APPROVAL SHEET FOR SUSPENDED LOAD OPERATIONS

SLO-KSC 2009-002

TITLE: Ares IX Super Stack 5 Lift

DOCUMENT NUMBER/TITLE: SE-HAN-0080 - Super Stack 5 Lift and Mate

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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

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NASA SUSPENDED LOAD OPERATION ANALYSIS/APPROVAL (SLOAA)

OPERATION: Ares IX Super Stack 5 mate to Super Stack 4 using the 325 or 250 ton bridge crane in VAB High Bay 3.

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

1. SAA09FY12-001, Systems Assurance Analysis of the 325-Ton Bridge Cranes at the Vehicle Assembly Building (VAB)
2. SAA09FY12-005/B, Systems Assurance Analysis of the 250-Ton Bridge Cranes at the Vehicle Assembly Building (VAB)
3. SAA09FT09-010, Systems Assurance Analysis of the H72-1245 175 and 250 Ton Crane Load Link Indicators
4. SE-HAN-0080, Super Stack 5 Lift and Mate

GENERAL DESCRIPTION: Two personnel are required to be directly under the suspended USS Super Stack 5 for alignment prior to mate to Super Stack 4 in VAB High Bay 3.

One person will be required to be under the suspended load to lower the 5-hole probe and TAT sensor cover removal tag.

Operations include the following:

1. Alignment of the USS Super Stack during mating operation in VAB High Bay 3
2. Unfurl the 5-hole probe and TAT reel that will be required to pull the protection from the probe at the pad and lower down the side of the vehicle.

The H72-1245 load cell link is installed in line with the crane for weight determination of the lift. The load cell link is then attached to the Stack 5 Lifting GSE/Super Stack 5. The Ares IX Super Stack 5 is then lifted to be mated to Super Stack 4 in High Bay 3. Super Stack 5 will come to within 6 feet of being mated to Super Stack 4 where two personnel (a move director and crane director) will then enter the Ares I-X stack to guide the segment over the stack for final alignment and mate. The personnel are required because there are no outside access capabilities to align from outside of the suspended load.

Prior to Super Stack 5 mate a NASA Prototype Engineer will go under the suspended load when the stack is approximately 12 inches from mating and static. The engineer will retrieve 2 Velcro bags staged inside the base of Stack 5. The engineer will take one Velcro bag at a time and unfurl the reels gently lowering the tethers down the side of the vehicle to another engineer that will be located at the Upper Stage Access Door. The engineer at the upper stage access door will tape the tethers to the vehicle, where accessible, and stow each of the bags inside the penetration below the ECS duct cutout. The engineer will immediately leave the suspended load operation so mating can continue.

RATIONALE/ANALYSIS: The suspended load tasks comply with the NASA Alternate Safety Standard for Suspended Load Operations as follows:

Alternate Standard Requirement #1a:

1. There are no outside access means to verify proper alignment during mate of the Super Segment stacks in VAB High Bay 3. Access stands are not built in VAB High Bay 3 to allow for proper visual alignment of the lifted Super Stack during mate. Operational options to use binoculars, telescopes, lifts and cameras for alignment outside of the stack were investigated but were not feasible as they could result or lead to flight hardware damage since a clear visual line of sight could not be obtained during the lowering of the and alignment of the lifted Super Stack. Personnel were required to give clear direction and alignment communication to the crane operator while maintaining this clear line of sight.

2. The critical 5-hole probe and TAT need to be covered while at the pad to just prior to launch. The covers were designed to be pulled off using a tether due to no physical access means to pull them off using personnel. Operational options were investigated and discussed for different means to cover and lower the tethers but were not feasible due to the delicate and criticality nature of the 5 hole probe and TAT sensors as improper lowering of the tether could result in the covers coming off and lead to flight hardware damage. It was felt the personnel who designed the cover and removal tether would be best suited to perform the task under the load. The load itself would be static while the tether was lowered.

Design and fabrication of abatement stands is not feasible to support the entire Super Stack 5 and GSE should a crane or lifting GSE failure occur.

Alternate Standard Requirement #1b: Secondary support systems to assume support of (catch) the load were evaluated and were not feasible for these operations; see Alternate Standard Requirement #1a:

Alternate Standard Requirement #1c: The maximum number of personnel under the Super Stack for mate is 3.

