NASA SUSPENDED LOAD OPERATION
ANALYSIS/APPROVAL

NUMBER: SLO-KSC-1991-027

OPERATIONS - To handle the core shell with forward end cone assembly or the experiment shell with aft end cone assembly in the Operations and Checkout (O&C) Building.

SUPPORTING DOCUMENTS - The associated operational procedure and System Assurance Analysis (SAA) are as follows:

- OMI L5049 (Rev A, 10/28/81), Module Segment Transfer between Transportation MGSE/MHC
- SAA01FS027-002 (Rev A, 07/26/88), 27.5 Ton Bridge Cranes - O&C

GENERAL DESCRIPTION - The tasks below require up to four persons to be under the suspended hoist beam during handling of the core shell/experiment shell as follows:

- OMI L5049, seq 07-009 through 07-020, Hoisting Operation and Positioning of Tilting Beam
- OMI L5049, seq 08-001 through 08-019, Hoisting and Rotation Operation of the Module Segment
- OMI L5049, seq 09-001 through 09-015, Mating Operation - Module Segment to MHC
- OMI L5049, seq 10-008 through 10-039, Module Segment 4.0M Handling Ring Removal Operation

Core shell/experiment shell operations are performed in the O&C low bay using dual 27.5 ton bridge cranes. The suspended hoist/tilting beam extends out beyond the module segments, which exposes personnel to a suspended load while positioning the hoist/lifting beam over the module segments, attaching the beam to the module segments to be rotated from vertical to horizontal configuration, mating the module segments to the module handling cage, and removing the handling rings from the module segments.

RATIONALE/ANALYSIS - The suspended load tasks comply with the NASA Alternate Safety Standard as follows:

Alternate Standard Requirement #1a - These operations cannot be conducted without placing personnel beneath the suspended hoist/tilting beam assembly. The hoist/tilting frame is wider than the Module segments and the connections are inboard of the hoist/tilting beam ends. Personnel must place themselves under the beam to connect and disconnect the payload segments.

Module segment hoisting, rotating, and handling operations in the O&C have been evaluated for alternate methods to complete these tasks. It has been determined that there are no operational or procedural means to eliminate exposure to a suspended load because there is no other access to make the connections and disconnections.

The hoist/tilting beam was designed specifically to rotate Module segments. The design of a support structure for the beam was considered, but proper positioning of the fixture would be precluded by the location of the Module segments in the MHC.

Alternate Standard Requirement #1b - The possible use of a secondary support system, to catch the load in the event of a crane failure, was analyzed. It was determined that the use of a secondary support system was not feasible because of positioning of the Module segments in the MHC.

Alternate Standard Requirement #1c - The maximum number of personnel permitted under the suspended hoist/tilting beam during Module segment hoisting, rotating, and handling operations is four.

Alternate Standard Requirement #1d - Core shell or experiment shell handling will be accomplished as quickly and safely as possible to minimize exposure time. It will take up to four persons no longer than 30 minutes to complete an individual task. The mating task (Module segments in the MHC) requires approximately 30 minutes to complete.

Alternate Standard Requirement #4 - OMI L5049 has been revised to permit only the approved number of persons under the suspended hoist/tilting beam. The OMI is available on site for inspection during the operation.

Alternate Standard Requirement #6 - Suspended load operations associated with hoisting, rotating, and handling Module segments in the O&C involve two 27.5 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.

The 27.5 ton crane hoists are equipped with two magnetic holding brakes (one on the motor shaft and one on the gear reducer input shaft extension), each capable of holding the load up to the crane's rated capacity. Each brake's ability to hold the rated load (27.5 tons) is verified annually. The cranes are designed to meet a 5 to 1 safety factor based on ultimate strength for the hoist load bearing components.

Dual 27.5 ton cranes are being utilized for these tasks. The weight of the load is 18,370 lbs, which is 16.7% of the cranes' capacity.

The lifting slings are rated at 18,370 lbs and are designed to meet a 2.25 to 1 safety factor based on yield strength and a 5 to 1 safety factor based on ultimate strength.

The 27.5 ton cranes are load tested annually at 100% of their rated capacity. Detailed preventive maintenance is performed monthly, quarterly, semiannually, and annually on the cranes to ensure proper operation. A detailed inspection of the lifting slings is performed annually. Nondestructive testing of the slings and crane hooks is performed annually.

Alternate Standard Requirement #7 - A System Assurance Analysis (SAA) has been completed on the 27.5 ton bridge cranes in the O&C. The SAA includes a failure modes and effects analysis/ critical items list (FMEA/CIL) and a hazard analysis (see supporting documents).

The SAA identifies one single failure point (SFP), the hoist gear reducer, which transmits power and reduces rotational speed from the hoist motor to the rope drum. A sheared key or broken teeth would cause interruption of the load path at the gearbox. This failure would result in the load dropping, which could cause loss of life and/or payload.

There is no history of failure with the SFP in the critical failure mode. A detailed inspection of the gear reducer is performed monthly, and gear reducer oil samples are verified annually. 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.

The associated SAA CIL Sheets (pp. 62 and 63) identify all the rationale for accepting the risk of the SFP including design information, failure history, and the operational controls in effect to minimize the risks (maintenance, inspection, test, etc.).

Alternate Standard Requirement #8 - Visual inspections for cracks or other signs of damage or anomalies are performed on the hoist hooks, hoist beams, hoist cables, hoist rod assemblies, and hoist fittings, and crane functional checks are performed before each operation per NSS/GO-1740.9.

Alternate Standard Requirement #9 - Trained and licensed crane operators shall remain at the hoist controls while personnel are under the load.

Alternate Standard Requirement #10 - Appropriate safety control areas are established before initiating operations. Only the minimum number of people (manloaded in the procedure) will be permitted in this area.

Alternate Standard Requirement #11 - A pretask briefing and a safety walkdown of the area are conducted prior to the lift to ensure that all systems and personnel are ready to support. All participants are instructed on their specific tasks and warned of any hazards involved. Following any crew change, the new personnel are instructed by the task leader on their specific tasks and warned of any hazards involved.

Alternate Standard Requirement #12 - Personnel beneath the suspended load will be in voice contact with the hoist operator/ task leader. 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 - Personnel working beneath the load shall be in continuous sight of the hoist operator/task leader.

APPROVAL: DATE: CONCURRENCE: DATE:

Warren I. Wiley 1/29/92

Warren I. Wiley
Acting Director
Safety and Reliability (RT)
Kennedy Space Center

Charles W. Mertz 10 OCT 92

Charles W. Mertz
Director, Safety Division
Office of Safety &
Mission Quality (QS)
NASA Headquarters