

# APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

SLO-KSC-1993-010

TITLE External Tank (ET) Off-load from Transporter  
Using 325-Ton Crane

DOCUMENT NUMBER/TITLE OMI T5002.012 - ET Lift from  
Transporter and Rotate to Vertical

PREPARED BY Malcolm Colenn

DATE 2/16/99

**REQUIRED APPROVAL**

CONTRACTOR       DESIGN               R & QA               OPERATIONS               SAFETY  
 NASA               DESIGN               R & QA               OPERATIONS               SAFETY

TYPE OR PRINT NAME	SIGNATURE	ORGN.	DATE
Malcolm Colenn	<i>Malcolm Colenn</i>	ET-C-A	2/16/99
JOHN BLUE	<i>[Signature]</i>	USA-ETM	2-16-99
JORGE E. RIVERA	<i>Jorge E. Rivera</i>	PK-H	2-16-99
J. W. GARRETT	<i>J. W. Garrett</i>	SIS1	2/26/99
Alfred M. Sturcus	<i>Alfred M. Sturcus</i>	USA SRE	3/3/99

CONTRACTOR DIRECTOR OF SAFETY

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ANALYSIS/APPROVAL (SLOAA)**

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**OPERATION:** External Tank (ET) Off-load from Transporter Using 325-Ton Crane

**SUPPORTING DOCUMENTS:** The associated operational procedure/systems assurance analyses are as follows:

1. OMI T5002.012, ET Lift from Transporter and Rotate to Vertical.
2. SAA09FY120-001, System Assurance Analysis of the 325-Ton Bridge Cranes at the Vehicle Assembly Building (VAB).
3. SAA09FY12-006, System Assurance Analysis of the 175-Ton Bridge Crane at the Vehicle Assembly Building (VAB).

**GENERAL DESCRIPTION:**

1. Require four personnel to be directly under the suspended ET forward sling set during installation of the forward sling set to the ET, and while the ET is on the transporter.
2. Require up to seven personnel to be directly under the suspended ET/ET forward lifting sling set during initial stages of ET lift from the transporter.

The ET off-load from the transporter uses both the 325-ton and 175-ton bridge cranes in the Vehicle Assembly Building (VAB). With the ET/transporter in the off-load position, personnel board aerial lifts and position themselves adjacent to the forward lifting attach points on either side of the ET intertank. Because of the weight and rigidity of the sling set cables and hoisting adapters, two personnel per side are required to stabilize and install the hoisting adapters on the ET.

The forward sling set, with hoisting adapters, is lowered so the hoisting adapters are adjacent to the forward lifting attach points on either side of the ET intertank. The personnel guide the hoisting adapters into position on the forward attach point on each side of the ET, then work to install and torque fastening hardware. The technicians are directly under the extreme ends of the sling set main beam during these operations.

At the aft end of the ET, personnel (a maximum of three) are under the suspended ET during initial ET lift to observe alignment and measure distance of the ET with respect to the aft transportation fitting on the transporter.

Personnel on aerial lifts at the forward attach points guide/monitor the forward sling set/cables and forward lifting adapters until the ET is safely "floating" off the transporter attach fittings and steadily suspended via the sling sets.

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The personnel are directly under the suspended ET at the aft end of the transporter, and directly under the extreme ends of the forward sling set main beam at the forward end of the transporter, during these initial lift stages. All personnel are required to leave the area under the suspended load once the ET is satisfactorily demated from the transporter.

**Alternate Standard Requirement #1a:** The ET off-load from the transporter has been evaluated and it has been determined the operation cannot be practically/feasibly conducted without personnel beneath the load. Engineering evaluations included, but were not limited to, the following:

- Fabrication of additional GSE safety stands to support both the ET forward and aft sling sets in the event of a failure. These safety stands would require the use of an overhead crane to move and position the stands. Because of the size and positioning of the stands, it was determined the overall safety of the entire operation would be compromised in an effort to improve one specific phase of the operation.
- Modification to existing personnel lift platforms which could provide an overhead safety cage to protect personnel from a possible falling load. Evaluation of this proposal showed no feasible solution existed to provide a structurally sufficient enclosure due to overall weight limitations of existing platforms. The size and type of such an enclosed lift platform, which could positively protect personnel, would severely hinder operational procedures.
- Numerous procedural alterations were evaluated/tested for practicality and subsequently rejected as unworkable. No operational methods could be devised to preclude the requirement for personnel working under the suspended loads in the specific operations listed in this document.

**Alternate Standard Requirement #1b:** The use of a secondary support system (stand) was evaluated and deemed not feasible for this operation. Because of the size and positioning of a stand to support the ET sling, the overall safety of the operation would be compromised.

**Alternate Standard Requirement #1c:** The maximum number of personnel required under the load at any time is seven: four (two per each side of ET) at the forward end, and three at the aft end.

**Alternate Standard Requirement #1d:** Personnel required under the load will perform their operations as quickly as possible (approx. 25 minutes) and remove themselves from exposure immediately upon task completion.

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**Alternate Standard Requirement #2:** Suspended load operations are reviewed and approved on a case-by-case/specific need basis - see General Description and Alternate Standard Requirement #1.

**Alternate Standard Requirement #3:** Only those suspended load operations approved by the Center NASA Safety Assurance Director will be permitted. A list of approved suspended load operations will be maintained by the Center NASA Safety Assurance Directorate.

**Alternate Standard Requirement #4:** OMI T5002.012 is written to allow up to seven personnel under the suspended load during sling installation and initial ET lift procedures. The OMI is available on site for inspection during the operation.

