. Test system.	System and parts may not be compliant	Order Processing Delay	10	Needed components are not available at the time of need.	10	QA Inspection and Test Procedure 103-001-03	1	100	Continue current practices.	Closed 1/27/00					
Quality techs. inspect product for build requirements.	Specific build requirements may not be fully addressed.	On time delivery and integrity of the product may be compromised if this issue is not addressed.	5	Requirements Overlooked.	1	Individuals are contacted to resolve issues.	5	25	Continue current practices.						

	IO panel not installed Label on CPU Incorrect No feet or other components installed No extension cables Missing cables IO panel gasket not installed Wrong ICD cards provided Dome calibrator included	Loss of business with the customer.	1	Human Error	5	Build Procedure for individual PathSpeed Model	5	25	Update Build Procedures to clearly define product requirements specific to the model being integrated.	Closed 8/21/00					
Product serial numbers scanned into	Numbers may be incorrect	Order Processing Delay	3	Requirements Overlooked.	3	Individuals are contacted to resolve issues.	1	9	Continue current practices.	Closed 1/27/00					
Change made after batch release	Control of requirements may be lost	Order Processing Delay	1	Requirements Overlooked.	1	Individuals are contacted to resolve issues.	1	1	Continue current practices.	Closed 1/27/00					
Order placed on hold when change is made.	Shipping deadlines may not be met	Order Processing Delay	3	Requirements Overlooked.	3	Individuals are contacted to resolve issues.	1	9	Continue current practices.	Closed 1/27/00					
Design Process reinitiates	Control of requirements may not be	Order Processing Delay	3	Process Failure	1	Individuals are contacted to resolve issues.	1	3	Continue current practices.	Closed 1/27/00					
Whse. invoices and ships order per customer's shipping method.	Wrong Shipping method may be used	On time delivery and integrity of the product may be compramisid if this issue is not addressed.	7	Process Failure	1	Individuals are contacted to resolve issues.	1	7	Continue current practices.	Closed 1/27/00					
Quality techs. inspect shipment for CII/SHC requirements.	Specific packing labeling and shipping requirements may not be fully addressed.	On time delivery and integrity of the product may be compramisid if this issue is not addressed.	10	Requirements Overlooked.	3	Customer Inspection Instruction/ Special Handling Codes Process 033-001-02	3	90	Continue current practices.	Closed 1/25/00					

	Label on outside of box did not match S/N on CPU.	Loss of business with the customer.	1	Human Error	3	CII 033-001-006	3	9	Revisit contents of GE CII 033-001-006 to assure all requirements are clearly communicated to the warehouse operators and quality technicians	9/11/2000					
Product ships to customer.	Products misshipped	On time delivery and integrity of the product may be compramisid if this issue is not addressed.	7	Needed components are not available at the time of need.	3	Individuals are contacted to resolve issues.	7	147	Continue current practices.	Closed 1/27/00					
Coordinator closes project & files quality records.	Documents not filed correctly	Documents may not be retrievable	3	Documents may not be retrievable	1	Individuals are contacted to resolve issues.	1	3	Continue current pracices.	Closed 1/25/00					

Severity

Effect	SEVERITY of Effect	Ranking
Hazardous without warning	Very high severity ranking when a potential failure mode affects safe system operation without warning	10
Hazardous with warning	Very high severity ranking when a potential failure mode affects safe system operation with warning	9
Very High	System inoperable with destructive failure without compromising safety	8
High	System inoperable with equipment damage	7
Moderate	System inoperable with minor damage	6
Low	System inoperable without damage	5
Very Low	System operable with significant degradation of performance	4
Minor	System operable with some degradation of performance	3
Very Minor	System operable with minimal interference	2
None	No effect	1

Probability

PROBABILITY of Failure	Failure Prob	Ranking
Very High: Failure is almost inevitable	>1 in 2	10
	1 in 3	9
High: Repeated failures	1 in 8	8
	1 in 20	7
Moderate: Occasional failures	1 in 80	6
	1 in 400	5
	1 in 2,000	4
Low: Relatively few failures	1 in 15,000	3
	1 in 150,000	2
Remote: Failure is unlikely	<1 in 1,500,000	1

