APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

SLO-KSC- 1991-023

TITLE INSTALL/REMOVE PAYLOAD KEEL COVERS; GUIDE KEEL TRUNNIONS INTO KEEL LATCH. ATTACH MHC SHOES TO MHC; INSTALL MHC SHOES INTO MHC SPINDLES - INSTALLATION OF SPACEHAB TRANSFER TUNNEL

DOCUMENT NUMBER/TITLE OMI E5006, TRANSCAN/HORIZONTAL CARGO INSTALLATION/REMOVAL; OMI L5165; IPPLA TRANSCAN/HORIZONTAL CARGO INSTALLATION/REMOVAL

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REQUIRED APPROVAL

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NASA SUSPENDED LOAD OPERATION
ANALYSIS/APPROVAL

OPERATIONS

1. To install or remove the payload keel cover(s).

2. To guide the keel trunnions into the keel latches.

3. To attach the Module Handling Cage (MHC) shoes to the Module.

4. To install MHC shoes onto the MHC spindles.

5. To install the Spacehab Transfer Tunnel into its workstand.

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

- OMI E5006, Transcan/Horizontal Cargo Installation/Removal
- OMI L5165, IPPLA Transcan/Horizontal Cargo Installation/Removal
- SAA01FS027-002, 27.5 Ton Bridge Cranes - O&C
- SAA09FY091-001, 30 Ton Bridge Cranes - OPF (Bays 1 and 2)
- SAA09FY091-007, 30 Ton Bridge Cranes - OPF (Bay 3)
- SAAZ1CRSS1-001, 30 Ton Bridge Cranes – Space Station Processing Facility (SSPF)

GENERAL DESCRIPTION

OMI E5006

1. Installation or removal of the payload keel trunnion cover(s) requires 1 or 2 persons to be under the suspended payload (depending on the number of keel trunnions) and 3-16 persons to be partially under (hands only) the suspended NASA payload strongback during payload transfer from the test stand to the payload canister and removal of the payload from the canister.

2. Guiding the keel trunnion(s) into the keel latch(es)/fittings requires up to 4 persons to be under the suspended payload (depending on the number of keel trunnions).

3. Attachment of the MHC shoes (8 total) to the Module requires up to 4 people working under the suspended load.

4. Installation of the MHC shoes onto the MHC spindles requires up to 6 persons working under the suspended load.

5. Installation of the Spacehab Transfer Tunnel into its workstand requires 4 persons working under the suspended load.

These tasks are completed in the following OMI sequences:

- OMI E5006, Payload Transfer from Test Stand and Installation into Canister (O&C)
- OMI E5006, Payload Removal from Canister (OPF)
- OMI E5006, Payload Installation into Canister (OPF)
- OMI E5006, Payload Removal from Canister (O&C)
- OMI E5006, Module Transfer into MHC

Payload transfer from the test stand involves removal of the payload from the test stand by hoisting the payload strongback, positioning the strongback over the payload, attaching the strongback linkages to the payload trunnions, removing the payload from the test stand, and placing it in the canister. During removal of the payload from the canister, the procedure is reversed.

During installation or removal of the keel trunnion cover(s), the persons working at the trunnions will be partially exposed (hands only) to the suspended payload strongback. If the load should fall, arms or hands should be pushed out of the way (the payload trunnions are suspended above the retention fittings 6-12 inches).

Module transfer into the MHC involves the use of MHC shoes interface and engagement. First, the MHC shoes are attached to the Module and then installed onto the MHC spindles. Both operations are conducted under the suspended load.

Spacehab Transfer Tunnel involves persons under the load to guide the tunnel into the cradle support fixtures and adjust the fixture to accept the tunnel.

During contingency payload grounding operations, one person will be permitted to work under the suspended load.

Also, during contingency ingress to or egress from the canister, personnel may pass under the suspended strongback one at a time.

OMI L5165

1. Installation or removal of the payload keel trunnion cover requires 1 person to be under the suspended payload and 4-6 persons to be partially under (hands only) the suspended Integrated Partial Payload Lifting Assembly (IPPLA) during removal and installation of the payload from and into the payload canister.

2. Guiding the keel trunnion into the keel latch requires 1 person to be under the suspended payload.

These tasks are completed in the following OMI sequences:

- OMI L5165, Payload Removal from Canister (OPF)
- OMI L5165, Payload Installation into Canister (OPF)

Payload removal from the canister involves removal of the payload from the canister by hoisting the IPPLA, positioning the IPPLA over the payload, attaching the linkages to the payload trunnions, removing the payload from the canister, and turnover of the IPPLA and payload to the Shuttle Processing Contractor (SPC) for installation in the orbiter. During installation of the payload into the canister, the procedure is reversed.

During installation or removal of the keel trunnion cover, the persons working at the trunnions will be partially exposed (hands only) to the suspended IPPLA. If the load should fall, arms or hands should be pushed out of the way (the payload trunnions are suspended above the retention fittings 6-12 inches).

Also, during contingency ingress to or egress from the canister, personnel may pass under the suspended IPPLA one at a time.

