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National Aeronautics and
Space Administration

SAFETY STANDARD FOR LIFTING DEVICES AND EQUIPMENT

Office of Safety and Mission Quality
Washington, D.C. 20546

NASA SAFETY STANDARD FOR LIFTING DEVICES AND EOUIPMENT

PREFACE

EFFECTIVE DATE: November 1991

The NASA Safety Standard for Lifting Devices and Equipment establishes uniform design, testing, inspection, maintenance, operational, personnel certification, and marking requirements for lifting devices and associated equipment used in support of NASA operations.

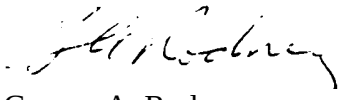
This standard expands on NHB 1700.1(V1), "NASA Basic Safety Manual," policy and guidelines for safety assurance. It is a compilation of pertinent requirements from the Occupational Safety and Health Administration (OSHA), American National Standards Institute (ANSI), Crane Manufacturers Association of America (CMAA), and unique NASA requirements. The intent is to provide an opportunity to combine the knowledge of all NASA centers, standardize definitions, clarify/document OSHA interpretations, address the subject of criticality, and develop standardized requirements. The intent is not to be a substitute for OSHA requirements as OSHA requirements apply to NASA operations in full.

Compliance with this standard is mandatory for all NASA-owned and NASA contractor-supplied equipment used in support of NASA operations at NASA installations. The individual installation safety organizations are responsible for implementation and enforcement. This document establishes minimum safety requirements; NASA installations are encouraged to assess their individual programs and develop additional requirements as needed.

This standard is issued in loose-leaf form and will be revised by page changes.

Comments or suggestions concerning the application of these requirements to specific projects should be referred to the National Aeronautics and Space Administration Headquarters, Director, Safety Division, Office of the Associate Administrator for Safety and Mission Quality, Washington, DC 20546.

This Safety Standard cancels NSS/GO-1740.9, dated July 1988.



George A. Rodney
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RECORD OF CHANGES

Change Number	**Date**	**Page(s) Affected**	**Description**
1	3/93	iii	Update Record of Changes.
2	3/93	vi	Update Table of Contents for Chapter 7.
3	3/93	2-20 3-18 4-17	In Paragraphs 207a, 307a, and 407a; second to the last sentence; change “open propellant grain” to “exposed propellant grain.”
4	3/93	3-13	In Paragraph 306a(9) change “crane” to “crane/derrick.”
5	3/93	6-2	In the first sentence of Paragraph 602c(1) change “test weight” to “test load.”
6	3/93	7-4 through 7-12	Expand the operational test requirements in Paragraph 702c.

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CHAPTER 1: INTRODUCTION

100 GENERAL

This publication establishes NASA's minimum safety requirements for the design, testing, inspection, personnel certification/recertification, maintenance, and use of overhead and gantry cranes (including top running monorail, underhung, and jib cranes), mobile cranes, derricks, hoists, and special hoist supported personnel lifting devices (these do not include elevators, ground supported personnel lifts, or powered platforms; see Chapter 7). It also addresses minimum requirements for the testing, inspection, and use of Hydra-sets, hooks, and slings.

101 POLICY

a. Compliance with this standard is mandatory for all NASA-owned and NASA contractor-supplied equipment used in support of NASA operations at NASA installations. The individual installation safety organizations are responsible for implementation and enforcement. This document establishes minimum safety requirements; NASA installations should assess their individual programs and develop additional requirements as needed. The need for compliance with this standard at contractor installations performing NASA work should be evaluated and made a contractual requirement where deemed necessary by the contracting officer and the responsible NASA installation/program safety office.

b. This document is not a substitute for OSHA requirements. OSHA requirements apply to all NASA operations. This document meets or exceeds Federal OSHA requirements. Some States have their own OSHA programs that must comply with Federal OSHA and may be stricter. All NASA installations are responsible for keeping up to date with the Federal and State OSHA requirements that apply to their operations. This standard contains some OSHA requirements where deemed necessary to stress the importance of the requirement, clarify the requirement, document interpretation of the requirement, and/or define NASA's program for meeting the requirement. The NASA Safety Division, with assistance from the field installations, shall monitor subsequent OSHA requirements for any impact on NASA's safe lifting program.

c. There are two categories of lifting operations for the purposes of this standard, critical and noncritical.

   (1) Critical lifts involve lifting and lowering operations with special, high dollar items, such as spacecraft, one-of-a-kind articles, or major facility components, etc., whose loss would have serious programmatic impact. Critical lifts also include operations with special personnel and equipment safety concerns beyond normal lifting hazards.

(a) Each installation or program shall develop a process to identify critical lifting operations and lifting devices/equipment that must meet critical lift requirements. Input shall be gathered from facility, program, user, and assurance personnel. The results of the process shall be documented and approved, as a minimum, by the installation NASA Safety Director.

(b) It is NASA policy that the comprehensive safeguards outlined in this standard be provided for critical lifting operations. This includes special design features, maintenance, inspection, and test intervals for the lifting devices/equipment used to make critical lifts.

(c) Specific written procedures shall be prepared and followed for all critical lifts.

(d) Individuals with a designated safety responsibility (NASA or contractor) shall be present to monitor critical lift operations for compliance with this document.

(2) Noncritical lifts typically involve routine minimal hazard lifting operations and are governed by standard industry rules and practices except as supplemented with unique NASA testing, operations, maintenance, inspection, and personnel licensing requirements contained in this standard.

d. The requirements for critical and noncritical lifts outlined in this standard shall be followed unless a specific deviation/waiver is approved as outlined in Paragraph 104. Different levels of risks associated shall be evaluated using the risk determination criteria in NHB 1700.1(V1).

102 RECORDKEEPING AND TREND ANALYSIS

A data collection system shall be established at each installation or location to support NASAwide lifting device trend and data analysis. Data entered locally would typically be associated with type and manufacturer of the equipment, age, maintenance history, operational problems and their corrective actions, lifting mishaps, safety notices, inspection discrepancies, waivers, and proof and load test results. The data shall be provided to the NASA Safety Information System (NSIS) for use in analyzing the overall state of NASA and NASA contractor support lifting equipment and in establishing a historical data base. The NSIS is currently in development at NASA Headquarters Safety Office. Further guidance on the effect of the NSIS on this document shall be provided upon system implementation.

103 APPLICABILITY AND EXCLUSIONS

a. The testing, inspection, maintenance, operational, and operator certification/recertification/licensing requirements apply to new and existing lifting devices and equipment.

b. The design/hardware requirements contained in this document are applicable to new lifting devices/equipment purchased after 6 months from the issue date of this document. Existing equipment and that purchased during the first 6 months from issue of this document shall be reviewed for compliance with all design/hardware aspects of this standard within 12 months of its issue and the need to update such equipment shall be evaluated.

c. Deviations/waivers from the requirements of this document (including design/hardware requirements for both new and existing equipment) shall be approved as outlined in Paragraph 104. The deviation/waiver documentation shall include any alternate or special criteria or procedures that will be imposed to ensure safe design and operations for those devices that do not meet the applicable requirements.

d. Portions of this standard refer to various national consensus codes/standards for equipment design/hardware requirements (e.g., ANSI, CMAA, etc.). Lifting devices and equipment purchased after the initial review required in Paragraph 103b shall comply with the specified codes/standards in effect at the time of manufacture. Each installation shall periodically review subsequent codes/standards and evaluate the need to update existing equipment. Based on an evaluation of NASA's overall safe lifting program and any significant changes in the consensus codes/standards, the NASA Safety Division with concurrence from the field installations shall decide when the next complete review (as described in Paragraph 103b) is warranted.

e. This document does not include coverage for winches, forklifts, front-end loaders, elevators, aerial buckets, boom supported work platforms, scissor lifts, and manlifts.

104 DEVIATIONS AND WAIVERS

a. If a mandatory requirement cannot be met, a deviation/waiver package shall be prepared according to NHB 1700.1(V1). NASA deviations/waivers to requirements in this document shall be approved, as a minimum, by the installation NASA Safety Director.

b. The deviation/waiver package shall be forwarded to NASA Headquarters Safety for concurrence if it falls into one or both of the following categories:

(1) Deviations/waivers of OSHA requirements. OSHA requirements

may not be circumvented by a NASA deviation/waiver unless approved by OSHA (e.g., NASA Alternate Standard for Suspended Load Operations, Appendix B). After review by Headquarters, the deviation/waiver will be forwarded to OSHA for approval.

(2) Deviations/waivers that apply to the installation's lifting safety program/policy as a whole (not just a specific lifting device or operation) and will be in effect for more than a total of 45 days (including any extensions). For example:

(a) An installation prefers to perform rated load tests on cranes every 5 years rather than every 4.

(b) An installation prefers not to perform periodic load tests on slings.

(c) An installation prefers that the minimum approval authority for deviations/waivers be someone other than the installation NASA Safety Director.

c. All deviation/waiver documentation shall be provided to NASA Headquarters for incorporation into the NSIS.

105 REFERENCE DOCUMENTS

a. Department of Labor. Occupational Safety and Health Administration (OSHA); Occupational Safety and Health Standards, 29 CER 1910.

(1) 1910.179, Overhead and Gantry Cranes.

(2) 1910.180, Crawler, Locomotive, and Truck Cranes.

(3) 1910.181, Derricks.

(4) 1910.184, Slings.

(5) 1910.29, Manually Propelled Mobile Ladder Stands and Scaffolds (Towers).

(6) 1910.67, Vehicle-Mounted Elevating and Rotating Work Platforms.

b. American National Standards Institute (ANSI).

(1) B30.2, Overhead and Gantry Cranes (multiple girder).

(2) B30.5, Crawler, Locomotive, and Truck Cranes.

(3) B30.6, Derricks.

(4) B30.7, Base Mounted Drum Hoists.

(5) B30.9, Slings.

(6) B30.10, Hooks.

(7) B30. 11, Monorails and Underhung Cranes.

(8) B30. 16, Overhead Hoists.

(9) B30. 17, Overhead and Gantry Cranes (single girder).

(10) MH27.1, Specifications for Underhung Cranes and Monorails.

(11) A58.1, Minimum Design Loads for Buildings and Other Structures.

(12) A10.4, Safety Requirements for Personnel Hoists.

(13) A10.22, Safety Requirements for Rope Guided and Nonguided Workman's Hoist.

(14) A10.28, Safety Requirements for Workplatforms Suspended from Cranes or Derricks.

(15) A39.1, Safety Requirements for Window Cleaning.

(16) ANSI/NFPA 1904-1975, American National Standard Practice for the Maintenance, Care, Testing, and Use of Fire Department Aerial Ladders and Elevating Platforms.

(17) ANSI/ASME HST-1M-1982, Performance Standard for Electric Chain Hoists.

(18) ANSI/ASME HST-2M-1983, Performance Standard for Hand Chain Manually Operated Chain Hoist.

(19) ANSI/ASME HST-3M-1985, Performance Standard for Manually Lever Operated Chain Hoist.

(20) ANSI/ASME HST-4M-1985, Performance Standard for Overhead Electric Wire Rope Hoists.

(21) ANSI/ASME HST-5M-1985, Performance Standard for Air Chain Hoists.

(22) ANSI/ASME HST-6M-1986, Performance Standard for Air Wire Rope Hoists.

c. National Aeronautics and Space Administration (NASA).