Detectability

Detection	Likelihood of DETECTION by Design Control	Ranking
Absolute Uncertainty	Design control cannot detect potential cause/mechanism and subsequent failure mode	10
Very Remote	Very remote chance the design control will detect potential cause/mechanism and subsequent failure mode	9
Remote	Remote chance the design control will detect potential cause/mechanism and subsequent failure mode	8
Very Low	Very low chance the design control will detect potential cause/mechanism and subsequent failure mode	7
Low	Low chance the design control will detect potential cause/mechanism and subsequent failure mode	6
Moderate	Moderate chance the design control will detect potential cause/mechanism and subsequent failure mode	5
Moderately High	Moderately High chance the design control will detect potential cause/mechanism and subsequent failure mode	4
High	High chance the design control will detect potential cause/mechanism and subsequent failure mode	3
Very High	Very high chance the design control will detect potential cause/mechanism and subsequent failure mode	2
Almost Certain	Design control will detect potential cause/mechanism and subsequent failure mode	1

System NASA 5 Ton Crane
 Subsystem _____
 Component 5 Ton TRDG Crane
 Design Lead Jared Rea
 Core Team _____

Failure Mode and Effects Analysis

Key Date _____

FMEA Number 1
 Prepared By Jared Rea
 FMEA Date 8/12/2003
 Revision Date _____
 Page 1 of 20

Item	Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	P r o b	Current Controls	D e t	R P N	Recommended Action(s)	Responsibility & Target Completion Date	Action Results				
												Actions Taken	New Sev	New Occ	New Det	New RPN
1	Mechanical Failure A. Hoist B. trolley C. Bridge	A. Hook (Not Including Lifting Tooling)	Loss of human life & or flight hardware	10	Overload	5	Planning, Known Loads, Design SF, Hooks Labeled	1	50							
2				10	Improper Setup	3	Operator Training, Safety Pin, Design SF, Hooks Labeled	2	60							
3				10	Improper Use	1	Operator Training, Operator Awareness/Daily Checklist, Annual NDT, Hooks Labeled	2	20							
4				10	Fatigue	1	Operator Awareness/Daily Checklist, Design SF, Annual NDT, PM (Visual)	1	10							
5		A) Wire rope	Loss of human life & or flight hardware	10	Overload	1	Known loads, hoist overload device, vendor certification, rigging plan	1	10	Create load charts, load test overload device, write rigging plan	Plant operations Nov 2003					
6				10	Incorrect reeving/setup	1	Load test, Inspection after rope change	1	10	Maintenance training						
7				10	Improper Use	3	Operator Training, Planning, Operator Awareness/Daily Checklist	2	60							

8				10	Wear	1	Operator Training, Operator Awareness/Daily Checklist, PM	1	10	Crane Inspector Training							
9				10	Improper Lubrication	1	PM	1	10	Crane Inspector Training							
10				10	Spooling Error	4	Operator Training	5	200	Operator training							
11				10	Wear/Failed Grooves	1	Operator Awareness/Daily Checklist, PM, Design SF	1	10	Crane Inspector Training							
12				10	Rope Damage	3	Operator Training, Operator Awareness/Daily Checklist, PM	2	60	Additional Operator Training, Crane Inspector Training							
13		A) Sheaves	Loss of human life & or flight hardware	10	Overload	1	Planning, Known Loads, Design SF	1	10								
14				10	Improper Setup	1	Load Test, Maintenance Training/Manuals, Keeper Plate	1	10	Maintenance Training							
15				10	Improper Use	1	Operator Training, Operator Awareness/Daily Checklist	2	20								
16				10	Misalignment	1	Maintenance Training/Manual, Vendor Certification	1	10	Maintenance Training							
17				10	Improper Lubrication	3	PM	3	90	Crane Inspector Training							
18				10	Failed Locknut	1	Operator Awareness/Daily Checklist, PM	1	10	Crane Inspector Training							
19				10	Wear/Fatigue	1	Operator Awareness/Daily Checklist, PM (Wear), Design SF	1	10	Crane Inspector Training							
20		A) Lower Block, or Upper Block	Loss of human life & or flight hardware	10	Overload	1	Planning, Known Loads, Design SF	1	10								

