APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

TITLE: MSL MMRTG Lift utilizing Suspended Parasol SLO-KSC-2011-002

MSL Suspended Load Identification and Description

DOCUMENT
NUMBER/TITLE: MSL-213-3316B

PREPARED BY: Ronald T. Welch, MSL Project Safety DATE: 6/10/2011

CHECK APPROPRIATE BOX:

☐ Single Occurrence Operation ☒ Multiple Occurrence Operation ☐ Revision to Existing SLOAA

IF REVISION TO EXISTING SLOAA, SUMMARIZE CHANGES / RATIONALE:

REQUIRED APPROVAL:

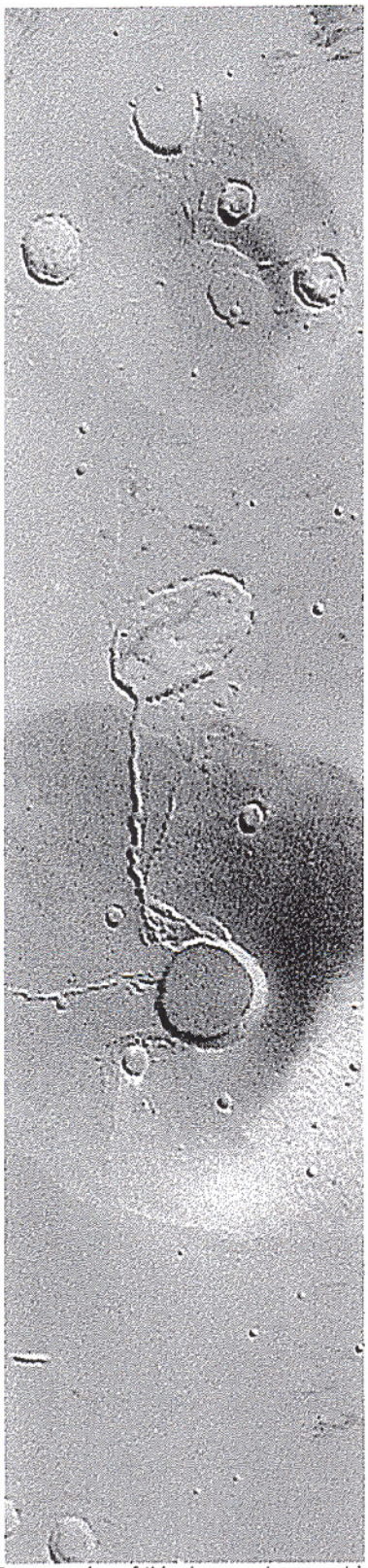
CONTRACTOR _____DESIGN _____R & QA _____OPERATIONS _____SAFETY

NASA _____DESIGN _____R & QA _____OPERATIONS _____SAFETY

TYPE OR PRINT NAME	SIGNATURE	ORG.	DATE
Megan Jaunich		SA-D1	06/30/11
Joe Torsani		SA-G2	30 Jun 11
Michael Wetmore		SA	30 June 11
Wilson Harkins		OSMA	30 JUNE 2011

CONTRACTOR DIRECTOR OF SAFETY
[See SLOAA Cover for additional signatures]

This page intentionally left blank



Mars Science Laboratory

Suspended Load Operations Conducted at the Kennedy Space Center RTG Facility (RTGF)

JPL D-67901B
MSL 213-3316B

June, 2011

Prepared by:

Karan L Hennard 6/28/11
Ronald T. Welch - MSL Project Safety Engineer

Approved by:

Cami Vongsouthy 6/23/11
Cami Vongsouthy - JPL Systems Safety Program Office Manager

Frederick W Battle 6/29/2011
Fred Battle – JPL Lifting Device Manager

Dal C Gruel 6/28/11
Dave Gruel – MSL ATLO Manager

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

This page intentionally left blank

MSL Suspended Load Operation – Use of Parasol During MMRTG Lifts

1.0 Scope:

During the MSL Multi Mission Radioisotope Thermoelectric Generator (MMRTG) Operations at the KSC Radioisotope Thermoelectric Generator Facility (RTGF-M7-1472), the MSL MMRTG is moved from its Department of Energy (DOE) transporter, re-configured and placed back onto the transporter in preparations for various on-going operations at the RTGF and PHSF.