(1) NHB 1700.1 (V-1A), Basic Safety Manual.

(2) NHB 7320.1, Facilities Engineering Handbook.

(3) NASA SPECSINTACT, Standard Construction Specification System.

(4) NASA SPECSINTACT, Section 14370, Monorails and Hoists.

(5) NASA SPECSINTACT, Section 14380, Electric Overhead Cranes.

d. Crane Manufacturers Association of America, Inc. (CMAA).

(1) CMAA Specification No. 70, Specifications for Electric Overhead Traveling Cranes.

(2) CMAA Specification No. 74, Specification for Top Running and Under Running Single Girder Electric Overhead Traveling Cranes.

e. Other.

(1) NFPA No. 70, National Electric Code.

(2) NEMA - National Electrical Manufacturers Association.

(3) SAE J765, Crane Load Stability Test Code.

(4) American Welding Society (AWS) D1.1-86, Structural Welding and Cutting Code.

(5) ANSI/AWS D14.1-82, Specifications for Welding Industrial and Mill Cranes.

(6) American Institute of Steel Construction, Inc. (AISC) “Manual of Steel Construction,” 400 North Michigan Avenue, Chicago, Illinois 60611.

(7) PCSA - Power Crane and Shovel Association, Standards No. 1, No. 2, No. 4, and No. 5.

CHAPTER 2: OVERHEAD CRANES

200 GENERAL

This chapter establishes safety standards for the design, test, inspection, maintenance, operation, and personnel certification/recertification for overhead and gantry cranes, including underhung, monorail, and jib cranes.

201 SAFETY ASPECTS

Generally, high quality off-the-shelf, Original Equipment Manufacturer (OEM) type equipment is acceptable for critical and noncritical lifts if it is designed, maintained, operated, etc., according to this standard.

a. Safety Design Criteria that should be emphasized during overhead crane design are contained in the documents listed in Paragraph 105.

b. Labeling/Tagging of Cranes.

(1) The rated load of all cranes shall be plainly marked on each side of the crane. If the crane has more than one hoisting unit, each hoist load block shall be marked with its rated load. This marking shall be clearly legible from the ground floor (OSHA requirement for all overhead cranes).

(2) Cranes that have the specified design features, maintenance/inspection, and test intervals to lift critical loads shall be marked conspicuously so that the operator and assurance personnel can distinguish that the crane is qualified for critical lifts.

(3) A standard system of labeling shall be established and used throughout the installation.

(4) A standard tag-out system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance operations, etc.

(5) Certification/recertification tags are required as described in Paragraph 202e.

c. Safety Analysis and Documentation of Cranes Used for Critical Lifts. A hazard analysis shall be performed on all cranes used for critical lifts. The analysis shall, as a minimum, determine potential sources of danger, identify most probable failure modes, and recommend resolutions for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, or loss of crane, facility, or load. The analysis also shall include crane description, reference

documentation, severity assessment, and assessment of specified passive and structural components between the hook and the holding brakes. Hazards that are identified shall be tracked (recorded and current status maintained) until final closure is verified. A system of risk acceptance is required for hazards that cannot be eliminated. The hazard analysis shall be done as part of the initial crane certification process, included in the crane documentation, and updated as required to reflect any changes in operation and/or crane configuration.

d. Performance. Operational life, crane service classification, load capability, and the desired control characteristics with which the crane handles the load shall be addressed for all designs. The expected operational life shall be specified or detailed for system components. Crane service classification requirements shall be based on the worst expected duty the unit will encounter. Each load-bearing component shall be specified or detailed to lift the maximum imposed loads resulting from zero to rated hook load with appropriate safety factors. Operational requirements shall be considered in the design phase to ensure load and function are adequately defined and critical crane design features are incorporated on the delivered units.

e. Structural. Structural design shall be in accordance with industry standards for material selection, welding, allowable stresses, design limitations, framing, rails, wheels, and other structural elements. Refer to ANSI and CMAA standards for specific design details.

f. Mechanical.

(1) The use of high quality, off-the-shelf, OEM type equipment is acceptable for critical and noncritical lift applications if it meets all user requirements and the requirements of this document. This high quality commercial equipment employs a modular type construction of the hoist unit with standard frame sizes and interchangeable gear boxes, drums, motors, brakes, and controls to achieve a wide range of capacities, lifts, operating speeds, reeving arrangements, and controls. These interchangeable parts are standardized for each manufacturer’s product line and the hoists are built to order.

(2) The mechanical design requirements for crane components are as follows:

(a) They shall meet all applicable requirements of OSHA, ANSI, and CMAA.

(b) For critical lift application, speed reduction from the motor to the drum on the hoist should be achieved by enclosure in a gear case. If open gears are required, they shall be guarded with a provision for lubrication and inspection.

(c) Gearing shall be designed and manufactured to comply with the latest American Gear Manufacturers Association (AGMA) gear standards.

(d) Hooks shall meet the manufacturer's recommendations, and shall not be overloaded. Swiveling hooks should rotate 360 degrees on antifriction bearings with means for lubrication. If grease is a contamination concern, drip funnels (cups) or nonlubricated bearings should be provided. Latch-equipped hooks shall be used unless the application makes the use of a latch impractical or unnecessary. When required, a latch or mousing shall be provided to bridge the throat opening of the hook to retain slings, chains, or other similar parts under slack conditions.

(e) Each hoisting unit shall be provided with at least two means of braking: a holding brake and a control brake. The torque ratings, physical characteristics, and capabilities of the brakes shall be in accordance with CMAA specifications.

(f) For cranes used for critical lifts, two means of braking shall be provided, each capable of bringing a rated load to zero speed and holding it (with and without power). If the control brake and holding brake are designed to operate as a system and cannot independently stop and hold a rated load, then another means of braking is required for cranes used for critical lifts (e.g., emergency brake). The brakes shall be designed so that they can be tested as required in Paragraph 202c(4).

(g) Worm gears shall not be used as a braking means unless the lead angle is sufficient to prevent back driving. The braking properties of a worm gear tend to degrade with use; the design engineer shall consider this when purchasing new equipment or in existing installations where the hoist is subject to heavy use.

(h) In the procurement of new lifting equipment, the use of cast iron components in the hoist load path shall be approved, as a minimum, by the installation NASA Safety Director. The material properties of cast iron allow catastrophic failure and should not be considered as reliable as steel or cast steel. The engineer shall consider this when selecting equipment and avoid the use of load bearing cast iron materials where possible.

(i) Safe and adequate access to crane components to inspect, service, repair, or replace equipment shall be provided for during design. The design shall provide for visual and physical accessibility.

(j) Pneumatic cranes shall have the capability to lock out the supply air pressure to prevent unauthorized use.

(k) Based on the sensitivity of the loads to be lifted, cranes shall have appropriate speed modes that provide for safe, smooth starting and stopping to preclude excessive "G" forces from being applied to the load.

(l) All wire rope hoists shall have not less than two wraps of hoisting rope on the drum when the hook is in its extreme low position. Drum grooves, when provided, shall be as recommended by CMAA. The rope ends shall be anchored securely by a clamp or a swaged terminal in a keyhole slot, provided a keeper is used to prohibit the swage from moving out of the narrow slot. Other methods recommended by the hoist or wire rope manufacturer are acceptable if the rope termination anchor together with two wraps of rope on the drum will give an anchor system equal to or greater than the breaking strength of the wire rope.

(m) Manually operated (nonpowered) hoist cranes that are off-the-shelf OEM type are acceptable for critical and noncritical lift applications. They shall comply with applicable ANSI requirements. These hoists need only be equipped with at least one brake as described in industry standards and no limit switches, if proper over-travel restraint is provided.

(n) Air operated chain hoists can be equipped with over-travel protection devices instead of the hoist travel limit switches.

(o) Initial and final upper limit switches (limit control valves) shall be provided and tested for critical air operated hoists as described in Paragraph 201g(9). The final upper limit switch (limit control value) shall exhaust air from the crane hoist, set the brakes, and require reset at the upper limit switch (limit control valve) level.

(p) A minimum clearance of 3 inches overhead and 2 inches laterally shall be provided and maintained between the crane and all obstructions.

(3) When the use of high quality, off-the-shelf, OEM type equipment is not possible due to unique design and operation requirements, then built-up type equipment must be used. These built-up cranes generally use many commercially available or made-to-order motors, brakes, couplings, gear reducers, etc. These components are then custom engineered together as an assembly mounted on custom designed and built equipment frames. In many cases, gear reducers, drums, and drive shafts are custom designed and built. Structural and mechanical parts, such as sheave pins, hook-block components, bridge girders, bridge and trolley drives, etc., are also custom designed and built as components or assemblies. The built-up type crane should only be used where commercial equipment is not available to meet the user/operational requirements described in this paragraph. Due to the nature of its one of a kind design and construction, this type of equipment is generally more prone to break down and should be considered as less reliable than commercial equipment. These units shall meet the mechanical design requirements provided in Paragraph 201f(2) and the following additional minimum requirements:

(a) Drum supporting structures should be designed so that bearings are mounted under compression to (1) minimize wearing of the bearings and (2) increase the probability of maintaining the mesh between the drum gear and the drive gear in the case of bearing failure. The structure shall be designed to preclude failure of the bearings and drum supports. Pillow block bearings shall have steel, or cast steel housings (the use of cast iron is not permitted).

(b) In descending order of preference, the drum gear when used shall be integrally attached, splined, bolted with close fitting body-bound bolts to a flange on the drum, or pressed on and keyed to either the periphery of the hub or shell of the drum, or attached by other means of equal safety.

(c) Couplings shall be located immediately next to bearings. Couplings between closely spaced bearings shall be of a full flexible type with integral gear form or grids, having metal to metal contact, and shall run in oil or be lubricated as recommended by the manufacturer. All couplings for hoists shall be pressed fit with keys.

g. Electrical. Electrical design requirements are as follows:

(1) Wiring and safety devices shall be in accordance with National Fire Protection Association (NFPA) National Electrical Code. Conduit and wiring shall be such that on-site work is minimized. Hard wire conductors such as festooned cables or articulated cable carriers, instead of power or feed rails, shall be considered to provide power

and control to overhead cranes handling explosives or solid propellants, or to cranes with solid state controls.

(2) Electrical enclosures shall provide protection for the contained equipment against environmental conditions according to the class rating established by National Electrical Manufacturers Association (NEMA).

(3) Though not a requirement, besides electrical power overload protection required by the National Electrical Code, under-voltage, and phase reversal should be considered.

(4) Control stations shall operate on 150 volts DC, 120 volts AC, or less. Positive detent pushbuttons or a control lever shall be used for speed control. Controls shall return to the off position when the operator relieves pressure. A red, emergency stop pushbutton shall be provided to operate the mainline contactor and/or the main circuit breaker. A positive lockout to the controls shall be provided to ensure the safety of maintenance personnel.

(5) All cab-operated cranes with step type control shall be equipped with lever controls. The levers shall be of the continuous effect type and provided with a deadman feature that will not unduly tire the operator during lengthy operations.

(6) The electrical system shall be designed fail-safe to ensure that a failure of any component will not cause the crane to operate in a speed range faster than commanded. A failure that causes a speed different from that selected is acceptable provided no hazards are introduced. Failure modes that cause the bridge, trolley, or hoist to slow down or come to a safe stop are acceptable; those that could cause a hard stop, unplanned directional shifts, and/or loss of control are unacceptable.