21				10	Failed Bearings	3	Redundant with Sheave Pin, Design SF, PM (Noise)	1	30	Crane Inspector Training								
22				10	Failed Bolts	1	Safety Pin, Design SF, Annual Torque Check with Load Test, PM	4	40	Crane Inspector Training								
23				10	Failed Sheave Pin	1	Operator Awareness/Daily Checklist, PM, Design SF	4	40	Crane Inspector Training								
24				10	Failed Safety Pin	1	Operator Awareness/Daily Checklist, PM, Bolt Torque	2	20	Crane Inspector Training								
25				10	Block Structure Failure	1	Operator Awareness/Daily Checklist, Design Sf, Load Test, Known Loads, Weigh System, Planning, PM	1	10	Crane Inspector Training								
26				10	Two Blocking	5	Operator Training, Operator Awareness/Daily Checklist, Power Limit Switch and Geared Limit Switches	1	50									
27		A) Drum	Loss of human life & or flight hardware	10	Overload	1	Overload Control in VFD, Planning, Known Loads, Design SF	1	10									
28				10	Improper Setup	1	Load Test, Vendor Certification	1	10									
29				10	Improper Use	1	Operator Training, Operator Awareness/Daily Checklist, Planning	1	10									
30				10	Failed Bearings	3	Redundant with Saddle, Design SF, PM	2	60									

31				10	Failed Drum Shaft	1	Load Test, Design SF, Vendor Certification	8	80									
32	A) Hoist Gear box	Loss of human life & or flight hardware		10	Overload	1	Overload Control in VFD, Planning, Known Loads, Design SF	1	10									
33				10	Improper Setup	1	Load Test, Vendor Certification	1	10									
34				10	Improper Use/Shock Loads	1	Operator Training, Operator Awareness/Daily Checklist, Planning	1	10	Additional Operator Training								
35				10	Contamination	3	PM	2	60	Crane Inspector Training								
36				10	Failed Bearings	3	Operator Awareness/Daily Checklist (Leaks), Annual Oil Sample, Design SF, PM	1	30	Crane Inspector Training								
37				10	Wear	3	Design SF, PM	1	30	Crane Inspector Training								
38				10	Misalignment	4	PM, inspection	1	40	Crane Inspector Training								
39				10	Improper Lubrication	3	Operator Awareness/Daily Checklist (Leaks), PM Annual Oil Sample, Heating System (Main)	2	60	Crane Inspector Training								
40				10	Failed Set Screw/Key	4	Splined shafts	2	80	None-Difficulty Outweighs Benefit, and Adequate Redundancy								
41	A) Hoist Motor	Loss of human life & or flight hardware		10	Improper Use	1	Operator Training, Operator Awareness/Daily Checklist, Planning	1	10									

42				10	Failed Bearings	3	Operator Training	1	30	Crane Inspector Training						
43				10	Misalignment	3	Vendor Certification, Maintenance Training/Manuals	1	30	Additional Maintenance Training						
44				10	Housing Fatigue	1	PM, Vendor Certification	1	10	Crane Inspector Training						
45				10	Improper Paint (Over Thick) or Under Lubrication	2	PM, Vendor Certification	2	40	Crane Inspector Training						
46				10	Failed Set Scre/Key	3	Design SF, Vendor Certification, Load Test	4	120							
47		A) Hoist	Loss of human life & or flight hardware	10	Overload	1	Shaft Redundant with Holding Brake, Drive Train Redundancy, Planning, Known Loads, Design SF	1	10	Additional Operator Training						
48				10	Improper Setup	1	Shaft Redundant with Holding Brake, Drive Train Redundancy, Planning, Known Loads, Design SF	1	10							
49				10	Improper Use	1	Shaft Redundant with Holding Brake, Drive Train Redundancy, Operator Training, Operator Awareness/Daily Checklist, Planning	1	10	Additional Operator Training						
50				10	Misalignment	3	Shaft Redundant with Holding Brake, Drive Train Redundancy, Vendor Certification, Maintenance Training/Manuals	1	30	Additional Maintenance Training						