2.0 Requirements

The following requirements are from the NASA Lifting Standard 8719.9, Appendix A.

A.4.1 All suspended load operations will be approved by the Center/facility NASA Director of Safety based upon a detailed engineering hazards analysis of the operation. The hazards analysis will be prepared by the responsible safety organization and coordinated through appropriate engineering and design offices. The analysis documentation will include the following:

a. A justification why the operation cannot be conducted without personnel beneath the load. Feasible procedure/design options will be investigated to determine if the work can be accomplished without personnel working under a load suspended from a crane/hoist.

As a protective measure against potential contamination, each lift of the MMRTG has, as part of the lifting device load path, a parasol (see Figure 2) protecting critical hardware from debris that could potentially fall from the overhead crane mechanical elements. Because the parasol is not part of the crane assembly, but instead is a separate element hanging off of the crane hook, it is considered to be a suspended load as it is necessary for technicians to be under the parasol during assembly of the lift path elements and during certain lift operations involving the MMRTG as described herein.

The following operations will specifically require the use of the MMRTG Parasol:

RTGF Operations and approximate exposure time:

1. Rigging/de-rigging of lift elements (parasol, hydra-set , ballast and load cell):

   - Total number of operations: 4
   - Total personnel under load for each operation: 2 technicians
   - Exposure time for each operation: 10 min max

2. Lift and Turnover Fixture (LTOF) Hoist on/off stand:

   - Total number of operations: 4
   - Total personnel under load for each operation: 2 technicians
   - Exposure time for each operation: 10 min max

3. MMRTG Hoist on/off of stand:

   - Total number of operations: 2
   - Total personnel under load for each operation: 2 technicians
   - Exposure time for each operation: 10 min

   Note: the above operation (#3) will also involve 2 Idaho National Labs (INL) technicians for approximately 10 min under the parasol. JPL technicians will not be under the load when INL is conducting their operations.

The MSL MMRTG is a critical component on the MSL Spacecraft and as such cleanliness is extremely important to maintain the integrity and functionality of this system. The use of a drip shield (parasol) is imperative to maintaining this cleanliness. Technicians must position themselves under the shadow of the parasol to conduct the three operations listed above because the connection between the parasol and the load is centered beneath the parasol. Once each operation is completed, however, the technicians will move out from under the parasol and away from the suspended load. A secondary load support stand was considered, but the option was determined infeasible due to the light weight parasol skirt's inability to support the weight of the crane's load block itself. The MSL Project has also considered not using the parasol, but it was determined that the likelihood of hardware contamination was unacceptable. Conversely, the likelihood of hoist main gear reducer failure resulting in dropping the load during the limited time technicians are under the parasol is near zero. There is no history of such a failure on this or any crane at Kennedy Space Center. The intensive maintenance and inspections imposed by NASA-STD-8719.9 and KSC procedures provide a high degree of confidence in this crane. Given that the crane's hook will be static and the fact that the load imposed by the parasol and associated rigging is less than 3% of the crane's rated capacity, there is no real concern as to the safety of technicians beneath the parasol during these operations.

b. Details of the precautions taken to protect personnel should the load drop. Secondary support systems, i.e., equipment designed to assume support of (catch) the load preventing injury to personnel should the crane/hoist fail, shall be evaluated and used whenever feasible. Secondary support systems will be constructed with a minimum safety factor of 2 to yield.

There are no secondary support (fall arrest) systems that can be utilized during the exposure timeframe for these lift operations. The mitigation is the large factors of safety on the parasol interface attachment member. The parasol itself weighs approximately 50 lbs.

c. The maximum number of exposed personnel allowed. Steps shall be taken to limit the number of personnel working under a load suspended from a crane/hoist. Only those essential personnel absolutely necessary to perform the operation will be allowed to work in the safety controlled area.

The steps involved in this lift are accomplished by two technicians located on the inside of the parasol footprint during lift device attachment to the crane hook.

d. The time of exposure. Steps shall be taken to ensure that personnel do not remain under the load any longer than necessary to complete the work.

The time of technician's exposure to the suspended load will be minimized (see pages 5 and 6) to assure that the connections are made safely but at the same time their exposure is no longer than necessary.

A.4.2 Each operation will be reviewed on a case-by-case basis.

JPL as well as INL, KSC Safety will witness each lift of the MMRTG utilizing this SLOAA in accordance with detailed handling procedures.