Alternate Standard Requirement #1d: Personnel will accomplish the required suspended load tasks as quickly as possible to minimize time exposure. Total exposure time is approximately 30 minutes for segment alignment.

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 and Mission Assurance Directorate

Alternate Standard Requirement #4: The following Solumina WAD was written to allow only the required personnel under the suspended load and are available on site during the operation:

Stack 5 (CM/LAS/SM) **SE-HAN-0080**

Alternate Standard Requirement #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 Safety and Mission Assurance 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.

Alternate Standard Requirement #6: Suspended load operations in the VAB associated with lifting Super Stack 5 involve the use of one of the 325-ton bridge or 250-ton bridge cranes. The cranes are designed, tested, inspected, maintained and operated in accordance with NASA-STD-8719.9, the NASA Standard for Lifting Devices and Equipment. The cranes are designed with a minimum safety factor of 5 (based on the ultimate material strength) for the hoist load bearing components.

The cranes are equipped with redundant hoist drive systems (including hoist wire ropes and holding brakes) each capable of lifting and holding the load to the cranes capacity. The cranes have a dual braking system with overspeed braking. A load test is performed annually to 100 percent of the rated capacity of the crane.

The cranes undergo a monthly, quarterly, semiannual and annual preventative maintenance program. The wire rope is inspected monthly for discrepancies. The hook undergoes an annual Non-Destructive Testing (NDT) inspection.

The Stack 5 Lifting GSE was designed to a 5.5 to 1 safety factor for failure and 4 to 1 for yield. The Stack 5 Lifting GSE was proofloaded to 160,000 pounds and the SWL is 80,000 pounds. There are no critical welds on the Stack 5 Lifting GSE. The Stack 5 Lifting GSE is scheduled for use only with the Ares IX Super Stack 5 segments and is not scheduled for periodic load testing.

The H72-1245 Fwd Lifting Link had a one time proofload of 540,000 pounds and is load tested annually for the purpose of strain-gage/readout unit checkout and calibration to 290,000 pounds.

Alternate Standard Requirement #7: A System Assurance Analysis (SAA) has been completed on the VAB 325-ton bridge and VAB 250-ton bridge cranes. The 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 of 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 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 the brakes.

The SAA for the 250-ton crane identifies 11 Single Failure Points (SFP's), 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 at approximately 10 feet/minute (2 inches/second). Failure of the remaining SFP's would allow the load to lower with regenerative braking at approximately 0.25 feet/minute (0.05 inches/second). There are no SFP's when the hoist is static.

The SAA for the lifting Link identifies no SFP's for its use.

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

Alternate Standard Requirement #8: The 325-ton bridge and 250-ton bridge cranes undergo a visual inspection and pre-operational checkout prior to each use per NASA-STD-8719.9.

There is no history of failure with the SFP's 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 operators cab, can stop the crane if a failure indication is observed.

Alternate Standard Requirement #9: A trained, licensed and certified operator will remain at the controls while personnel are under a suspended load. In addition, a qualified Emergency Stop operator is stationed in the vicinity of personnel working under the suspended load. All personnel responsible for the direction and/or performance of the operation undergo training that meets or exceeds the required certifications per NASA-STD-8719.9.

Alternate Standard Requirement #10: Control areas are established per the controlling WAD for the operation. Only essential personnel are allowed in the control area for the lifting operation.

Control areas are established using ropes and placards to ensure non-essential personnel are kept out of the area. For lifting operations a badge board is maintained in the immediate area. Only those personnel badged and with the approval of the Task Leader are allowed under the load.

Alternate Standard Requirement #11: Pre-operational briefings are held by the Task Leader and all essential personnel involved with the operation. Shift change pre-operational briefings are held if operations are to occur on multiple shifts.

Alternate Standard Requirement #12: Communications (by voice, radio and visual) are maintained with all personnel under a suspended load. Emergency procedures contain instructions and personnel are trained to discontinue operations if communications are lost. The hardware is safed and the area is cleared if additional hazards warrant clearing the control area. All personnel are cleared from under a suspended load during loss of communications.

Alternate Standard Requirement #13: All personnel remain within sight of the Move Director and the Emergency Stop operator.

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

Alternate Standard Requirement #15: The NASA Safety and Mission Assurance Directorate will provide copies of approved SLOAA's, 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.

3/11/09

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