**Alternate Standard Requirement #5:** A 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 Center NASA Safety Assurance Director.

**Alternate Standard Requirement #6:** Suspended load operations associated with ET forward sling set installation and ET lift from the transporter in the VAB involve the 175-ton and one of the two 325-ton bridge cranes. The cranes are designed, tested, inspected, maintained, and operated in accordance with the NASA Safety Standard for Lifting Devices and Equipment, NSS/GO-1740.9. These cranes are designed to a minimum safety factor of 5 (based on the ultimate yield strength) for the hoist load-bearing components. The H70-0597 orbiter lifting sling is designed with a safety factor of 5 against ultimate strength and a safety factor of 3 against yield.

The cranes are equipped with redundant hoist drive systems (including hoist wire ropes and holding brakes), each capable of lifting and holding the load up to the crane rated capacity. The cranes have a dual braking system with overspend braking.

The cranes were one-time proofloaded at 125 percent of rated capacity, are load tested annually at 100 percent of rated capacity, and have a monthly, semiannual and annual preventive maintenance program to ensure proper operation.

The wire rope is inspected monthly for discrepancies. Nondestructive testing of the crane hooks is performed annually.

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The ET forward sling set total weight is approximately 23,000 pounds. The ET weight ranges from approximately 58,000 pounds (Super Lightweight Tank) to approximately 65,000 pounds (Lightweight Tank). The ET aft sling set weight is approximately 5,000 pounds. The total suspended weight for these operations will range from approximately 86,000 pounds to approximately 93,000 pounds depending on the ET.

**Alternate Standard Requirement #7:** System Assurance Analyses (SAAs) have been completed on the VAB 325-ton and 175-ton bridge cranes. Each SAA includes a Failure Modes and Effects Analysis/Critical Item List (FMEA/CIL) and a hazard analysis (see Supporting Documents).

The SAA for the 325-ton crane identifies 1 Single Failure Point (SFP), the Programmable Logic Controller (PLC). The PLC controls motion for the hoist, bridge and trolley. The identified failure mode is an unsolicited command from the PLC could initiate or continue a crane motion in an uncommanded direction or speed. The PLC is designed to industry standards and is UL listed. Internal diagnostics verify all crane controls each time the crane is used and crane control functional checks are performed before each use. The PLC is electrically isolated from external voltages/currents. Crane software was validated and extensively tested per the acceptance test procedure. If a failure were to occur, the crane operators can secure the load by applying brakes.

The SAA for the 175-ton bridge crane identifies 3 SFPs in the main hoist system when the hoist is lifting or lowering. Failure of the motor-generator set (one each) or the main hoist motors (two each) would allow the load to lower without regenerative braking. There are no SFPs when the hoist is static.

There is no history of failure with the SFPs in the critical failure mode. The use of high quality, reliable components and a comprehensive maintenance, inspection, and test program, including preoperational checks ensures that the crane systems operate properly. If a failure were to occur, it can be recognized by the selsyn position which is in view of both crane operators. The crane operators would secure the load by applying the brakes.

Emergency (E) stop operators, remote from the crane operator's cab, can stop the crane if a failure indication is observed.

The associated SAA CIL sheets identify the rationale for accepting the risk of the SFPs, including design information, failure history, and the operational controls in effect to minimize the risks (maintenance, inspection, test, etc.).

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**Alternate Standard Requirement #8:** Visual inspections for cracks or other signs of damage or anomalies are performed on the crane hooks and lifting sling assembly along with crane functional checks prior to each operation per NSS/GO-1740.9.

**Alternate Standard Requirement #9:** The crane operators, E-stop operators, and mechanical technicians are all trained and have current certifications. Operators will remain at the crane controls while personnel are under the load.

**Alternate Standard Requirement #10:** Appropriate control areas are established and maintained prior to and during the operation. Only required personnel (man loaded in the procedure) are permitted in this area.

**Alternate Standard Requirement #11:** Personnel are briefed just prior to performing the task about the hazard involving the suspended load. A pretask briefing and a safety walkdown of the area are conducted prior to the lift to ensure all systems and personnel are ready to support. All participants are instructed on their specific tasks and warned of the hazards involved. Following any crew change, new personnel are instructed by the task leader on their specific tasks and warned of the hazards involved.

**Alternate Standard Requirement #12:** Personnel beneath the suspended load will be in radio, visual, or voice contact with the crane controller and/or signal person. Upon loss of communication, the operation shall stop immediately, personnel shall clear the hazardous area, and the load shall be safed. Operations shall not continue until communications are restored.

**Alternate Standard Requirement #13:** Ground controllers and E-stop operators are properly positioned during all phases of the lifting operation in full view of the load block, lifting fixtures and fixture attach points. One E-stop operator, remote from the crane operator's cab, can stop the crane if a failure indication is observed. Personnel working beneath the load shall remain in continuous sight of the operator and/or signal person.

**Alternate Standard Requirement #14:** The Center NASA Safety Assurance Directorate shall conduct periodic reviews to ensure the continued safety of suspended load procedures.

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**Alternate Standard Requirement #15:** The Center NASA Safety Assurance Directorate will provide copies of approved SLOAAs, a list of approved suspended load operations, a list of cranes/hoists used for suspended load operations and copies of the associated FMEA/CIL and hazards analyses to NASA Headquarters.

APPROVAL:

DATE: 2/26/99

Malcolm Henne for  
Bruce L. Jansen  
Acting Director, Safety Assurance  
Kennedy Space Center