(7) Provisions for grounding the hook are required for handling explosives, solid propellants, flammables, or any other load that requires a nonelectrical or static-free environment. See Paragraph 207.

(8) For cranes used for critical lifts, an assessment shall be performed to determine the operational needs for remote emergency stops independent from the operator controlled emergency stop. Not all cranes used for critical lifts require a remote emergency stop. Remote emergency stops are required for cranes used for critical lifts where the crane operator’s view is restricted/obstructed. When provided, this independent remote emergency stop should be located such that the independent remote emergency stop operator(s) can clearly see the critical lift area(s). The remote emergency stop circuit shall be separate from and take precedence

over the operator control circuit. The control, when activated, shall cause all drives to stop and the brakes to set. Hand-held remote emergency stop pendants should be standardized and should include power and circuit continuity indication. For those cranes required to make critical lifts and have not been modified to provide a remote emergency stop, handling procedures shall be developed and implemented to minimize the risk.

(9) For cranes used for critical lifts, dual upper limit switches are required. For electric cranes, the limit switches shall meet the following requirements:

(a) Initial upper limit switch electrical contacts shall be a set of normally closed contacts in the “raise” contactor circuit such that movement in the raise direction shall be precluded after the limit switch is encountered. Movement in the “lower” direction will not be inhibited.

(b) Final upper limit switch electrical contacts shall be a set of normally closed electrical contacts wired into the mainline circuit, hoist power circuit, main contactor control circuit, or hoist power contactor control circuit such that all crane motion or all hoist motion shall be precluded after the limit switch is encountered. These normally closed contacts may be located in the low voltage control circuitry.

(c) After a final upper limit switch has been activated, movement of the load will require action (resetting) at the final upper limit switch level. An inspection shall be made to determine the cause of failure of the initial upper limit switch. Stopping crane motion by the above design configuration may result in a hazardous suspended load condition. The crane design should include a means of detecting limit switch failure and allow for safe inspection and repair. For example, a system may be equipped with two different colored annunciator lights, one for each limit switch. A reset button may be included so that when a final upper limit switch is tripped, the load can be lowered immediately. The reset button should be secured to prevent unauthorized use.

(d) The initial upper limit switch shall be adjusted sufficiently low to preclude inadvertent actuation of the final upper limit switch if the hoist actuates the initial upper limit switch at full speed with no load. Similarly, the final upper limit switch shall be adjusted sufficiently low to ensure that the hoist will not two-block (or otherwise damage wire rope) if the hoist actuates the final upper limit switch at full speed with no load. Both limits shall be tested from slow speed to

full speed to verify correct operation. It should be noted that this requirement effectively lowers the usable hook height of the hoist. The limit switch arrangement shall be considered during new equipment design.

(10) For cranes used for critical lifts, lower limit switches to prevent reverse winding of the wire rope shall be provided.

(11) Electrical cranes shall have the capability to be locked out at the main breaker to prevent unauthorized use.

(12) Cranes shall be designed fail-safe in the event of a power outage.

202 TESTING

Three types of tests are required for cranes: proof load tests, rated load tests, and operational tests. The proof load tests and operational tests shall be performed prior to first use for new cranes, or for existing cranes that have had modifications or alterations performed to components in the load path. This applies only to those components directly involved with the lifting or holding capability of a crane that has been repaired or altered. Repairs or alterations to nonlifting, secondary lifting, or holding components such as suspension assemblies, electrical system, crane cab, etc., do not require a load test, although a functional check should be performed to determine if the repairs or alternations are acceptable. The rated load and operational tests shall be performed at least every 4 years. Cranes used frequently for critical lifts shall be load tested annually. Cranes used infrequently for critical lifts shall be load tested before the critical lift if it has been more than a year since the last test. If a crane is upgraded (increased lifting capacity), a proof load test and an operational test shall be performed based on the upgraded rating. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures approved by NASA and/or contractor safety representatives. An inspection of the crane and lifting components shall be performed after each load test and prior to the crane being released for service to ensure there is no damage. This inspection may include Nondestructive Evaluation (NDE) of components that are suspected to be cracked or otherwise affected by the test. The rated load test requirement may be fulfilled by a concurrently performed proof load test.

a. Proof Load Test. Before first use and after installation, all new, extensively repaired, extensively modified, or altered cranes shall undergo a proof load test with a dummy load as close as possible to, but not exceeding 1.25 times the rated capacity of the crane. A proof load test also should be performed when there is a question in design or previous testing. The load shall be lifted slowly and in an area where minimal damage will occur if the crane fails. The load rating of the crane shall be clearly marked to be legible from the operator's or user's position and shall not be more than the proof test weight divided by 1.25.

b. Rated Load Test. Each crane shall be tested at least once every 4 years with a dummy load equal to the crane's rated capacity. Cranes used frequently for critical lifts shall be load tested at least once per year. Cranes used infrequently for critical lifts shall be load tested before the critical lift if it has been more than a year since the last test. The acceptable tolerance for rated load test accuracy is +5/-0 percent unless otherwise specified by design.

c. Operational Test. Together with proof load and rated load tests, the following shall be performed with a dummy rated load unless otherwise specified (except as noted in Paragraph 202c(5)):

(1) Load hoisting, lowering at various speeds (maximum safe movement up and down as determined by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations), and braking/holding mechanisms. Holding brakes shall be tested to verify stopping capabilities and demonstrate the ability to hold a rated load.

(2) Trolley and bridge travel (maximum safe movement in all directions with varying speeds as determined by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations).

(3) All limit switches, locking devices, emergency stop switches, and other safety devices, excluding thermal overload and circuit breakers. The limit switch, emergency stop, and locking device tests except for the final upper limit switch shall be performed with no load on the hook at full speed. The final upper limit switch can be tested by manually tripping the switch and verifying that all hoist motion is precluded (see Paragraph 204b(3)).

(4) Cranes used for critical lifts are required to be equipped with at least two means of braking (hoist), each capable of bringing a rated load to zero speed and holding it (see Paragraph 201f(2)(f)). The operational test must demonstrate each brake's ability to stop and hold a rated load. This can be done in one of the following ways:

(a) Each brake's ability to hold shall be statically tested (under no load) with 150 percent of the rated load hoisting torque at the point of brake application.

(b) Alternately, each brake shall be tested for its ability to stop a rated load moving at full speed in the down direction. (CAUTION: It must be possible to quickly reenergize the out-of-circuit brake or provide other safety measures to perform this test safely.)

(c) Other methods as specified by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations.

(5) The operational test for a modified crane can be tailored to test those portions of the equipment that were modified only if the normal rated load and operational test interval has not expired.

d. An organization may certify a crane for a specific lift (critical or noncritical). A load test and an operational test with a dummy load are required. In this case, the test weight shall be at least equal to the specific load that the crane is being certified to lift and may be greater as determined by the user and maintenance organization. The test weight shall not exceed 125 percent of the crane's rated capacity.

e. Test Reports and Periodic Recertification Tags. After each test, designated personnel shall prepare written, dated, and signed test reports including procedure reference. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be kept on file by the owner organization for a minimum of two test cycles and shall be made readily available. Following the rated load test, cranes shall be given a permanently affixed tag identifying the equipment and stating the next required rated load test date or certification expiration date.

203 INSPECTION

a. Daily and periodic safety inspections shall be performed on all cranes and crane accessories. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, corrected prior to further use. Inspections shall be made by qualified designated personnel according to approved technical operating procedures.

b. All new, extensively repaired, or modified cranes shall be given a daily and a periodic inspection prior to first use. For component repair on cranes, only the inspections that apply to the repaired portion need to be performed prior to first use unless a periodic inspection interval expires during the downtime (see Paragraph 203e).

c. Cranes in regular service (used at least once a month) shall be inspected as required in Paragraphs 203d and 203e. Idle cranes shall be inspected according to Paragraph 203f.

d. Daily Inspections. These inspections shall be performed by the certified operator prior to first use each day the crane is used, and shall include the following:

(1) Check functional operating and control mechanisms for maladjustments that could interfere with normal operations.

(2) Without disassembling, visually inspect lines, tanks, valves, drain pumps, gear casings, and other components of fluid systems for deterioration and leaks. This applies to components that can be seen from the ground level or for which there is safe access via crane inspection walkways.

(3) Without disassembling, visually inspect all functional operating and control mechanisms for excessive wear and contamination by excessive lubricants or foreign matter.

(4) Visually inspect hooks for cracks and deformities (see Chapter 5).

(5) Visually (without climbing up to bridge) inspect rope reeving for proper travel and drum lay, and inspect wire rope for obvious kinks, deformation, wire clips, and/or damage.

(6) Visually inspect hoist chains for excessive wear or distortion.

e. Formal Periodic Inspections. These inspections shall be performed at varying intervals, depending on activity, severity of service, environment, and criticality.

(1) Annual Inspections. At least once per year, inspect for:

(a) Deformed, cracked, or corroded members and welds and loose bolts or rivets in crane structure and runway. Various methods of nondestructive examination such as ultrasonics, x-ray, magnetic particle, dye penetrant, etc., shall be used as needed.

(b) Cracked or worn sheaves and drums.

(c) Wear or cracks in pins, bearings, shafts, gears, followers, and locking and clamping devices. NDE techniques should be used if cracks are suspected.

(d) Wear in brake and clutch system parts, linings, pawls, and ratchets that are readily accessible without major disassembly beyond an acceptable limit. Major teardown to inspect such parts should be based on a frequency consistent with gearbox lubrication analysis and other manufacturers' recommended maintenance programs for these components.

(e) Inadequacies in load and other indicators over full range.

(f) Wear in chain drive sprockets and stretch in the chain beyond an acceptable limit.

(g) Gasoline, diesel, electric, or other power plants for proper performance or noncompliance with applicable safety requirements.

(h) Evidence of a malfunction in travel, steering, braking, and locking devices.

(i) Evidence of a malfunction in any safety device.

(j) Pitting or other signs of deterioration in electrical apparatus. Special attention shall be given to feed rails.

(k) Evidence of overheating.

(2) Monthly Inspections. At least once per month:

(a) Inspect for wear, twist, distortion, or stretch of hoist chains.

(b) Perform a thorough inspection of all ropes paying particular attention to the signs of deterioration and damage outlined in Paragraph 204c(3).

(c) Inspect for visible deformation or cracks in hooks (see Chapter 5).

f. Idle and Standby Cranes. Cranes idle for more than 1 month shall be inspected prior to first use according to the requirements of Paragraphs 203d and 203e that were not performed at required intervals and recorded during the standby period.

g. Inspection Reports. After each formal periodic inspection, qualified, authorized personnel shall prepare written, dated, and signed inspection reports. These reports shall include procedure reference and adequacy of the crane/crane components. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and be made readily available by the organizational element responsible for crane inspection.

204 MAINTENANCE

A preventive maintenance program shall be established based on manufacturers' recommendations and/or experience gained from use of the equipment. The program shall include procedures and a scheduling system for normal periodic maintenance items, adjustments, replacements, and repairs. The program also

shall ensure that records are kept and unsafe test and inspection discrepancies are documented and corrected.

a. Maintenance procedures. Before maintenance, adjustments, repairs, and replacements are initiated, the following safety precautions shall be taken:

(1) Move crane to an area where maintenance will not interfere with other operations.