51				10	Improper Lubrication	3	Shaft Redundant with Holding Brake, Drive Train Redundancy, PM	1	30	Crane Inspector Training							
52				10	Bad Factory Setup	1	Shaft Redundant with Holding Brake, Drive Train Redundancy, Vendor Certification, Load Test	1	10								
53				10	Failed Set Screw/Key	4	Shaft Redundant with Holding Brake, Drive Train Redundancy, Design SF, Vendor Certification, Load Test	2	80	None-Difficulty Outweighs Benefit, and Adequate Redundancy							
54		B. Trolley C. Bridge	Serious Injury, Flight Hardware Damage	10	Overload Trolley	2	Overload control in VFD, Planning, Known Loads, Weight Test (B), Design SF	1	20								
55				10	Overload Bridge	1	Overload control in VFD, Planning, Known Loads, Weight Test (B), Design SF	1	10								
56				10	Improper Setup	1	Overload control in VFD, Planning, Known Loads, Design SF	1	10								
57				10	Improper Use	1	Operator Training, Operator awareness, Planning	1	10								
58				10	Wear, Burrs	4	Operator Awareness, Design SF, PM	2	80	Crane Inspector Training							
59				10	Failed Disk	3	Redundant with Other Disks, Design SF, PM, Operator Awareness	2	60	Crane Inspector Training							

60				10	Failed Springs	2	Design SF, PM Operator Awareness	2	40	Crane Inspector Training								
61				10	Loose Set Screw	4	Redundant with Eddy Current Brake, PM, Operator Awareness, Weight Test	2	80	Crane Inspector Training, No Other Recommendation, Difficulty Outweighs Benefit, and Adequate Redundancy								
62				10	Failed Shaft	1	Design SF, PM, Operator Awareness, Load Test	1	10	Crane Inspector Training								
63		A. Hoist	Loss of human life & or flight hardware	10	Overload	1	Redundant with MLB, Planning, Known Loads, Design SF	1	10									
64				10	Improper Setup	3	Redundant with MLB, Operator Awareness/Daily Checklist, PM, Maintenance Training/Manuals, Inspection After Modification	1	30	Additional maintenance Training, Crane Inspector Training								
65				10	Failed Spring	3	Redundant with MLB, Operator Awareness, PM, Load Test, Design SF, Maintenance Training/Manuals	2	60	Additional Maintenance Training, Crane Inspector Training								
66				10	Misadjustment	4	Redundant with MLB, Operator Awareness, PM, Maintenance Training/Manuals	2	80	Add to PM-Measure Setting of Torque Brake Bolt, Crane Inspector Training, Additional Maintenance Training								

67				10	Overheating	1	Redundant with MLB, Operator awareness, Design SF, Operator Training, Known Loads, Planning	2	20								
68	A. B. C. Bearings	Loss of human life & or flight hardware		10	Overload	1	Bearings Redundant With Other Bearings (A), Overload control in VFD, Planning, Known Loads, Design SF	1	10								
69				10	Improper Setup	4	Bearings Redundant With Other Bearings (A), Maintenance Training/Manuals, Vendor Certification	1	40	Additional Maintenance Training							
70				10	Improper Use	1	Bearings Redundant with other Bearings (A), Operator Training, Operator Awareness/Daily Checklist, Planning	1	10								
71				10	Misalignment	2	Bearings Redundant with Other Bearings (A), Maintenance Training/Manuals, Vendor Certification	1	20	Additional Maintenance Training							
72				10	Improper Lubrication	4	Bearings Redundant with Other Bearings (A), PM	3	120	Add Use Meter, Crane Inspector Training							
73				10	Wear	8	Bearings Redundant with Other Bearings (A), Operator Awareness, PM Vendor Certification	2	160	New Vibration Analysis Equipment, Annual Vibration Analysis, Crane Inspector Training							
74				10	Fatigue	2	Design SF, PM	1	20	Crane Inspector Traing							