A.4.3 Only those suspended load operations approved by the Center/facility NASA Director of Safety will be permitted, subject to this standard. A list of approved suspended load operations will be maintained by NASA Safety and made available to OSHA personnel upon request.

This document satisfies the above requirement and will be filed with the KSC Safety Office and is available on-line at http://ksc-lde.ndc.nasa.gov/. The SLOAA will also be referenced in the text of the MMRTG Handling Procedures.

A.4.4 The operational procedures document (e.g., Operations and Maintenance Instruction, Technical Operating Procedure, Work Authorization Document) will be revised to specify the necessary additional requirements identified by the hazard analysis discussed in paragraph A.4.1. The procedures will be available on site for inspection during the operation.

The MSL MMRTG Handling Procedure (MSL-556-2023) will be available for review prior to utilization of the lifts in question as well as on the floor during the lift. The details of this lift will be discussed at the morning Safety Briefing prior to the start of the day's activities as well as at the pre-lift briefing.

A.4.5 During a suspended load operation, if a new procedure not covered by the original analysis is deemed necessary due to unusual or unforeseen circumstances, the NASA Center/facility Safety Office will be consulted and must approve and document the procedure before operations continue. Safety will coordinate with Operations, Engineering, and other organizations as appropriate. If the new procedure is to be performed on a regular basis, a detailed hazards analysis and approval as outlined in paragraph A.4.1 are required.

All MMRTG lifting operations that will be conducted in the RTGF will be reviewed by the KSC Lifting Device and Equipment Manager as well as KSC Safety. All recommendations, suggested changes, etc. will be addressed prior to conducting lift.

Note: Any new suspended load operation, not covered by this SLOAA, deemed necessary due to unusual or unforeseen circumstances where real time action is required, shall be documented and approved by the NASA KSC Director of Safety and Mission Assurance.

A.4.6 The crane/hoist shall be designed, tested, inspected, maintained, and operated in accordance with the NASA Standard for Lifting Devices and Equipment (NASA-STD-8719.9). Test, inspection, and maintenance procedures will be developed and approved by qualified, responsible NASA engineers. Qualified specialists will perform the procedures and resolve noted discrepancies. NASA Quality Assurance will perform an independent annual inspection of all cranes/hoists involved in suspended load operations. The results of the annual inspections will be maintained and made available to OSHA personnel upon request.

The RTGF (M7-1472) 10 ton bridge crane has undergone inspection and proof testing and will be in current certification at the time of the operations. The crane has been designed, maintained, inspected and tested in accordance with NASA STD 8719.9.

A.4.7 Each crane/hoist involved in suspended load operations shall undergo a Failure Modes and Effects Analysis (FMEA) that shall be approved by the Center/facility NASA Director of Safety. The FMEA will determine Single Failure Points (SFP), assessing all critical mechanical functional components and support systems in the drive trains and critical electrical components.

The RTGF crane has been analyzed for Single Point Failure modes (refer to KSC Doc ID: SAA01FS022-1012 "System Assurance Analysis for the 10 ton Bridge Crane Located at the RTG Storage Facility"). Passive components such as rope, drum, wire rope and hook are verified through preventive maintenance. The SAA identified the hoist main gear reducer as a SFP that will result in dropping the load. The identified failure mode is disengagement of the gears due to broken teeth or a sheared key. There is no history of failure of the hoist main gear reducer. The use of high quality components and a comprehensive maintenance, inspection and test program including pre-operational checks ensure that the crane system operates properly. Hoist system is load tested at 100% rated load annually. Additionally, the crane was re-roped and proof load tested to 125% of rated load on February 2011. Main gear reducer oil level is inspected semi-annually, and an oil sample is taken annually and analyzed for water and foreign material. Main gear reducer is inspected quarterly for evidence of distortion, cracks or oil leakage. The gears and shafts are designed in accordance with American Gear Manufactures Associate (AGMA) standards. Pinion gears are machined integrally with their shafts, and gears are fixed to shafts by interference fits and keys. Structural failure would be required for disengagement. There is no history of failure of the SFP in the critical failure mode. In the unlikely event of structural failure, the most probable result would be binding and/or noisy operation. Total lifted mass for the MMRTG lift is approximately 1000 Lbs, which is 10 % of the rated capacity of one of the 5 ton-hoists of the RTGF 10-ton bridge crane.

