# APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

SLO-KSC- 1991-017

CHANGE 1-JULY 1998

TITLE LOW PRESSURE OXIDIZER DUCT REMOVAL/INSTALLATION IN THE VERTICAL ASSEMBLY BUILDING (VAB) ENGINE SHOP AND SSMEPF

DOCUMENT NUMBER/TITLE OMI V5E02-SSME HIGH PRESSURE OXIDIZER TURBO PUMP REMOVAL/INSTALLATION AND OMI V5E63-SSME ALTERNATE HIGH PRESSURE OXIDIZER TURBO PUMP REMOVAL/INSTALLATION

PREPARED BY KATHLEEN MURRAY

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REQUIRED APPROVAL

CONTRACTOR ____ DESIGN ____ R & QA ____ OPERATIONS ____ SAFETY

NASA ____ DESIGN ____ R & QA ____ OPERATIONS ____ SAFETY

| TYPE OR PRINT NAME | SIGNATURE | ORGN. | DATE |
|---|---|---|---|
| J. LEWER, ROC SAFETY | J Lewer | ROC-SAF | 7-30-98 |
| K. HOSHSTRASSER, ROC MGR., SR&QA | Ken Hohstrasser | RC-S&MA | 7/31/98 |
| E. GARDZE, ROC MGR., SSME ENG | James D. Tubbs for | ROC | 7/31/98 |
| D. EWERS, ROC MGR., SSME TECH OPS | D. Ewers | ROC | 7-31-98 |
| D. HAUSMAN, ROC SITE DIR. | D. Ewers For | ROC | 7-31-98 |
| J. JAMBA, USA SLAP COORD. | John W Jamba | USA-SAF | 7/31/98 |
| J. GARRETT, USA SAFETY ENG | John W. Jamba | USA 5450 | 8/4/98 |
| A. STEVENS, USA MGR. S&RE | [illegible] | USA 5450 | 8/4/98 |
| M. GLENN, NASA SR&QA | M. Glenn | EI-C-A | 8/5/98 |
| | | | |
| | | | |
| | | | |

CONTRACTOR DIRECTOR OF SAFETY

[illegible] Mappi 3/5/93

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NASA SUSPENDED LOAD OPERATION
ANALYSIS/APPROVAL



**OPERATION** - Low Pressure Oxidizer Duct Removal/Installation in the Vehicle Assembly Building (VAB) engine shop.

**SUPPORTING DOCUMENTS** - The associated operational procedures/system assurance analysis are as follows:

- OMI V5E02-SSME High Pressure Oxidizer Turbo Pump Removal/Installation
- OMI V5E63-SSME Altemate High Pressure Oxidizer Turbo Pump Removal/Installation
- OMI V5E63-SSME Altemate High Pressure Oxidizer Turbo Pump Removal/Installation
- SAA09FY121-003 - System Assurance Analysis of the 10-Ton Bridge Crane at the Space Shuttle Main Engine Assembly Area in the VAB Low Bay
- SAA09CR00-001 - System Assurance Analysis of the 10 & 15-Ton Bridge Cranes at the SSMEPF

**GENERAL DESCRIPTION FOR OMI V5E02 AND V5E63:** Permit two (2) technicians to be directly under the suspended LPOD during installation/removal of the lifting hardware as follows:

Removal of Low Pressure Oxidizer Duct
Installation of Low Pressure Oxidizer Duct

The Low Pressure Oxidizer Duct (LPOD) removal/installation procedures are performed in the SSMEPF using the 10-ton bridge crane or in the VAB using the 10-ton bridge crane located in the Main Engine Shop. The 10-ton bridge crane is utilized with nylon lifting slings to lift the LPOD into position for installation or removal. The installation and removal of the LPOD requires the technicians involved to work under the suspended LPOD.

During the procedures to remove/install the low pressure oxidizer duct (LPOD), a maximum of two technicians will be required to work beneath the suspended LPOD for approximately 15 minutes.

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

**Alternate Standard Requirement #1a -** The operation cannot be conducted without personnel working beneath the LPOD during operations involving the connection and disconnection of the LPOD to the SSME prior to and post HPOTP installation/removal. LPOD lifting operations in the VAB low bay cell have been evaluated and it has been determined that there are no procedural/operational means to eliminate personnel exposure to the suspended load that reduce the hazard level. In addition, it is not feasible to redesign the lifting/handling equipment in such a manner as to eliminate the requirement for personnel to work under a suspended load during these operations.

**Alternate Standard Requirement #1b -** The possible use of a secondary support system to catch the load in the event of a crane failure has been reviewed and determined not to be feasible. This conclusion was reached primarily due to the requirement to position the LPOD directly over the SSME in order to connect or disconnect to/from the gimbal assembly before or after lifting operations.