75	A. B. C. Coupling	Loss of human life & or flight hardware	10	Overload (A), (B)	1	Planning, Known Loads, Design SF	1	10									
76			10	Improper Setup	2	Operator Awareness/Daily Checklist, PM	1	20	Crane Inspector Training								
77			10	Improper Use	2	Operator Training, Operator Awareness/Daily Checklist, Planning	1	20									
78			10	Misalignment	3	Maintenance Training, PM	3	90	Crane Inspector Training, Additional Maintenance Training								
79			10	Improper Lubrication	3	PM	1	30	Crane Inspector Training								
80			10	Wear	2	PM, (Visual-shavings or grease on floor, or evidence of misalignment)	3	60	Additional Maintenance Training								
81			10	Structural Failure	2	PM (visual-shavings or grease on the floor, or evidence of misalignment), Operator Training (Shock Loading)	2	40	Additional Maintenance Training, Additional Operator Training								
82	B. C. Festoon	Loss of human life & or flight hardware	10	Improper Setup	3	Vendor operation test, Maintenance Training, PM	1	30	Additional Maintenance Training								
83			10	Failed Trolley bearings	3	Design SF, PM	4	120	Change PM-Monthly Check of Free Moving Bearings, Crane Inspector Training								
84			10	Loose Bolts	4	PM	4	160	Verify Lockwire, Self Locking Nuts, or Locktight, Crane Inspector Training								

85	A. B. C Nuts and Bolts	Loss of human life & or flight hardware	10	Overload	2	Planning, Known Loads, Design SF	1	20	Lockwire, Self Locking Nuts, or Locktight								
86			10	Improper Setup/Torque	3	Vendor Certification, Maintenance Training, PM	3	90	Lockwire, Self Locking Nuts, or Locktight, Random torque checks during PM, Crane Inspector Training, Additional Maintenance Training								
87			10	Vibration	5	Design SF, PM (Loose /Broken Nuts and Bolts)	3	150	Lockwire, Self Locking Nuts, or Locktight, Crane Inspector Training								
88			10	Fatigue	2	Design SF, PM	1	20	Crane Inspector Training								
89			10	Wear	2	Design SF, PM	1	20	Crane Inspector Training								
90	B. C. Bumper Stops	Severe Injury, Damage Flight Hardware	10	Failed Rubber/Spring	1	Design SF, PM	1	10	Crane Inspector Training								
91			10	Abuse	3	Operator Training, Operator Awareness/DailyCheck list, Planning, PM	3	90	Increase Operator Training								
92	A. Limit Switch (Geared)	Loss of human life & or flight hardware	10	Improper Setup	2	Limit Switch Redundant with Weighted Limit Switch, Design SF, Maintenance Trainign, PM	2	40	Crane Inspector Training, Additional Maintenance Training								
93			10	Loose Screw Set	4	Limit Switch Redundant with Weighted Limit Switch, Design SF, PM	3	120	Add Check on Setscrew to PM, Whip End Dip								

94				10	Wear	2	Limit Switch Redundant with Weighted Limit Switch, Design Sf, PM	1	20	Crane Inspector Training							
95				10	Failed Roll Pin/Key	4	Limit Switch Redundant with Weighted Limit Switch, Design SF, PM	2	80	None-Difficulty Outweighs Benefit, and Adequete Redundancy, Cannot Be Checked							
96				10	Failed Coupling	3	PM	1	30	Crane Inspector Training							
97		A. Limit Switch (Power)	Loss of human life & or flight hardware	10	Failed Actuator	2	Switch Redundant With Geared Limit Switch, Pm	1	20	Crane Inspector Training							
98				10	Improper Setup	2	Switch Redundant With Geared Limit Switch, Vendor Test, Maintenance Training Manuals, PM	1	20	Crane Inspector Training, Additional Maintenance Training							
99				10	Loose Set Screw	4	Switch Redundant With Geared Limit Switch, PM Design SF	3	120	Add Check on Setscrew to PM, Whip End Dip							
100				10	Wear	2	Switch Redundant With Geared Limit Switch, PM	1	20	Crane Inspector Training							
101		A. Pillow Blocks (Mounted)	Loss of human life & or flight hardware	10	Overload	1	Redundant With Saddle, Weight System, Planning, Known Loads, Design SF	1	10								
102				10	Improper Setup, Alignment, or Torque	2	Redundant With Saddle, Vendor Certification, Maintenance Training	1	20	Additional Maintenance Training							