NOTE: The 10-ton Bridge crane consists of two 5-ton hoists sharing a single bridge and trolley. The overall crane capacity of 10 tons is based on the cumulative capacity of the two 5-ton hoists. Only one of the 5-ton hoists will be used for the lifts described herein.

A.4.8 Before lifting the load involved in a suspended load operation, the crane/hoist will undergo a visual inspection (without major disassembly) of components instrumental in assuring that the load will not be dropped (e.g., primary and secondary brake systems, hydraulics, mechanical linkages, and wire rope per NASA-STD-8719.9). Noted discrepancies will be resolved before the operation continues. This pre-lift inspection will be in addition to the inspections required in 29 CFR, 1910.179(j).

Prior to start of daily operations in the RTGF, the overhead crane will be inspected and run through all directions/ranges to be used to assure proper operation and functionality of the fail safe devices. Any noted discrepancies will be resolved before operations commence for the day. This pre-lift inspection will be in addition to the inspections required in 1910.179(j).

A.4.9 A trained and licensed operator (certified per NASA-STD-8719.9) shall remain at the crane/hoist controls while personnel are under the load.

JPL/INL Crane operators will be trained in accordance with NASA-STD-8719.9. In addition, each operator will have undergone hands-on specific training on the RTGF crane. The training will be overseen and conducted by a NASA/KSC Certified Crane Operator licensed and certified for the RTGF cranes.

Crane operator will remain at the crane controls when personnel are under the suspended load. Per JPL requirements, a person shall remain at the crane dead-man switch at all times when critical hardware is on the hook as well as when anyone is under a suspended load.

A.4.10 Safety controlled areas shall be established with appropriate barriers (rope, cones, etc.). All nonessential personnel shall be required to remain behind the barriers.

Non-essential personnel will be kept clear of the lift operation as noted in the procedure. A controlled area will be established for all crane operations in the RTGF. Appropriate barriers will be set-up prior to start of lift and removed only when lift has been completed. A detailed discussion of the controlled area will be conducted at the pre-lift briefing to assure all participants are familiar with the defined boundary.

A.4.11 Prior to the suspended load operation, a meeting with the crane/hoist operator(s), signal person(s), person(s) who will work under the load, and the person responsible for the task shall be held to plan and review the approved operational procedures that will be followed, including procedures for entering and leaving the safety controlled area.

At the pre-lift briefing (as described in 4.10) a detailed discussion will be conducted to go over the suspended load steps and precautionary measures. The meeting will include the crane operator, lift lead, JPL Safety Engineer, KSC Safety, JPL Quality Assurance Engineer, lift technicians and any other authorized parties. The Suspended Load Operation will also be discussed at the morning briefing and the details of the procedure addressed.

A.4.12 Communications (voice, radio, hard wired, or visual) between the operator(s), signal person(s), and the person(s) working under the load shall be maintained. Upon communication loss, operations shall stop immediately, personnel shall clear the hazardous area, and the load shall be safed. Operations shall not continue until communications are restored.

Communication and direct visual contact will be maintained at all times between the crane operator and lift lead as well as between the crane operator and the technician under the suspended load. Upon visual or communication loss the lift will be halted immediately and persons under the suspended load will move to a safe area outside the envelope of the suspended load until the line of sight and/or communication can be re-established. All lifts in the RTGF, including the suspended load lifts in question, will be conducted with direct voice communication w/o the use of communication devices.

A.4.13 Personnel working beneath the load shall remain in continuous sight of the operator(s) and/or the signal person(s).