(2) Turn off all controls, move main or emergency switch to OPEN, and lock and tag switch in OPEN position unless it is necessary to have power on to perform the maintenance task.

(3) If other cranes are operating on the same runway as the crane being repaired, ensure that proximity limit switches are operating on all cranes or that an observer is stationed to prevent interference with other cranes.

(4) Cranes shall not be operated until all safety devices have been activated and tested/adjusted if involved in the maintenance action.

b. Adjustments. Based upon the manufacturer's documentation and/or experience, adjustments shall be made to ensure that all crane components function properly, paying particular attention to:

(1) Brakes. (Appropriate precautions should be taken by inspectors, repair personnel, and others who may be potentially exposed to airborne dust fibers from any asbestos friction materials present in crane braking mechanisms.)

(2) Control system.

(3) Limit switches.

(a) The hoist initial upper limit switch shall be verified by running the empty hook at full speed into the limit switch. It is recommended that the switch be verified at slow speed prior to adjustment.

(b) For cranes used for critical lifts, the final upper limit switch shall be independently verified and adjusted as described above at installation and after modifications that could affect switch operation. The switch can be tested periodically by manually tripping it and verifying that all hoist motion is precluded.

(4) Power plants.

(5) Critical operating mechanisms and safety devices.

c. Repair/Replacements.

(1) For repair/replacement requirements for crane hooks with deformation or cracks, see Chapter 5. If repaired, crane hooks shall be proof load tested using the associated crane proof load value.

(2) Structural members that are cracked, bent, broken, excessively worn, or corroded shall be replaced or repaired. Use proper material and weld/repair procedures according to manufacturers' specifications and ANSI/AWS D14.1-82.

(3) The need to replace wire rope shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results. Any of the following signs of deterioration and damage are sufficient reasons for questioning continued use of the rope:

(a) Twelve randomly distributed broken wires in one rope lay or four broken wires in one strand in one lay.

(b) Individual outside wires with wear of 1/3 the original diameter.

(c) Kinking, crushing, bird caging, or any other damage resulting in distortion.

(d) Evidence of heat damage.

(e) End connectors that are cracked, deformed, or with evidence of rope pullout.

(f) Corrosion (internal or external) that results in reduction of rope diameter, or at end connectors.

(g) Reductions of nominal diameter (measured with a caliper or go/no-go gage) of more than:

1 1/64 inch for diameters of rope up to 5/16 inch.

2 1/32 inch for diameters 3/8 inch to 1/2 inch.

3 3/64 inch for diameters 9/16 inch through 3/4 inch.

4 1/16 inch for diameters 7/8 inch through 1-1/8 inches.

5 3/32 inch for diameters greater than 1-1/8 inches.

(h) If replaced, the new rope shall be proof load tested using the associated crane proof load value.

205 PERSONNEL CERTIFICATION

a. Program. Only certified (licensed) and trained operators shall be authorized to use/operate cranes. A training, examination, and licensing program shall be established or made available. For those NASA installations that do not have a training program, all crane operators shall be trained and certified by a recognized crane certification organization that normally performs this function. Certification also shall include riggers and flagmen.

b. Levels. Two levels of operator training and proficiency will be established. Operations where critical lifts are involved will require a more rigid operator certification program than those operations that involve more routine lifts that do not involve critical hardware or unique hazards.

(1) Noncritical Lifts. The certification program for noncritical lift operators shall include the following:

(a) Training

1 Classroom training in safety and first aid/emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

2 Hands-on training (for initial certification and as needed).

3 An annual review of the items in Subparagraph (a) above. (This may be conducted informally by local supervisory personnel.)

(b) Examination

1 Physical examination (criteria to be determined by the cognizant medical official using ANSI requirements).

2 Written examination.

3 Operational demonstration (for initial certification only).

(c) Licensing/Operator Certification

1 An organizational element shall be designated to issue operator licenses/operator certification. Provisions shall be made to revoke licenses for negligence,

violations of safety requirements, or failure to meet medical standards. Provisions shall be made for periodic checks of operators to verify they have licenses in their possession. The licenses shall indicate the type of crane the holder is qualified to operate. Alternately, the organizational element may elect to maintain a master list of licensed operators instead of issuing individual licenses, providing copies of the list are readily available to assurance and supervisory personnel at the work site.

2 Renewal of all licenses shall require demonstration of proficiency. Licenses or certifications will expire at least every 4 years. Renewal procedures will be established by each licensing organization but as a minimum, will include items in Paragraphs 205b(1)(a) and (b).

(2) Critical Lifts. Besides the training, examination, licensing, and renewal requirements for noncritical lifts, operators that are being certified to perform critical lifts must be trained in the specific hazards and special procedures associated with the lift. Operators also must demonstrate proficiency and operating finesse with the crane using a test load as appropriate for the initial certification or alternately be directly supervised by a certified operator during the first initial lifting period. The licenses will indicate specific cranes for which the operator is certified.

206 OPERATIONS

a. The following practices shall be observed for crane operations:

(1) General operating procedures describing crane operation, emergency steps, communication requirements, and special requirements including checklists and inspection requirements shall be prepared, approved, and followed for each crane. There must be a formal system for review, approval, and update to maintain valid operating procedures. Emergency procedures shall be developed for contingency actions such as power loss, brake failure, or other emergencies. (Also, see Paragraph 101c(1)(c).)

(2) Operations shall be analyzed for hazards. The analysis shall consider the environment in which the operation occurs, hazards associated with crane maintenance, and, in general, a systems safety analysis of the equipment, facility, load, and interfaces as a whole in support of the lifting operation.

(3) Methods and procedures shall be developed for lowering a load in the event of crane failure or other contingencies. These should be demonstrated and verified if practical.

(4) A crane shall not be loaded beyond its rated load (capacity) except for required testing.

(5) Cranes may be used to load test items such as slings, platforms, or lifting fixtures if specifically identified to do so based on a specified percentage of rated load and a safety analysis approved by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations. This is to ensure that the crane is not damaged due to sudden unloading should the test article fail.

(6) Cranes shall not be used for side pulls unless specifically designed to do so.

(7) There shall be a system for documenting crane problems/discrepancies. Prior to an operation, the operator shall review any previously noted problems/discrepancies to determine possible impact on planned activity.

(8) The operator shall ensure that the crane is within inspection and testing intervals by examination of the periodic recertification tags and/or documentation.

(9) Before each lift or series of lifts, the operator shall perform a pre-operational check to demonstrate operational readiness. If controls do not operate properly, the operator is responsible for notifying the supervisor. Repairs and adjustments shall be made before operations begin.

(10) The operator shall establish safety zones before initiating operations. Safety zones should have appropriate barriers (rope, cones, etc.) established prior to lift.

(11) Before each lift or series of lifts, the operator shall functionally test proper operation of the upper limit switch with no load on the hook. Upper limit switches shall not be used as operating controls.

(12) Before starting to hoist, the following conditions shall be noted: the hoist rope shall not be kinked, multiple part ropes shall not be twisted around each other, and the hook shall be centered over the load in such a manner as to prevent swinging or side pulls.

(13) When raising loads that approach the rated capacity of the crane, the operator shall know the weight of the working load. The operator shall test the holding brakes each time a load approaching

the rated load is handled. The brakes shall be tested by raising the load minimally above the surface and holding the load with the brake. The load should be held long enough to allow any dynamics to dampen out.

(14) If radio communications are to be used, crane operators and/or lift supervisors shall test the communication system prior to the operation. Operation shall stop immediately upon communication loss, and shall not continue until communication is restored.

(15) If hand signals are required, only standard signals shall be used according to Appendix C. Hand signals shall be posted in a conspicuous location.

(16) Crane crew emergency egress routes should be verified to be free of obstructions prior to hazardous operations. The availability of crane crew protective equipment should be verified prior to hazardous operations.

(17) If there is a slack rope condition, it shall be determined that the rope is properly seated on the drum and in the sheaves before starting the hoist.

(18) During hoisting, care shall be taken that there is no sudden acceleration or deceleration of the moving load and that the load does not contact any obstructions.

(19) Loads shall be secured, balanced, and controlled with proper slings. The use of tag lines to keep the load stabilized shall be required whenever load swinging is anticipated to be a viable hazard. Tag line personnel shall take care not to impart undesirable motion to the load.

(20) Person(s) shall not ride the hook or load at anytime. For personnel lifting requirements, see Chapter 7.

(21) Personnel shall not be located under suspended or moving loads unless the operation adheres to the OSHA-approved NASA Alternate Standard for Suspended Load Operations. (See Appendix B.)

(22) The load shall not be lowered below the point where less than two full wraps of rope remain on the hoist drum.

(23) A responsible person shall be in charge of the operation and shall instruct all personnel involved in the proper positioning, rigging, and moving to be done.

(24) An operator shall be at the crane controls at all times while a load is suspended (OSHA requirement). Due to the length of some NASA operations, an operator change may be required while a load is suspended. This shall be accomplished via a procedure designed for the specific crane and operation approved by the installation NASA Safety directorate, ensuring that the crane controls are manned at all times.

(25) Hands shall be free from encumbrances while personnel are using crane ladders. Articles that are too large to be carried in pockets or belts shall be lifted and lowered by handline.

(26) Necessary clothing and personal belongings in crane cab shall be stored so as not to interfere with access or operations. Tools, oil can, waste, extra fuses and other necessary articles shall be stored properly, and shall not be permitted to lie loose in the cab or on the crane. Operators shall be familiar with the operation and care of the fire extinguisher provided.

(27) Crane crew discipline shall be maintained at all times during a crane operation. There shall be no eating, drinking, or rowdiness during crane operation.

(28) Outdoor hoisting operations should not commence if winds are above 20 knots steady state or if gusts exceed 35 knots.

(29) A carbon dioxide, dry chemical, or equivalent fire extinguisher shall be kept in the cab or in the immediately available vicinity of the crane.

207 SPECIAL CRITERIA

a. Special precautions shall be taken while handling explosives or Electro Explosive Devices (EEDs). Safety support shall be available. Barricades and warning signs shall be erected to control access. Voltage checks on crane hooks that will handle explosives or EEDs shall be performed to verify that the measured energy level does not exceed 20 decibels below the maximum safe no-fire energy level in the bridge wire of the associated EED. (Example: For a NASA Standard Initiator with a maximum safe no-fire energy level of 1 watt, the measured energy level shall not exceed 10 milliwatts, which corresponds to 100 millivolts measured across a 1 ohm resistor.) The crane hook shall be connected to facility ground before connecting to explosives or EEDs. Electrical grounding of the hook and load shall be accomplished prior to lifting operations while handling explosives, EEDs, or electrically sensitive devices/payloads. The grounding shall be measured/verified to be within specification by inspection personnel and recorded prior to the lift. If a ground connection must be disconnected to facilitate operations, an alternate ground should be connected prior to disconnecting the existing ground. The final

attachment/detachment must be at least 10 feet from exposed propellant grain, explosives, or EEDs. The use of radio transmissions near explosives shall be evaluated for danger potential prior to the operation.

b. Policy shall be developed and enforced for crane operation during electrical storms. Operations are generally permitted without restriction within enclosed metal or framed buildings that are properly grounded. Restrictions are necessary for outside operations or for those that cannot tolerate power failure/loss.