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

Alternate Standard Requirement #1a

OMI E5006

These operations cannot be conducted without placing personnel under the suspended load. Payload trunnion connections and installation of the MHC shoes onto the MHC spindles require personnel to work under the NASA payload strongback (lifting fixture). Keel trunnion operations and installation of the MHC shoes to the Module require personnel to work beneath the suspended payload.

These trunnion operations at the O&C and the OPF as well as the MHC shoe installations, have been evaluated for alternate methods to complete these tasks, and it has been determined that there are no design, operational, or procedural means to eliminate personnel exposure to a suspended load.

During trunnion operations at the O&C and the OPF, while the payload is resting in the test stand (holding fixture), the technician has to lean over the rails of the test stand and reach up under the payload strongback to connect the strongback linkages to the payload trunnions. This task places the technician beneath the strongback, which is suspended overhead, to make the connection or disconnection as required.

Because of the size of the NASA payload strongback (which requires a dual-crane lift) and the position of the linkages (which are located inboard on the strongback), there is no other access to make the connection to or disconnection from the payload trunnions. These physical limitations preclude any operational or procedural workaround. A support structure for the strongback is not a feasible design consideration because the test stand would not support the weight of the payload, a support structure, and the strongback. Also, the position of the payload in the test stand and the location of the payload trunnions, in particular, would physically interfere with and prevent access for a support structure. The same is true for the installation of the MHC shoes onto the MHC.

During keel trunnion operations, the technician(s) must reach beneath the suspended payload to install or remove the payload keel trunnion cover(s) and to guide the keel trunnion(s) into the keel latch(es)/fittings. There is no alternate access to the keel trunnion(s) (located underneath the payload), and the cover(s) cannot be installed or removed while the payload is in the test stand or the payload canister. This physical limitation precludes any design, operational, or procedural changes that would eliminate personnel exposure to a suspended load. These limitations are also applicable to the installation of the MHC shoes to the module.

During the transfer of the Spacehab Transfer Tunnel, the technicians must work beneath the load to guide the tunnel into the workstand. The size of the tunnel and the overhead crane envelope prevent all work outside of the suspended load.

OMI L5165

These operations cannot be conducted without placing personnel under the suspended IPPLA (lifting fixture) during payload trunnion connections or beneath the suspended payload for keel trunnion operations. These trunnion operations at the OPF have been evaluated for alternate methods to complete these tasks, and it has been determined that there are no design, operational, or procedural means to eliminate personnel exposure to a suspended load.

While the payload is resting in the canister, the technician has to lean over the chains of the canister and reach up under the IPPLA to connect the linkages to the payload trunnions. This task places the technician beneath the IPPLA, which is suspended overhead, to make the connection or disconnection as required.

Because of the size of the IPPLA and the position of the linkages (which are located inboard), there is no other access to make the connection to or disconnection from the payload trunnions. These physical limitations preclude any operational or procedural workaround. A support structure for the IPPLA is not a feasible design consideration because of the position of the payload in the canister. In addition, the location of the payload trunnions would physically interfere with and prevent access for a support structure.

During keel trunnion operations, the technician must reach beneath the suspended payload to install or remove the payload keel trunnion cover and to guide the keel trunnion into the keel latch. There is no alternate access to the keel trunnion (which is located underneath the payload), and the cover cannot be installed or removed while the payload is in the canister. This physical limitation precludes any design, operational, or procedural changes that would eliminate personnel exposure to a suspended load.

Alternate Standard Requirement #1b

OMI E5006

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 payload over the test stand, under the payload strongback, or in the canister.

OMI L5165

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 payload under the IPPLA and in the canister.

Alternate Standard Requirement #1c

OMI E5006

1. The maximum number of personnel allowed under the load during installation or removal of the payload keel trunnion cover(s) is 1 or 2 persons (depending on the number of keel trunnions) with 3-16 persons partially exposed to the load (hands only).

2. The maximum number of personnel permitted under the load while guiding the keel trunnion(s) into the keel latch(es)/fittings are up to 4 persons (depending on the number of keel trunnions).

3. The maximum number of personnel allowed during the attachment of the MHC shoes to the Module is 4 persons.

4. The maximum number of personnel permitted during the installation of the MHC shoes onto the MHC spindles is 6 persons.

5. The maximum number of personnel permitted during the transfer into the workstand during Spacehab Transfer Tunnel work is 4 persons.

OMI L5165

1. The maximum number of personnel allowed under the load during installation or removal of the payload keel trunnion cover is 1 person with 4-6 persons partially exposed to the load (hands only).

2. The maximum number of personnel permitted under the load while guiding the keel trunnion into the keel latch is 1 person.

Alternate Standard Requirement #1d

OMI E5006

1. Installation or removal of the payload keel trunnion cover(s) will be accomplished as quickly and safely as possible to minimize exposure time. It will take 1 or 2 technicians (depending on the number of keel trunnions) up to 60 minutes to install or remove the keel trunnion cover(s).