103				10	Failed Bolt	1	Redundant With Saddle, Design SF, PM, Vendor Certification	1	10	Crane Inspector Training							
104				10	Broken Weld	2	Redundant With Saddle, PM	1	20	Crane Inspector Training							
105		B. C. Rail Stops	Loss of human life & or flight hardware	10	Failed Welds	2	Redundant With Building walls	1	20	Crane Inspector Training, Operator training, add travel limit switches							
106				10	Failed Bolts	1	PM	2	20	Crane Inspector Training							
107				10	Improper Design	1	Operational Test Design	1	10								
108				10	Improper Setup	1	Operational Test Design	1	10								
109				10	Abuse	3	Operator Training, Planning	2	60								
110		B. C. Rail Sweep	Loss of human life & or flight hardware	10	Failed Welds	2	PM Design SF	1	20	Crane Inspector Training, consider tethering sweep							
111				10	Failed Bolts	1	PM Design SF	2	20	Crane Inspector Training, consider tethering sweep							
112		B. C. Wheels	Loss of human life & or flight hardware	10	Failed Bearings	2	Design SF, PM Operator Awareness	3	60	Crane Inspector Training							
113				10	Misalignment Wheels Rail (C)	3	Operator Awareness, PM Vendor Certification, Maintenance Training	3	90	Re-align/Survey Runway Every 5 Years, Crane Inspector Training, Additional Maintenance Training							

114				10	Misuse	1	Operator Training, Operator Awareness/Daily Checklist, Planning	1	10								
115				10	Mismatching Wheels	1	Operational test will identify	1	10								
116				10	Improper Design	1	Vendor Certification, Operator Awareness/Daily Checklist PM (Wear Detection), operational test	1	10								
117		Strutural Failure: B. C. Beams, Trucks C. Girders	Loss of human life & or flight hardware	10	Failed Welds	2	Load test verification, Vendor Certification, Design SF, PM	2	40	Crane Inspector Training							
118				10	Failed Bolts	1	Load test verification, Vendor Certification, Design SF, PM	2	20	Crane Inspector Training							
119				10	Improper Design	1	Load Test Verification, Material Test Reports, Vendor Certification, Design SF, PM (Detection)	1	10								
120				10	Improper Installation	1	Load Test Verification, Vendor Certification, Design SF	2	20								
121				10	Rust	2	Vendor Certification, Design SF, PM, controlled atmosphere	3	60	Crane Inspector Training							
122				10	Overload	1	Redundant With Overwad Device, Planning, Known Loads, Design SF	1	10								

123				10	Misuse	1	Operator Training, operator Awareness/Daily Checklist, Planning	1	10								
124	ELECTRICAL FAILURE: A. Main Hoist Bridge Trolley	C. A. Motor D.	Loss of human life & or flight hardware	10	Failed Connections	2	Control Switch is "Dead Man", Operator Awareness/Daily Checklist, PM	2	40	Crane Inspector Training, Consider Megger Test							
125				10	Broken Wire	2	Motor Redundant With Control Switches (Operator Control), Megger Test Operator Awareness/Daily Checklist	2	40	Crane Inspector Training							
126				10	Electrical Overload	3	Control Switch is "Dead Man", Fuses, Heater	2	60								
127				10	Improper Lubrication	2	Control Switch is "Dead Man", Megger Test, PM	2	c	Crane Inspector Training							
128				10	Partial Power	2	Control Switch is "Dead Man", Megger Test, PM	2	40	Crane Inspector Training							
129		B. C. Brake Disk	Loss of human life & or flight hardware	10	Failed Connections	2	Control Switch is "Dead Man", Operator Awareness/Daily Checklist, PM	2	40	Crane Inspector Training							
130				10	Broken Wire	2	Control Switch is "Dead Man", Operator Awareness/Daily Checklist, PM	2	40	Crane Inspector Training							
131				10	Failed Solenoid	2	Control Switch is "Dead Man", Operator Awareness/Daily Checklist, PM	2	40	Crane Inspector Training							