CHAPTER 3: MOBILE CRANES AND DERRICKS

300 GENERAL

This chapter establishes safety standards for the design, testing, inspection, maintenance, and operation of mobile cranes and derricks.

301 SAFETY ASPECTS

Generally, high quality off-the-shelf, OEM type equipment is acceptable for critical and noncritical lifts if it is designed, maintained, operated, etc., according to this standard.

a. Safety Design Criteria that should be emphasized during mobile crane and derrick design are contained in the documents listed in Paragraph 105.

b. Labeling/Tagging of Mobile Cranes and Derricks.

(1) Mobile cranes and derricks that have the specified design features, maintenance/inspection, and test intervals to lift critical loads shall be marked conspicuously so that the operator and assurance personnel can distinguish that the crane/derrick is qualified for critical lifts.

(2) A standard system of labeling shall be established and used throughout the installation.

(3) A standard tag-out system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance operations, etc.

(4) Certification/recertification tags are required as described in Paragraph 302e.

c. Safety Analysis and Documentation of Mobile Cranes and Derricks Used for Critical Lifts. A hazard analysis shall be performed on all mobile cranes and derricks used for critical lifts. The analysis shall, as a minimum, determine potential sources of danger, identify most probable failure modes, and recommend resolutions for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personnel injury, or loss of crane/derrick, facility, or load. The analysis also shall include crane/derrick description, reference documentation, severity assessment, and assessment of specified passive and structural components between the hook and the holding brakes. Hazards that are identified shall be tracked (recorded and current status maintained) until final closure is verified. A system of risk acceptance is required for hazards that cannot be eliminated. The hazard analysis shall be done as part of the initial crane/derrick certification process, included

in the equipment documentation, and updated as required to reflect any changes in operation and/or configuration.

d. Performance. Operational life, load capability, and the desired controlled characteristics with which the crane/derrick handles the load shall be addressed for all designs. The expected operational life shall be specified or detailed for system components. Each load-bearing component shall be designed to sustain the maximum imposed loads with appropriate safety factors. Operational requirements shall be considered in the design phase to ensure load and function are adequately defined and critical crane/derrick design features are incorporated on the delivered units.

e. Structural. Structural design shall be in accordance with industry standards for material selection, welding, allowable stresses, design limitations, framing, wheels, and other structural elements. Refer to ANSI and Power Crane and Shovel Association (PCSA) standards for specific design details.

f. Mechanical. The mechanical design requirements for mobile crane and derrick components are as follows:

(1) They shall meet all applicable requirements of OSHA, ANSI, and PCSA.

(2) The drum gear shall be pressed on and keyed to either the periphery of the hub or shell of the drum, bolted with close fitting milled body bolts to a flange on the drum, or attached by other means of equal safety.

(3) Gearing shall be designed and manufactured to comply with the latest AGMA gear standards.

(4) Couplings shall be located immediately adjacent to bearings. Couplings between closely spaced bearings shall be of the full flexible type with internal gear form or grids, having metal-to-metal contact, and shall run in oil or be lubricated as recommended by the manufacturer. All couplings for hoists shall be pressed fit with keys.

(5) The rated load of a hoisting rope shall not exceed the rope's breaking strength divided by 3.5.

(6) Hooks shall meet the manufacturer's recommendations, and shall not be overloaded. Swiveling hooks should rotate 360 degrees on antifriction bearings with means for lubrication. If grease is a contamination concern, then either drip funnels (cups) or nonlubricated bearings should be provided. Latch-equipped hooks shall be used unless the application makes the use of a latch impractical or unnecessary. When required, a latch or mousing shall be provided to bridge the throat opening of the hook for the

purpose of retaining slings, chains, or other similar parts under slack conditions.

(7) Hoists shall be provided with at least two means of braking: a holding brake and a control brake. The torque ratings, physical characteristics, and capabilities of the brakes shall be in accordance with industry standards.

(8) For mobile cranes and derricks used for critical lifts, two means of braking shall be provided, each capable of bringing a rated load to zero speed and holding it (with and without power). If the control brake and holding brake are designed to operate as a system and cannot independently stop and hold a rated load, then another means of braking is required for cranes and derricks used for critical lifts (e.g., emergency brake). For a telescoping boom crane, the use of a counterbalance valve that locks the hydraulic fluid when the valve is in the neutral position is an acceptable braking means. The brakes shall be designed so that they can be tested as required in Paragraph 302c(6).

(9) A positive ratchet and pawl shall be provided on all boom hoist drum(s).

(10) Mobile cranes and derricks with booms shall be equipped with a boom angle indicator to assist the operator in ensuring that the crane/derrick is not loaded beyond the rated load for any given configuration.

(11) Safe and adequate access to components to inspect, service, repair, or replace equipment shall be provided for during design. The design shall provide for visual and physical accessibility.

(12) All wire rope hoists shall be designed to have not less than two wraps of hoisting rope on the drum when the hook is in its extreme low position. Drum grooves shall be provided as recommended by PCSA Standards No. 4 and No. 5. The rope ends shall be anchored securely by a clamp or a swaged terminal in a keyhole slot, provided a keeper is used to prohibit the swage from moving out of the narrow slot. Other methods recommended by the hoist or wire rope manufacturer are acceptable if the rope termination anchor together with two wraps of rope on the drum will give an anchor system equal to or greater than the breaking strength of the wire rope.

g. Electrical. Electrical design requirements are as follows:

(1) Wiring and safety devices shall be in accordance with the NFPA National Electrical Code.

(2) Electrical enclosures shall provide protection for the contained equipment against environmental conditions.

(3) Though not a requirement, besides overload protection required by the National Electrical Code, undervoltage and phase reversal should be considered.

(4) The electrical system shall be designed fail-safe to ensure that a failure of any component will not cause the crane/derrick to operate in a speed range faster than commanded. A failure that would cause the crane/derrick to go to a slower speed is acceptable as long as the stop function is still available. Failure modes that could cause a hard stop, unplanned directional shifts, and/or loss of control are unacceptable.

(5) Provisions for grounding the hook are required for handling explosives, solid propellants, flammables, or any other load that requires a nonelectrical or static-free environment (see Paragraph 307).

(6) Mobile cranes and derricks used for critical lifts do not require emergency stops or upper limit switches. This must be handled operationally. A telescoping boom crane shall be equipped with a two-blocking damage prevention feature.

302 TESTING

Three types of tests are required for mobile cranes and derricks: proof load tests, rated load tests, and operational tests. The proof load tests and operational tests shall be performed prior to first use for new, extensively repaired, or altered cranes and derricks. This applies only to those components directly involved with the lifting or holding capability of a crane/derrick that has been repaired or altered. Repairs or alterations to nonlifting, secondary lifting, or holding components such as suspension assemblies, electrical system, crane cab, etc., do not require a load test, although a functional check should be performed to determine if the repairs or alterations are acceptable. The rated load and operational tests shall be performed at least every 4 years. Cranes and derricks used frequently for critical lifts shall be load tested annually. Cranes and derricks used infrequently for critical lifts shall be load tested before the critical lift if it has been more than a year since the last test. If a crane/derrick is upgraded, a proof load test and an operational test shall be performed based on the upgraded rating. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures approved by NASA and/or contractor safety representatives. An inspection of the crane/derrick and lifting components shall be performed after each load test and prior to the crane/derrick being released for service to ensure there is no damage. This inspection shall include NDE of components that are suspected to be cracked or otherwise affected by the test. The rated load test requirement may be fulfilled by a concurrently performed proof load test.

a. Proof Load Test. Before first use, all new, extensively repaired, extensively modified, or altered cranes and derricks shall undergo a proof load test. A proof load test also should be performed when there is a question in design or previous testing. Mobile cranes and derricks shall be tested at the minimum working radius (and maximum working radius for new cranes and derricks only) with a load as close as possible to, but not exceeding 1.10 times the rated load at the given radius. The load shall be lifted slowly and in an area where minimal damage will occur if the crane/derrick fails. The minimum radius/maximum load capacity of the crane/derrick shall be clearly marked to be legible from the operator's or user's position and shall not be more than the proof test weight divided by 1.10. For cranes/derricks with separate lifting systems of different ratings, the markings will indicate the lifting capabilities of each system (e.g., main hook, whip hook, and auxiliary hook). Proof load tests conducted by the manufacturer prior to delivery are acceptable if the necessary test certification papers are provided to verify the extent and thoroughness of the test on that specific item.

b. Rated Load Test. Each mobile crane/derrick shall be tested at least once every 4 years with a dummy load equal to the rated capacity of the crane/derrick at the minimum working radius according to the manufacturer's load chart. Cranes/derricks used frequently for critical lifts shall be load tested at least once per year. Cranes/derricks used infrequently for critical lifts shall be load tested prior to the critical lift if it has been over a year since the last load test. A rated load test shall be performed after each boom change (when boom disassembly/assembly is required) if the crane/derrick is to be used for critical lifts. The acceptable tolerance for rated load test accuracy is + 5/-0 percent unless otherwise specified by design.

c. Operational Test. Together with proof load and rated load tests, the following shall be performed with a dummy rated load unless otherwise specified (except as noted in Paragraph 302c(7)):

(1) Load hoisting, lowering at various speeds with the boom at the minimum radius (maximum safe movement up and down as determined by the installation NASA Safety directorate and responsible engineering and operations/maintenance organizations), and braking/holding mechanisms. Holding brakes shall be tested to verify stopping capabilities and demonstrate the ability to hold a rated load.

(2) Boom hoisting and lowering through full safe operating range as determined by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations.

(3) Swinging and traveling mechanisms on mobile cranes (swinging for derricks) with boom at minimum radius.

(4) Boom extension and retraction mechanism on telescoping boom cranes.

(5) All limit switches, locking devices, emergency stop switches, boom angle indicators, and other safety devices, excluding thermal overload and circuit breakers. The limit switch tests shall be performed with no load on the hook.

(6) Cranes and derricks used for critical lifts are required to be equipped with at least two means of braking (hoist), each capable of bringing a rated load to zero speed and holding it (see Paragraph 301f(8)). The operational test must demonstrate each brake's ability to stop and hold a rated load. This can be done in one of the following ways:

(a) Each brake's ability to hold shall be statically tested (under no load) with 150 percent of the rated load hoisting torque at the point of brake application.

(b) Alternately, each brake shall be tested for its ability to stop a rated load moving at full speed in the down direction, using power-controlled lowering. (CAUTION: It must be possible to quickly reenergize the out-of-circuit brake or provide other safety measures to perform this test safely.)

(c) Other methods as specified by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations.

(7) The operational test for a modified crane/derrick can be tailored to test only those portions of the equipment that were modified, only if the rated load and operational test interval has not expired. After a boom change on a crane/derrick used for critical lifts, the operational test does not have to include verification of each brake (Paragraph 302c(6)) if it has been less than a year since the brakes were tested with a load equal to or greater than the maximum capacity of the crane/derrick with the new boom.

d. An organization may certify a mobile crane/derrick for a specific lift (critical or noncritical). A load test and an operational test with a dummy load are required. In this case, test weight shall be at least equal to the specific load that the crane/derrick is being certified to lift and may be greater as determined by the user and maintenance organization. The test weight shall not exceed 110 percent of the mobile crane's/derrick's rated capacity for the given configuration.

e. Test Reports and Periodic Recertification Tags. After each test, designated personnel shall prepare written, dated, and signed test reports including procedure reference. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be kept on file by the owner organization for a minimum of 2 test cycles and shall be made readily available. Following the rated load test, mobile cranes/derricks shall be given a permanently affixed tag identifying the equipment and stating the next required rated load test date or certification expiration date.