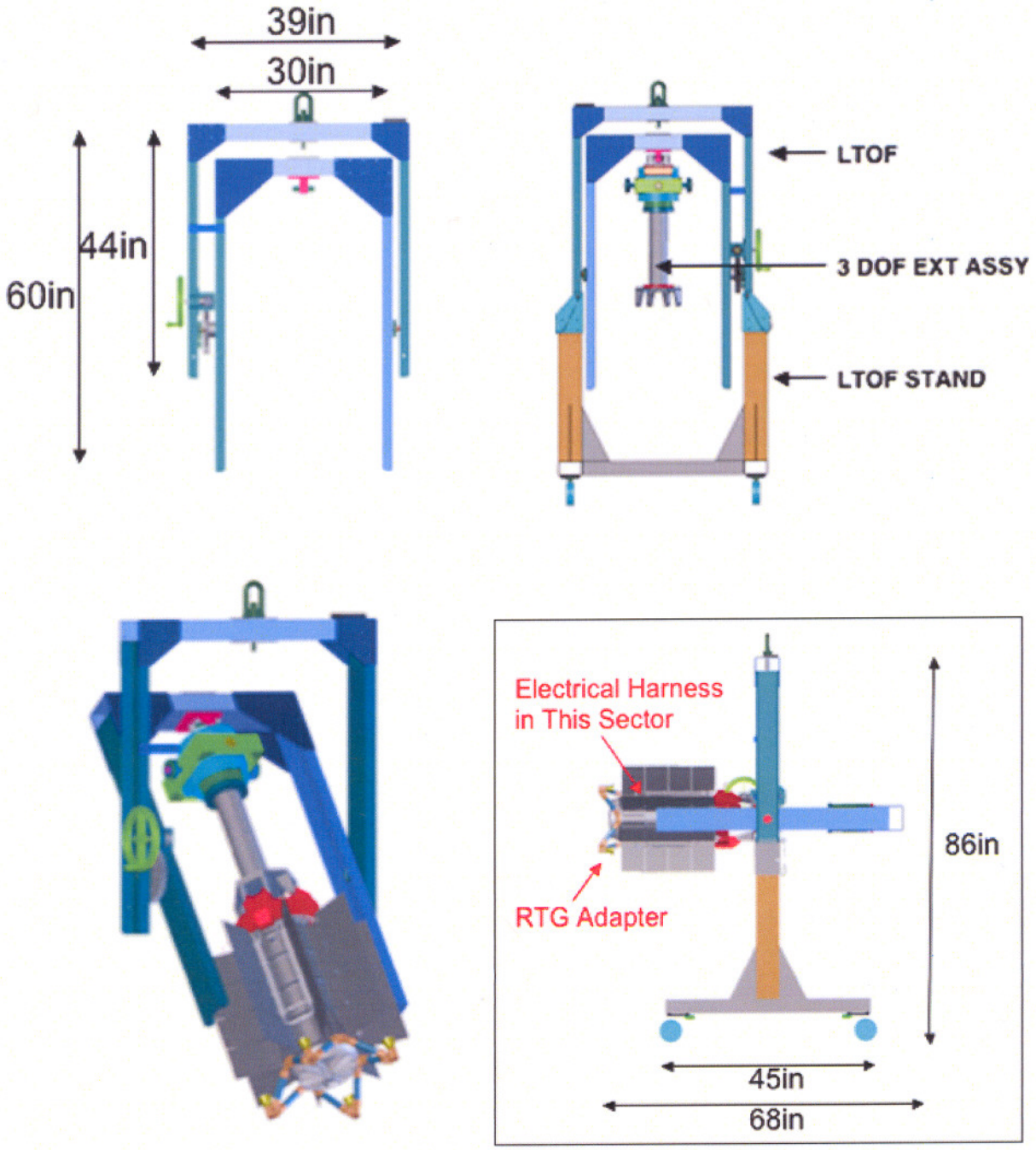
See above response

A.4.14 NASA shall conduct periodic reviews to ensure the continued safety of the procedures. As a minimum, NASA will annually evaluate the implementation of this procedure at each Center with operations on the suspended load list.

All hazardous procedures, including suspended load operations, will be reviewed in accordance with the standard TOPs review process as described in KNPR 8715.3. The appropriate NASA/KSC Safety organizations will review and approve all hazardous procedures well in advance of the commencement of the operation with at least seven days lead time after approval.

A.4.15 A list of approved suspended load operations, list of cranes/hoists used for suspended load operations, and copies of the associated hazards analyses will be provided to the OSHA Office of Federal Agency Programs via NASA Headquarters for distribution to the appropriate regional and area OSHA offices. (NASA Headquarters, in conjunction with OSHA, will develop a format for transmittal of this information.) Quarterly updates to the documentation will be provided as needed.