2. Guiding the keel trunnion(s) into the keel latch(es)/fittings will be accomplished as quickly and safely as possible to minimize exposure time. It will take up to 4 persons 15-60 minutes to guide the keel trunnion(s) into the keel latch(es)/fittings. I

3. Installation of the MHC shoes will be accomplished as quickly and safely as possible to minimize exposure time. It will take up to 1 hour for 4 technicians to install the MHC shoes to the Module and up to 3 hours for 6 technicians to install the MHC shoes onto the MHC spindles.

4. Installation of the Spacehab Transfer Tunnel into the workstand will be accomplished as quickly and as safely as possible to minimize exposure time. It will take 4 technicians up to 30 minutes to complete the task.

OMI L5165

1. Installation or removal of the payload keel trunnion cover will be accomplished as quickly and safely as possible to minimize exposure time. It will take 1 technician up to 30 minutes to install or remove the keel trunnion cover.

2. Guiding the keel trunnion into the keel latch will be accomplished as quickly and safely as possible to minimize exposure time. It will take 1 person up to 60 minutes to guide the keel trunnion into the keel latch.

Alternate Standard Requirement #4

OMI E5006

OMI E5006 has been revised to permit only the approved number of persons under the suspended payload. The OMI is available on site for inspection during the operation.

OMI L5165

OMI L5165 has been revised to permit only the approved number of persons under the suspended payload. The OMI is available on site for inspection during the operation.

Alternate Standard Requirement #6

OMI E5006

Suspended load operations associated with hoisting the payload strongback in the O&C involve two 27.5 ton bridge cranes. Payload strongback hoisting in the OPF or the SSPF involves two 30 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. I

The O&C 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. The OPF (Bays 1 and 2) 30 ton crane hoists are equipped with a gear reducer and mechanical load brake enclosed in one unit, an electric drive motor and motor brake at the south end of the drum, and a solenoid-actuated band brake at the north end of the drum. The OPF (Bay 3) 30 ton crane hoists are equipped with two electrical holding brakes at either end of the drum shaft. All brakes are capable of holding the load up to the respective crane's rated capacity. Each brake's ability to hold the rated load (27.5 tons - O&C cranes, 30 tons - OPF cranes) 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 in the O&C. Dual 30 ton cranes are used in the OPF. The weight of the NASA strongback is 28,000 lbs. and the payload can weigh as much as 34,000 lbs. The combined load is 62,000 lbs., which is 56.4% of the O&C cranes' capacity and 51.7% of the OPF cranes' capacity.

The lifting slings are rated at 34,000 lbs. and are designed for a maximum allowable stress of 20,000 psi in tension and compression for the truss structure. The attachment mechanism of the lifting slings is designed to meet a 5 to 1 safety factor based on ultimate strength.

The 27.5 ton cranes in the O&C and the 30 ton cranes in the OPF are load tested annually at 100% of their rated capacities. 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.

The suspended load operations addressed in this analysis involve one of the 30 ton SSPF 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 SSPF 30 ton crane hoists are equipped with two magnetic holding brakes, each capable of holding the load up to the crane's rated capacity. Each brake's ability to hold the rated load (30 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. The 30 ton cranes are load tested annually at 100% of their rated capacities. 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.

OMI L5165

Suspended load operations associated with IPPLA hoisting in the OPF involves one 30 ton bridge crane. The crane is designed, tested, inspected, maintained, and operated in accordance with the NASA Safety Standard for Lifting Devices and Equipment, NSS/GO-1740.9.

The OPF (Bays 1 and 2) 30 ton crane hoists are equipped with a gear reducer and mechanical load brake enclosed in one unit, an electric drive motor and motor brake at the south end of the drum, and a solenoid-actuated band brake at the north end of the drum. The OPF (Bay 3) 30 ton crane hoists are equipped with two electrical holding brakes at either end of the drum shaft. All brakes are capable of holding the load up to the respective crane's rated capacity. Each brake's ability to hold the rated load (30 tons - OPF cranes) 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.

A single 30 ton crane is used for IPPLA hoisting operations in the OPF. The weight of the load (including the lifting sling) is a maximum of 13,000 lbs., which is 21.6% of the OPF crane's capacity.

The lifting sling is rated at 12,000 lbs. and is designed to meet a 5 to 1 safety factor based on ultimate strength.

The 30 ton cranes in the OPF are load tested annually at 100% of their rated capacities. 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 - System Assurance Analyses (SAAs) have been completed on the 27.5 ton bridge cranes in the O&C and the 30 ton bridge cranes in the OPF (Bays 1, 2, and 3). The SAAs each include a failure modes and effects analysis/critical items list (FMEA/CIL) and a hazard analysis (see supporting documents).

O&C Cranes (OMI E5006)

The SAA for the 27.5 ton bridge cranes - O&C 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 for the 27.5 ton bridge cranes - O&C 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.).

- An SAA has been completed on the 30 ton bridge cranes in the SSPF. The SAA includes a Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) and a hazard analysis (see supporting documents). No critical single failure points were identified during this analysis.

OPF Cranes (OMIs E5006 and L5165)

The SAAs for the 30 ton bridge cranes - OPF (Bays 1, 2, and 3) identify no SFPs.

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 and/or 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 and/or task leader.

APPROVAL: DATE:

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