303 INSPECTION

a. Daily and periodic safety inspections shall be performed on all mobile cranes/derricks and accessories. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, corrected prior to further use. Inspections shall be made by designated personnel according to approved technical operating procedures.

b. All new, extensively repaired, or modified mobile cranes and derricks shall be given a daily and a periodic inspection prior to first use. For component repair on cranes/derricks, only the inspections that apply to the repaired portion need to be performed prior to first use unless a periodic inspection interval expires during the downtime (see Paragraph 303e).

c. Mobile cranes and derricks in regular service (used at least once a month) shall be inspected as required in Paragraphs 303d and 303e. Idle cranes shall be inspected according to Paragraph 303f.

d. Daily Inspections. These inspections shall be performed prior to first use each day the crane/derrick is used, and shall include the following:

(1) Check functional operating and control mechanisms for maladjustments that could interfere with normal operations.

(2) Without disassembling, visually inspect lines, tanks, valves, drain pumps, gear casings, and other components of fluid systems for deterioration and leaks. This applies to components that can be seen from the ground level or for which there is safe access via inspection walkways.

(3) Without disassembling, inspect all functional operating and control mechanisms for excessive wear and contamination by excessive lubricants or foreign matter.

(4) Inspect hooks for cracks and deformities (see Chapter 5).

(5) Inspect rope reeving for proper travel and drum lay.

(6) Inspect hoist chains for excessive wear or distortion.

(6) Inspect hoist chains for excessive wear or distortion.

e. Formal Periodic Inspections. These inspections shall be performed at varying intervals, depending on activity, severity of service, environment, and criticality.

(1) Annual Inspections. At least once per year, inspect for:

(a) Deformed, cracked, or corroded members and welds and loose bolts or rivets in crane structure. Various methods of NDE such as ultrasonics, x-ray, magnetic particle, dye penetrant, etc., shall be used as needed.

(b) Cracked or worn sheaves and drums.

(c) Excessive wear or cracks in pins, bearings, shafts, gears, followers, and locking and clamping devices. NDE techniques shall be used if cracks are suspected.

(d) Significant inadequacies in load, wind, boom, angle, and other indicators over full range.

(e) Excessive wear in chain drive sprockets and stretch in the chain.

(f) Abnormal performance in power plant(s) and compliance with applicable safety requirements, such as locations of guards on belts.

(g) Evidence of a malfunction in travel, steering, braking, and locking devices.

(h) Evidence of a malfunction in any safety device.

(i) Evidence of overheating.

(2) Monthly Inspections. At least once per month:

(a) Inspect for excessive wear in brake (hoist and boom) and clutch system parts, linings, pawls, and ratchets without major disassembly.

(b) Perform a thorough inspection of all ropes paying particular attention to the signs of deterioration and damage outlined in Paragraph 304c.

(c) Inspect for visible deformation or cracks in hooks (see Chapter 5).

f. Idle and Standby Cranes/Derricks. Cranes and derricks idle for more than 1 month shall be inspected prior to first use according to the requirements of Paragraphs 303d and 303e that were not performed at required intervals and recorded during the standby period.

g. Inspection Reports. After each formal periodic inspection, qualified, authorized personnel shall prepare written, dated, and signed inspection reports. These reports shall include procedure reference and adequacy of the crane/crane components. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and made readily available by the organizational element responsible for inspection.

304 MAINTENANCE

A preventive maintenance program shall be established based on manufacturers' recommendations and/or experience gained from use of the equipment. The program shall include procedures and a scheduling system for normal periodic maintenance items, adjustments, replacements, and repairs. The program shall also ensure that records are kept and unsafe test and inspection discrepancies are documented and corrected.

a. Maintenance procedures. Before maintenance, adjustments, repairs, and replacements are initiated, the following safety precautions shall be taken:

(1) Move to an area where maintenance will not interfere with other operations.

(2) Cranes/derricks shall not be operated until all safety devices have been activated and tested/adjusted if involved in the maintenance action.

b. Adjustments. Based upon the manufacturer's documentation and/or experience, adjustments shall be made to ensure that all components function properly, paying particular attention to:

(1) Brakes. (Appropriate precautions should be taken by inspectors, repair personnel, and others who may be potentially exposed to airborne dust fibers from any asbestos friction materials present in braking mechanisms.)

(2) Control system.

(3) Power plants.

(4) Critical operating mechanisms and safety devices.

(5) Operator mechanical and electrical controls.

c. Repairs/Replacements. Repairs/replacements shall be promptly provided for safe operation.

(1) For repair/replacement requirements for hooks with deformation or cracks, see Chapter 5. If repaired, hooks shall be proof load tested using the associated mobile crane/derrick minimum working radius proof load value.

(2) Structural members that are cracked, bent, broken, excessively worn, or corroded shall be replaced. Proper material and weld/repair procedures will be used according to ANSI/AWS D14.1-82 and manufacturer specifications. Procedures will be conducted by properly qualified personnel.

(3) The need to replace wire rope shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results. Any of the following signs of deterioration and damage are sufficient reasons for questioning continued use of the rope:

(a) Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay.

(b) Individual outside wires with wear of 1/3 the original diameter.

(c) Kinking, crushing, bird caging, or any other damage resulting in distortion.

(d) Evidence of heat damage.

(e) End connectors that are cracked, deformed, or with evidence of rope pullout.

(f) Corrosion (internal or external) that results in reduction of rope diameter, or at end connectors.

(g) Reductions of nominal diameter (measured with a caliper or go/no-go gage) of more than:

1 1/64 inch for diameters of rope up to 5/16 inch.

2 1/32 inch for diameters 3/8 inch to 1/2 inch.

3 3/64 inch for diameters 9/16 inch through 3/4 inch.

4 1/16 inch for diameters 7/8 inch through 1-1/8 inches.

5 3/32 inch for diameters greater than 1-1/8 inches.

(h) If replaced, the new rope shall be proof load tested using the associated mobile crane/derrick minimum working radius proof load value.

305 PERSONNEL CERTIFICATION

a. Program. Only certified (licensed) and trained operators shall be authorized to use/operate mobile cranes and derricks. A training, examination, and licensing program shall be established or made available. For those NASA installations that do not have a training program, all operators shall be trained and certified by a recognized certification organization that normally performs this function. Certification also shall include riggers and flagmen.

b. Levels. Two levels of operator training and proficiency will be established. Operations where critical lifts are involved will require a more rigid operator certification program than those operations that involve more routine lifts that do not involve critical hardware or unique hazards.

(1) Noncritical Lifts. The certification program for noncritical lift operators shall include the following:

(a) Training

1 Classroom training in safety and first aid/emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

2 Hands-on training (for initial certification and as needed).

3 An annual review of the items in Subparagraph (a) above. (This may be conducted informally by local supervisory personnel.)

(b) Examination

1 Physical examination (criteria to be determined by the cognizant medical official using ANSI requirements).

2 Written examination.

3 Operational demonstration (for initial certification only).

(c) Licensing

1 An organizational element shall be designated to issue operator licenses. Provisions shall be made to revoke licenses for negligence, violations of safety requirements, or failure to meet medical standards. Provisions shall be made for periodic checks of operators to verify they have licenses in their possession. The licenses shall indicate the type of crane/derrick the holder is qualified to operate. Alternately, the organizational element may elect to maintain a master list of licensed operators instead of issuing individual licenses, providing copies of the list are readily available to assurance and supervisory personnel at the work site.

2 Renewal. Licenses or certifications will expire at least every 4 years. Renewal procedures will be established by each licensing organization but as a minimum will include items in Paragraphs 305b(1)(a) and (b).

(2) Critical Lifts. Besides the training, examination, licensing, and license renewal requirements for noncritical lifts, operators that are being certified to perform critical lifts must be trained in the specific hazards and special procedures associated with the lift. Operators must also demonstrate proficiency and operating finesse with the crane/derrick using a test load for the initial certification or alternately be immediately supervised by a certified operator during the first initial lifting period. The licenses will indicate specific cranes/derricks for which the operator is certified.

306 OPERATIONS

a. The operator is responsible for being totally familiar with the information contained in the crane/derrick operating manual and load chart. The operator must understand the correct meaning of all notes and warnings and be able to calculate or determine the crane's/derrick's actual net capacity for every possible machine configuration. The following practices shall be observed for crane/derrick operations:

(1) General operating procedures describing operation, emergency steps, communication requirements, and special requirements shall be prepared, approved, and followed for each crane/derrick. There must be a formal system for review, approval, and update to maintain valid operating procedures. Emergency procedures shall be developed for contingency actions such as power loss, brake failure, or other emergencies. (Also, see Paragraph l01c(l)(c).)

(2) Operations shall be analyzed for hazards. The analysis shall consider the environment in which the operation occurs, hazards associated with crane/derrick maintenance, and, in general, a systems safety analysis of the equipment, facility, load, and interfaces as a whole in support of the lifting operation.

(3) Appropriate load charts shall be located in the crane/derrick cab, if so equipped. Otherwise, the load charts shall be kept in a central, easily accessible place. Mobile cranes and derricks shall not be operated without an appropriate load chart.

(4) For critical lifts, the load shall not exceed 75 percent of the crane's/derrick's rated capacity for the respective radius unless approved, as a minimum, by the installation NASA Safety Director. For critical lifts greater than 75 percent of rated capacity, extra care shall be taken to calculate exact weight, center of gravity, and lift radius.

(5) Methods shall be developed and demonstrated for lowering a load in the event of crane/derrick failure or other contingencies. These should be demonstrated and verified if practical.

(6) A crane/derrick shall not be loaded beyond its rated load (capacity) except for required testing.

(7) Cranes/derricks may be used to load test items such as slings, platforms, or lifting fixtures if specifically identified to do so based on a specified percentage of rated load and a safety analysis approved by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations. This is to ensure that the crane/derrick is not damaged due to sudden unloading should the test article fail.

(8) Cranes/derricks shall not be side loaded or used to drag loads sideways unless specifically designed to do so. Side loading of the boom shall be limited to freely suspended loads.

(9) There shall be a system for documenting crane/derrick problems/discrepancies. Prior to an operation, the operator shall review any previously noted problems/discrepancies to determine possible impact on planned activity.

(10) The operator shall ensure that the crane/derrick is within inspection and testing intervals by examination of the periodic recertification tags and/or documentation.

(11) Before each lift or series of lifts, the operator shall perform a pre-operational check to demonstrate operational readiness. If controls do not operate properly, the operator is responsible for notifying the supervisor. Repairs and adjustments shall be made before operations begin.

(12) The operator and ground lead man shall establish appropriate safety zones before initiating operations. Safety zones should have appropriate barriers (rope, cones, etc.) established prior to lift.

(13) Before starting to hoist, the following conditions shall be noted: the hoist rope shall not be kinked, multiple part ropes shall not be twisted around each other, and the hook shall be centered over the load to prevent swinging.

(14) When raising loads that approach the rated capacity of the crane/derrick, the operator shall know the weight of the working load. The operator shall test the holding brakes each time a load approaching the rated load is handled. The brakes shall be tested by raising the load minimally above the surface and holding the load with the brake. The load should be held long enough to allow any dynamics to dampen out.