132	A. Brake Shoe	Loss of human life & or flight hardware	10	Failed Connections	2	Shoe Redundant With MLB, Operator Awareness/Daily Checklist, PM	2	40									
133			10	Broken Wire	2	Shoe Redundant With MLB, Operator Awareness/Daily Checklist (C), PM, Vendor Certification	2	40	Crane Inspector Training								
134			10	Failed Solenoid	2	Shoe Redundant With MLB, Operator Awareness/Daily Checklist, PM	2	40	Crane Inspector Training								
135	A. Limit Switch (Geared)	Loss of human life & or flight hardware	10	Failed Contacts	2	Limit Switch Redundant With Power Limit Switch, Operator Awareness/Daily Checklist, PM	1	20	Crane Inspector Training								
136			10	Failed Connections	2	Limit Switch Redundant With Power Limit Switch, Operator Awareness/Daily Checklist, PM	1	20	Crane Inspector Training								
137			10	Broken Wire	2	Limit Switch Redundant With Power Limit Switch, Operator Awareness/Daily Checklist, PM, Vendor Certification	1	20	Crane Inspector Training								
138			10	Improper Adjustment	3	Limit Switch Redundant With Power Limit Switch, Maintenance Training/Manuals	2	60	Additional Maintenance Training								
139	A. Limit Switch (Power)	Loss of human life & or flight hardware	10	Failed Contacts	2	Switch Redundant With Geared Limit Switch, Operator awareness/Daily Checklist, PM	2	40	Crane Inspector Training								

140				10	Failed Connections	2	Switch Redundant With Geared Limit Switch, Operator awareness/Daily Checklist, PM	1	20	Crane Inspector Training								
141				10	Broken Wire	2	Switch Redundant With Geared Limit Switch, Operator awareness/Daily Checklist, PM	1	20	Crane Inspector Training								
142				10	Improper Adjustment	1	Switch Redundant With Geared Limit Switch, Maintenance Training/Manuals, Vendor Certification	1	10	Additional Maintenance Training								
143		A. B. C. Hard Wire Controls (Pendant, Solenoid, Contactors)	Loss of human life & or flight hardware	10	Failed Contacts	2	Operator Awareness/Daily Checklist, PM, Heater	3	60	Crane Inspector Training								
144				10	Failed Connections	2	Operator Awareness/Daily Checklist, PM	3	60	Crane Inspector Training								
145				10	Broken Wire	2	Operator Awareness/Daily Checklist, PM, Vendor Certification	3	60	Crane Inspector Training								
146				10	Improper Setup	1	Maintenance Training/Manuals	1	10	Additional Maintenance Training								
147				10	Switch Failure	3	Operator Awareness, PM, Maintenance/Train. Manuals	2	60	Crane Inspector Training, Additional Maintenance Training								
148				10	Overload Protection Failure	2	Brakes Set At Failure	1	20									