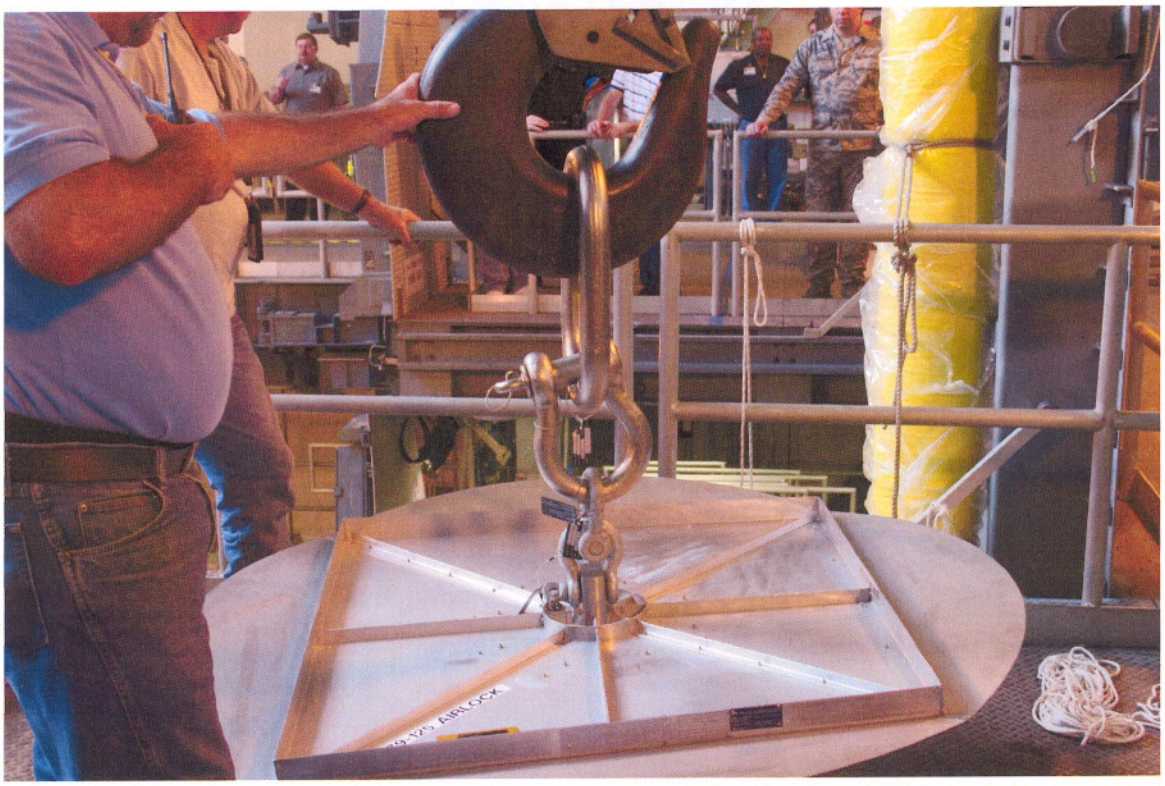
Figure 1.0 Lift and Turnover Fixture (LTOF) and Stand



LTOF = 178#
Extension Assembly = 130#
Red Ring = 16#
MMRTG Assembly = 100#
Load Cell = 60#
Hydra-set = 75#
Ballast Mass = 450#

Total Weight of MMRTG plus Lift elements = 1009 #

Figure 2.0 MMRTG Crane Parasol Allowable Loads and Proof Test Results:



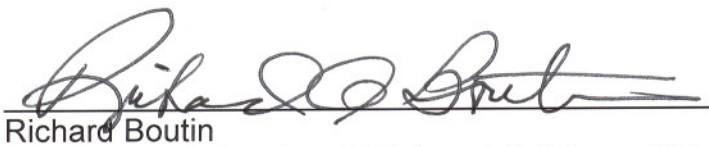
Parasol Factors of Safety (FOS):

- Rated Load: 8,722#
- Proof Load: 17,444#
- Proof Test AIDS #: 504108, Jan 12, 2011
- Design Yield: 32,708#
- Yield Factor of Safety (based on rated load): 3.75
- Design Ultimate: 43,610#
- Design Factor of Safety (based on rated load): 5.0
- Actual Working Load: 1000#
- Actual FOS on Working Load (ultimate): 43
- Actual FOS on Proof Load: 17

Figure 3.0 MMRTG on LTOF (pictures taken from trailblazer operations)

This page intentionally left blank

KSC/NASA Approval:



6/30/2011
Date:

Richard Boutin
Chief, Launch Services Division of Safety and Mission Assurance

This page intentionally left blank