(15) If radio communications are to be used, operators and/or lift supervisors shall test the communication system prior to the operation. Operation shall stop immediately upon communication loss, and shall not continue until communication is restored.

(16) If hand signals are required, only standard signals shall be used according to Appendix C. Hand signals shall be posted in a conspicuous location.

(17) Crane/derrick crew emergency egress routes should be verified to be free of obstructions prior to hazardous operations. The availability of crew protective equipment should be verified prior to hazardous operations.

(18) If there is a slack rope condition, it shall be determined that the rope is properly seated on the drum and in the sheaves before starting the hoist.

(19) During hoisting, care shall be taken that there is no sudden acceleration or deceleration of the moving load and that the load does not contact any obstructions.

(20) Load shall be secured, balanced, and kept under control with proper slings. The use of tag lines to keep the load stabilized may be required. Tag line personnel shall take care not to impart undesirable motion to the load.

(21) Person(s) shall not ride the hook or load at anytime.

(22) Personnel shall not be located under suspended or moving loads unless the operation adheres to the OSHA-approved NASA Alternate Standard for Suspended Load Operations. (See Appendix B.)

(23) The load shall not be lowered below the point where less than two full wraps of rope remain on the host drum.

(24) A responsible person shall be in charge of the operation and shall instruct all personnel involved in the proper positioning, rigging, and moving to be done.

(25) An operator shall be at the crane/derrick controls at all times while a load is suspended (OSHA requirement). Due to the length of some NASA operations, an operator change may be required while a load is suspended. This shall be accomplished via a procedure designed for the specific crane/derrick and operation, approved by the installation NASA Safety directorate, ensuring that the crane controls are manned at all times.

(26) Hands shall be free from encumbrances while personnel are using crane/derrick ladders. Articles that are too large to be carried in pockets or belts shall be lifted and lowered by handline.

(27) Necessary clothing and personal belongings in cabs shall be stored so as not to interfere with access or operations. Tools, oil can, waste, extra fuses, and other necessary articles shall be stored properly, and shall not be permitted to lie loose in the cab or on the crane. Operators shall be familiar with the operation and care of the fire extinguishers provided.

(28) Crane/derrick crew discipline shall be maintained at all times during an operation. There shall be no eating, drinking, or rowdiness during crane/derrick operation.

(29) Mobile cranes shall be level and, where necessary, outriggers shall be extended and/or the crane shall be blocked properly before the load is moved. Wood blocks used to support outriggers shall be strong enough to prevent crushing, free from defects, and of sufficient width and length to prevent shifting or toppling under load. For critical lifts, wood blocking is not permitted under outriggers unless approved by the installation NASA Safety directorate and the responsible engineering and operations organizations.

(30) On truck mounted cranes, loads shall not be lifted over the front area except as approved by the crane manufacturer.

(31) Outriggers shall be used when load to be handled at a particular radius exceeds rated load without outriggers, as specified by the crane manufacturer's load chart. Floats, where used, shall be securely attached to the outriggers.

(32) Neither the load nor the boom shall be lowered below the point where less than two full wraps of rope remain on the respective drums.

(33) For mobile cranes in transit, the following precautions shall be taken: boom shall be stowed/carried in line with direction of motion, superstructure shall be secured against rotation, except in negotiating turns when there is an operator in the cab or boom is supported on a dolly, and hook shall be lashed or otherwise restrained so that it cannot swing freely while in transit or moving.

(34) When traveling a mobile crane with a load, a person shall be designated responsible for determining and controlling safety and making decisions as to position of load, boom location, ground support, travel route, and speed of movement.

(35) A mobile crane with or without a load shall not be traveled with the boom so high that it may bounce back over the cab.

(36) When rotating cranes/derricks, sudden starts and stops shall be avoided. Speed shall be such that the load does not swing out beyond radii at which it can be controlled. A tag line shall be used when rotation of load is hazardous.

(37) Ropes shall not be handled on a winch head without the knowledge of the operator.

(38) While a winch head is being used, the operator shall be within convenient reach of the power unit control lever.

(39) If the load must remain suspended for any considerable length of time, the operator shall hold the drum from rotating in the lowering direction by activating the positive control lever of the operator's station.

(40) Mobile cranes shall not be operated without the full amount of ballast or counterweight in place as specified by the manufacturer. The ballast or counterweight, as specified by the manufacturer, shall not be exceeded.

(41) Refueling with small portable containers shall be done with Underwriter's Laboratories or Factory Mutual Laboratories approved (or equivalent) safety type can equipped with an automatic closing cap and flame arrestor.

(42) Machines shall not be fueled with engines running. After fueling, wait at least 5 minutes for flammable vapors to clear before starting the engine.

(43) A carbon dioxide, dry chemical, or equivalent fire extinguisher shall be kept in the cab or vicinity of the crane/derrick.

(44) Except where the electrical distribution and transmission lines have been deenergized and visibly grounded at the point of work, or where insulating barriers, not a part of or an attachment to the crane, have been erected to prevent physical contact with power lines, mobile cranes shall be operated in accordance with the following:

(a) For lines rated 50kV or below, minimum clearance between lines and any part of crane or load shall be 10 feet.

(b) For lines rated over 50kV, minimum clearance between lines and any part of crane or load shall be 10 feet plus 0.4 inch for each 1kV over 50kV, or twice the length of the line insulator, but never less than 10 feet.

(c) The crane shall be positioned to preclude the boom or load from contacting or falling across the power line(s) in the event of crane failure.

(d) In transit, with no load and boom lowered, the clearance shall be a minimum of 4 feet.

(e) Clearance observers shall be provided with an acceptable means of giving a warning in time for operators to react to insufficient clearance.

(f) Crane boom tips shall have two red flags (minimum of 12 inches x 12 inches each).

(45) Before starting operation near electrical lines, the organization responsible for the lines shall be notified and provided with all pertinent information. The responsible organization’s cooperation shall be requested.

(46) Any overhead wire shall be considered an energized line unless and until the person responsible for such line or the electrical utility authorities indicate that it is not an energized line.

(47) Outdoor hoisting operations should not commence if winds are above 20 knots steady state or if gusts exceed 35 knots.

(48) Cranes/derricks left outdoors shall be secured by the operator when operations are complete.

307 SPECIAL CRITERIA

a. Special precautions shall be taken while handling explosives or Electro Explosive Devices (EEDs). Safety support shall be available. Barricades and warning signs shall be erected to control access. Voltage checks on crane hooks that will handle explosives or EEDs shall be performed to verify that the measured energy level does not exceed 20 decibels below the maximum safe no-fire energy level in the bridge wire of the associated EED. (Example: For a NASA Standard Initiator with a maximum safe no-fire energy level of 1 watt, the measured energy level shall not exceed 10 milliwatts, which corresponds to 100 millivolts measured across a 1 ohm resistor.) The crane/derrick hook shall be connected to facility ground before connecting to explosives or EEDs. Electrical grounding of the hook and load shall be accomplished prior to lifting operations while handling explosives, EEDs, or electrically sensitive devices/payloads. The grounding shall be measured/verified to be within specification by inspection personnel and recorded prior to the lift. If a ground connection must be disconnected to facilitate operations, an alternate ground should be connected prior to disconnecting the existing ground. The final attachment/detachment must be at least 10 feet from exposed propellant grain, explosives, or EEDs. The use of radio transmissions near explosives shall be evaluated for danger potential prior to the operation.

b. Policy shall be developed and enforced for crane/derrick operation during electrical storms. Operations are generally permitted without restriction within enclosed metal or framed buildings that are properly grounded. Restrictions are necessary for outside operations or for those that cannot tolerate power failure/loss.

CHAPTER 4: HOISTS

400 GENERAL

This chapter establishes safety standards for the design, inspection, test, maintenance, and operation of hoists. These standards apply to electric, air-powered, and manual hoists, including those used to raise/lower empty personnel work platforms, surfaces, or stations. This does not include hoists connected to platforms used to raise or lower personnel. For these, see Chapter 7, Special Hoist Supported Personnel Lifting Devices.

401 SAFETY ASPECTS

Generally, off-the-shelf, OEM type equipment is acceptable for critical and noncritical lifts if it is designed, maintained, operated, etc., according to this standard.

a. Safety Design Criteria that should be emphasized during hoist design are contained in the documents listed in Paragraph 105.

b. Labeling/Tagging of Hoists.

(1) The hoist's rated capacity shall be marked on it or its load block. This marking shall be clearly legible from the ground floor.

(2) Hoists that have the specified design features, maintenance/inspection, and test intervals to lift critical loads shall be marked conspicuously so that the operator and assurance personnel can distinguish that the hoist is qualified for critical lifts.

(3) A standard system of labeling shall be established and used throughout the installation.

(4) A standard tag-out system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance operations, etc.

(5) Certification/recertification tags are required as described in Paragraph 402e.

c. Safety Analysis and Documentation for Hoists used for Critical Lifts. A hazard analysis shall be performed on all hoists used for critical lifts. The analysis shall, as a minimum, determine potential sources of danger, identify most probable failure modes, and recommend resolutions for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, or loss of crane, facility, or load. The analysis also shall include hoist description, reference

documentation, severity assessment, and assessment of certain passive and structural components between the hook and the holding brakes. Hazards that are identified shall be tracked (recorded and current status maintained) until final closure is verified. A system of risk acceptance is required for hazards that cannot be eliminated. The hazard analysis shall be done as part of the initial certification process, included in the hoist documentation, and updated as required to reflect any changes in operation and/or configuration.

d. Performance. Operational life, duty cycle, load capability, and the desired control characteristics with which the hoist handles the load shall be addressed for all designs. The expected operational life shall be specified or detailed for system components. Duty cycle requirements shall be based on the worst expected duty the unit will encounter. Each load-bearing component shall be specified or detailed to lift the maximum imposed loads resulting from zero to rated hook load with appropriate safety factors. Operational requirements shall be considered in the design phase to ensure load and function are adequately defined and critical hoist design features are incorporated on the delivered units. Environmental conditions must also be considered.

e. Structural. Structural design shall be in accordance with industry standards for material selection, welding, allowable stresses, design limitations, framing, wheels, and other structural elements. Refer to CMAA standards for specific design details.

f. Mechanical. The use of high quality, off-the-shelf, OEM type equipment is acceptable for critical and noncritical lift applications if it meets all user requirements and the requirements of this document. This high quality commercial equipment employs a modular type construction of the hoist unit with standard frame sizes and interchangeable gear boxes, drums, motors, brakes, and controls to achieve a wide range of capacities, lifts, operating speeds, reeving arrangements, and controls. These interchangeable parts are standardized for each manufacturer's product line and the hoists are built to order. The mechanical design requirements for hoist components are as follows:

(1) They meet all applicable requirements of OSHA, ANSI, and CMAA.

(2) Electric and air operated hoists should be provided with at least two means of braking: a holding brake and a control brake. The torque rating, physical characteristics, and capabilities shall be in accordance with CMAA specifications.

(3) Powered (electric and air) hoists used for critical lifts shall have two means of braking, each capable of bringing a rated load to zero speed and holding it (with and without power). If the control brake and holding brake are designed to operate as a system and cannot

independently stop and hold a rated load, then another means of braking is required (e.g., emergency brake). The brakes shall be designed so that they can be tested as required in Paragraph 402c(5).