149				10	Transformer Failure	2	Brakes Set At Failure	1	20								
150				10	Heater Failure	2	PM	1	20	Crane Inspector Training							
151	A. B. C. Wiring	Loss of human life & or flight hardware		10	Failed Connections	2	Operator Awareness/Daily Checklist, Pm	3	60	Crane Inspector Training							
152				10	Current Overload	2	Fuses Circuit Breakers	1	20	Crane Inspector Training							
153				10	Age	2	PM	3	60	Crane Inspector Training							
154				10	Vibration	2	Vendor Certification, PM (Loose Connections)	1	20	Crane Inspector Training							
155				10	Abuse	1	Operator Training	2	20								
156	A. B. C. Festoon Runway	Loss of human life & or flight hardware		10	Failed Connections	2	Operator Awareness/Daily Checklist, PM	3	60	Crane Inspector Training							
157				10	Current Overload	2	Fuses, Circuit Breakers, Vendor Certification, PM	1	20	Crane Inspector Training							
158				10	Age	2	PM	1	20	Crane Inspector Training							
159				10	Vibration	2	PM (Loose Connections)	1	20	Loctite							
160				10	Movement/Kinked Cable	1	Maintenance Training/Manuals, Pm, Vendor Certification	3	30	Crane Inspeccor Training, Additional Maintenance Training							
161				10	Contaminatioin	2	PM	3	60	Crane Inspector Training							

162		A. B. C. Power Spike	Loss of human life & or flight hardware	10	Lightning	4	Surge Protection, Lightning Protection, Proper Grounding, Do Not Operate in Lightning Storm	1	40	Operator Maintenance Training, Add Surge Protection in Building							
163				10	Power Company	4	Surge Protection, Lightning Protection, Proper Grounding	2	80	Install Isolation Transformer							
164		A. B. C. Power Supply (3 Phase)	Loss of human life & or flight hardware	10	Failed Connections	2	Operator Awareness/Daily Checklist, PM, Limited Backup Power	2	40	Crane Inspector Training							
165				10	Broken Wire	2	Operator Awareness/Daily Checklist, PM Vendor Certification	2	40	Crane Inspector Training							
166				10	Power Source	2	Limited Backup Power, Computerized Monitoring	2	40								
167				10	Stuck Contactor	3	Eddy Current Brake, Operator Training, Pm (Audible)	2	60	Crane Inspector Training							
168	Electronic Failure	A. B. C Radio Transmitter		10	Abuse	9	Operator Training, Operator Awareness/Daily Checklist	3	270								
169				10	Failed Battery	9	Low Battery LED, Low Signal Dropout	3	270	Heated Storage							
170				10	Failed Connections	5	Operator Awareness/Daily Checklist, Electronic PM, Bad Signal Dropout	2	100	Electronic Maintenance Training							

171				10	Failed Switches	4	Operator Awareness/Daily Checklist, Electronic PM, Bad Signal Dropout	2	80	Electronic Maintenance Training								
172				10	Failed Components	3	Operator Awareness/Daily Checklist, Electronic PM, Bad Signal Dropout	2	60	Electronic Maintenance Training								
173		A. B. C. Radio Receiver	Loss of human life & or flight hardware	10	Stray Signal	1	Receiver Band Width, Bad Signal Dropout, Coordination of Frequency	1	10									
174				10	Broken Antenna	1	Design SF, Electronic PM, Low Signal Dropout	2	20	Electronic Maintenance Training								
175				10	Failed Components	2	Operator Awareness/Daily Checklist, Operator Training, Electronic PM	2	40	Electronic Maintenance Training								
176				10	Overheat	2	Fan, Electronic PM	1	20	Electronic Maintenance Training								
177				10	Failed Transfer Switch	2	Operator Awareness/Daily Checklist, Electronic PM	2	40	Electronic Maintenance Training								
178				10	Improper Setup/Adjustment	3	Maintenance Training/Manuals, Operator Awareness/Daily Checklist, Electronic PM	2	60	Electronic Maintenance Training								
179				10	Failed Connections	2	Operator Awareness/Daily Checklist, Electronic PM	2	40	Electronic Maintenance Training								

180				10	Broken Wire	1	Operator Awareness/Daily Checklist, Electronic PM, Vendor Certification	2	20	Electronic Maintenance Training								
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Legend:

PM = Preventative Maintenance

SF = Safety Factor

NDT = Non Destructive Test (eg Dye Penetrant, mag. Particle)

VFD = Variable Frequency Drive

TRDG = Top Running Double Girder