**Alternate Standard Requirement #1c -** The maximum number of personnel permitted under the load at any time is
two (2).

**Alternate Standard Requirement #1d -** The two technicians will accomplish their task as quickly and safely as
possible in order to minimize exposure time.

**Alternate Standard Requirement #4 -** Operation and Maintenance Instructions (OMI) V5E02 and V5E63 have been revised to permit only the minimum required number of personnel under the suspended load during the installation/removal of the required hardware. The OMI is available on site during the operation for inspection.

**Alternate Standard Requirement #6 -** Suspended load operations associated with LPOD lifting use the SSMEPF 10-ton bridge crane or the VAB Engine Shop 10-ton bridge crane. The crane is designed, tested, inspected, maintained and operated in accordance with NSS/Go-1740.9. The crane is designed with a minimum safety factor of 5:1, based on ultimate material strength of the hoist load carrying components.

The SSMEPF 10-ton bridge crane is equipped with a hoist motor brake and a load hold/halt drum brake, each capable of stopping and holding the load at the crane's rated capacity. The motor brake provides retarding torque to hold the load when no power is being transmitted. It is an electrically released disc brake set by spring compression to apply load holding torque to the motor shaft. The load hold/halt drum brake provides retarding torque to hold the load when no power is being transmitted if the load moves down after stopping. This electrically released brake applies load holding torque directly to the hoist drum.

The VAB 10-ton bridge crane is equipped with mechanical and magnetic braking systems with overspeed braking, each of which is capable of stopping and holding the load at the crane's rated capacity. The mechanical load brake controls the lowering speed of the hoist motor. If the speed of the load begins to exceed that of the motor, the brake begins to set slowing the rate of descent. The magnetic load brake provides braking torque to the hoist motor pinion shaft. Whenever the hoist motor is energized the solenoid in the magnetic load brake is also energized causing the magnetic load brake to release. Therefore whenever power is removed from the hoist motor, the magnetic brake will set.

The crane is load tested annually at 100% of rated load and the Operational Maintenance Requirements and Specifications Document (ONMD), File VL requires verification of the load test prior to any critical lift. The acceptance test of the crane was performed in the VAB in 1982 at 125% of rated load. Detailed preventative maintenance is performed monthly, quarterly and annually on the crane to ensure proper operation.

**Alternate Standard Requirement #7** - A System Assurance Analysis (SAA) has been completed on the ten-ton crane. The analysis includes a Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) and a hazard analysis (see supporting documents).

The SAA for the SSMEPF 10 & 15-Ton Bridge Cranes identifies one SFP, the Programmable Logic Controller (PLC). The PLC controls motion for the hoist, bridge and trolley. The identified failure mode is erroneous input or output which could cause the load to travel in an uncommanded direction. The PLC is designed to industry standard 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.

The SAA for the VAB 10-ton bridge crane identifies one single failure point (SFP) for the ten-ton bridge crane in the hoist gear drive when the system is hoisting or lowering. The identified failure mode is disengagement of the drive gear as a result of structural failure of the teeth, shafts or keys which will allow the load to drop. There is no history of failure with the SFP in the critical failure mode. 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. The gears and shafts are designed in accordance with American Gear Manufacturers Association and Crane Manufacturers of America Association standards and all load bearing parts are designed so that the static stress, calculated for rated load, does not exceed 20 percent of the average ultimate material strength.

The associated SAA CIL Sheets identify all rationale for accepting the risk of the SFP, including design information-, failure history and the operational controls in effect to minimize the risks associated with crane operation.

**Alternate Standard Requirement #8** – Visual inspections for cracks or other signs of damage or anomalies are performed on the crane, hook and lifting assembly 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 crane controls while personnel are under the load

**Alternate Standard Requirement #10 -** Appropriate safety clear areas are established before initiating operations. Only the minimum of number of personnel will be permitted in this area.

**Alternate Standard Requirement #11 -** A pre-task 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 hazards involved. Following any crew change, the new personnel are instructed by the task leader on their tasks and warned of hazards involved

**Alternate Standard Requirement #12 -** Personnel beneath the suspended load will be in voice contact with the crane controller/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 resume until communications are restored.

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**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 attach points. Personnel working beneath the load shall remain in continuous sight of the operator/signal person.

APPROVAL: DATE:

Joel R. Reynolds 8/5/98

Joel R. Reynolds
Director
Safety Assurance (EI)
Kennedy Space Center

APPROVAL: DATE

8/6/98

James D. Lloyd
Director
Safety and Risk Management (QS)
NASA Headquarters