(4) For critical lift application, speed reduction from the motor to the drum on the hoist should be achieved by enclosure in a gear case. If open gears are required, they shall be guarded with a provision for lubrication and inspection.

(5) All wire rope hoists shall have not less than two wraps of hoisting rope on the drum when the hook is in its extreme low position. Drum grooves, when provided, shall be as recommended by CMAA. The rope ends shall be anchored securely by a clamp or a swaged terminal in a keyhole slot, provided a keeper is used to prohibit the swage from moving out of the narrow slot. Other methods recommended by the hoist or wire rope manufacturer are acceptable if the rope termination anchor together with two wraps of rope on the drum will give an anchor system equal to or greater than the breaking strength of the wire rope.

(6) Safe and adequate access to hoist components to inspect, service, repair, or replace equipment shall be provided for during design. The design shall provide for visual and physical accessibility.

(7) Manually operated (nonpowered), off-the-shelf OEM type hoists are acceptable for critical and noncritical lift applications. They shall comply with applicable ANSI requirements. These hoists shall have at least one brake as described by industry standards. No limit switches are required if proper over-travel restraint is provided.

(8) Air operated chain hoists can be equipped with over-travel protection devices instead of the hoist travel limit switches.

(9) Initial and final upper limit switches (limit control valves) shall be provided and tested for air-operated hoists as described in Paragraph 401g(7). The final upper limit switch (limit control valve) shall exhaust air from the hoist, set the brakes, and require reset at the upper limit switch (limit control valve) level.

(10) Worm gears shall not be used as a braking means unless the lead angle is sufficient to prevent back driving. The braking properties of a worm gear tend to degrade with use; the design engineer shall consider this when purchasing new equipment or in existing installations where the hoist is subject to heavy use.

(11) In the procurement of new lifting equipment, the use of cast iron components in the hoist load path shall be approved, as a minimum, by the installation NASA Safety Director. The material properties of cast iron allow catastrophic failure and should not be considered as reliable as steel or cast steel. The engineer shall consider this when selecting equipment and avoid the use of load bearing cast iron materials where possible.

(12) Gearing shall be designed and manufactured to comply with the latest AGMA gear standards.

(13) Hooks shall meet the manufacturer's recommendations, and shall not be overloaded. Swiveling hooks should rotate 360 degrees on antifriction bearings with means for lubrication. If grease is a contamination concern, drip funnels (cups) or nonlubricated bearings should be provided. Latch-equipped hooks shall be used unless the application makes the use of a latch impractical or unnecessary. When required, a latch or mousing shall be provided to bridge the throat opening of the hook to retain slings, chains, or other similar parts under slack conditions.

g. Electrical. Electrical design requirements are as follows:

(1) Wiring and safety devices shall be in accordance with the NFPA National Electrical Code.

(2) Electrical enclosures shall provide protection for the contained equipment against environmental conditions.

(3) Though not a requirement, besides overload protection required by the National Electrical Code, undervoltage and phase reversal should be considered.

(4) For powered hoists used for critical lifts, an assessment shall be performed to determine the operational needs for remote emergency stops independent from the operator controlled emergency stop. Not all hoists used for critical lifts require a remote emergency stop. Remote emergency stops are required for hoists used for critical lifts where the operator's view is restricted/obstructed. When provided, this independent remote emergency stop should be located such that the independent remote emergency stop operator(s) can clearly see the critical lift area(s). The remote emergency stop circuit shall be separate from and take precedence over the operator control circuit. The control, when activated, shall cause all drives to stop and the brakes to set. Hand-held remote emergency stop pendants should be standardized and should include power and circuit continuity indication. For those hoists required to make critical lifts and have not been

modified to provide a remote emergency stop, handling procedures shall be developed and implemented to minimize the risk.

(5) Electrical control stations shall operate on 150 volts DC, 120 volts AC, or less. Positive detent pushbuttons or a control lever shall be used for speed control. Controls shall return to the off position when the operator relieves pressure. A red, emergency stop pushbutton shall be provided to operate the mainline contactor, main circuit breaker, or pneumatic source. A dump valve is acceptable for the emergency stop for a pneumatic hoist.

(6) The electrical system shall be designed fail-safe to ensure that a failure of any component will not cause the hoist to operate in a speed range faster than commanded. A failure that causes a speed different from that selected is acceptable provided no hazards are introduced. Failure modes that cause the hoist to slow down or come to a safe stop are acceptable; those that could cause a hard stop, unplanned directional shifts, and/or loss of control are unacceptable.

(7) For hoists used for critical lifts (except manual), dual upper limit switches are required. For electric hoists, the limit switches shall meet the following requirements:

(a) Initial upper limit switch electrical contacts shall be a set of normally closed contacts in the “raise” contactor circuit such that movement in the raise direction shall be precluded after the limit switch is encountered. Movement in the “lower” direction will not be inhibited.

(b) Final upper limit switch electrical contacts shall be a set of normally closed electrical contacts wired into the mainline circuit, hoist power circuit, main contactor control circuit, or hoist power contactor control circuit such that all hoist motion shall be precluded after the limit switch is encountered. These normally closed contacts may be located in the low voltage circuitry.

(c) After a final upper limit switch has been activated, movement of the load will require action (resetting) at the final upper limit switch level. An inspection shall be made to determine the cause of failure of the initial upper limit switch. Stopping hoist motion by the above design configuration may result in a hazardous suspended load condition. The hoist design should include a means of detecting limit switch failure and allow for safe inspection and repair. For example, a system may be equipped with two different colored annunciator lights, one for each limit switch. A reset button may be included so that when a final

upper limit switch is tripped, the load can be lowered immediately. The reset button should be secured to prevent unauthorized use.

(d) The initial upper limit switch shall be adjusted sufficiently low to preclude inadvertent actuation of the final upper limit switch if the hoist actuates the initial switch at full speed with no load. Similarly, the final upper limit shall be adjusted sufficiently low to ensure that the hoist will not two-block (or otherwise damage wire rope) if the hoist actuates the final switch at full speed with no load. Both limits shall be tested from slow speed to full speed to verify correct operation. It should be noted that this requirement effectively lowers the usable hook height of the hoist. The limit switch arrangement needs to be considered during new equipment design.

402 TESTING

Three types of tests are required on hoists: proof load tests, rated load tests, and operational tests. The proof load tests and operational tests shall be performed prior to first use for new, extensively repaired, or altered hoists. The rated load and operational tests shall be performed at least every 4 years. For hoists used for critical lifts, these tests shall be based on frequency of usage. Hoists used frequently for critical lifts shall be load tested annually. Hoists used infrequently for critical lifts shall be load tested before each critical lift if it has been more than a year since the last test. If a hoist is upgraded, a proof load test and an operational test shall be performed based on the upgraded rating. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures approved by NASA and/or contractor Safety representatives. An inspection shall be performed after each load test and prior to the hoist being released for service to ensure there is no damage. If cracks or structural damage is suspected, suitable NDE techniques shall be used to determine the condition.

a. Proof Load Test. Before first use and after installation, all new, extensively repaired, modified, or altered hoists shall undergo a proof load test with a dummy load as close as possible to, but not exceeding 125 percent of the rated load. The hoist rating will not be more than 80 percent of the proof load test weight. For platform hoists, test the hoist at 125 percent of rated capacity prior to hookup to the platform. With the platform attached, verify that the actual lift does not exceed the rated capacity of the hoist. The rated load of a hoist shall be clearly legible from the operator's or user's position. Platform hoist systems shall be clearly marked with the maximum load to be lifted by the system.

b. Rated Load Test. All hoists, except platform hoists shall be tested at least once every 4 years with a dummy load equal to hoist's rated capacity. For hoists used for critical lifts, these tests shall be based on frequency of

usage. Hoists used infrequently for critical lifts shall be load tested before each critical lift if it has been over a year since the last test. Hoists used frequently for critical lifts shall be load tested at least once per year. The acceptable tolerance for rated load test accuracy is + 5/-0 percent unless otherwise specified by design. The rated load test can be fulfilled by a concurrently performed proof load test. Platform hoists do not require rated load tests.

c. Operational Test. Together with proof load and rated load tests, the following shall be performed with a dummy rated load unless otherwise specified (platform hoists shall be operationally tested every 4 years using the attached platform only):

(1) Perform all hoist functions in an unloaded condition.

(2) Test operation of brakes and limit, locking, and safety devices.

(3) Determine trip setting of limit switches and limiting devices by tests under no load conditions. Conduct tests first by hand, if practical, and then under the slowest speed obtainable. Test with increasing speeds up to the maximum speed. Locate actuating mechanisms so that they will trip the switches or limiting devices in time to stop motion without damaging the hoist.

(4) After testing in the unloaded state, apply the test load to the hoist to check the proper load control. Test load hoisting, lowering at various speeds (maximum safe movement up and down as determined by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations), and braking/holding mechanisms (holding brakes shall be tested to verify stopping capabilities and demonstrate the ability to hold a rated load). The load should be held long enough to allow any dynamics to dampen out.

(5) Powered hoists used for critical lifts are required to be equipped with at least two means of braking, each capable of bringing a rated load to zero speed and holding it (see Paragraph 401f(3)). The operational test must demonstrate each brake's ability to stop and hold a rated load. This can be done in one of the following ways:

(a) Each brake's ability to hold shall be statically tested (under no load) with 150 percent of the rated load hoisting torque at the point of brake application.

(b) Alternately, each brake shall be tested for its ability to stop a rated load moving at full speed in the down direction. (CAUTION: It must be possible to quickly reenergize the out of circuit brake or provide other safety measures to perform this test safely.)

(c) Other methods as specified by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations.

(6) The operational test for a modified hoist can be tailored to test only those portions of the equipment that were modified, only if the rated load and operational test interval has not expired.

d. An organization may certify a hoist for a specific lift (critical or noncritical). A load test and an operational test with a dummy load are required. In this case, the test weight shall be at least equal to the specific load that the hoist is being certified to lift and may be greater as determined by the user and maintenance organization. The test weight shall not exceed 125 percent of the hoist's rated load.

e. Test Reports and Periodic Recertification Tags. After each test, designated personnel shall prepare written, dated, and signed test reports, including procedure reference. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and shall be made readily available by the organization responsible for testing the hoist. Following the rated load test, all hoists shall be given a permanently affixed tag identifying the equipment and stating the next required rated load test date or certification expiration date.

403 INSPECTION

a. Daily and periodic safety inspections shall be performed on all hoists in regular service.

b. Prior to first use, all new or altered hoists shall be inspected to the requirements of both daily and periodic inspections. Inspections shall be performed by qualified personnel according to approved technical operating procedures. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, corrected prior to further use. For hoists that are idle, see Paragraph 403e.

c. Daily Inspections. These inspections shall be performed each day the hoist is used and shall include the following:

(1) Inspect braking mechanisms for evidence of slippage under load.

(2) Inspect load chain for wear, twists, damage links, or foreign matter.

(3) Visually inspect hooks for deformation, chemical damage, or cracks (see Chapter 5).

(4) Inspect load bearing components for damage.

(5) Inspect running rope or chain for discrepancies.

d. Formal Periodic Inspections. These inspections shall be performed at varying intervals, depending on activity, severity of service, environment, and criticality.

(1) Annual Inspections. At least once per year:

(a) Check for loose bolts and rivets and cracked or worn drums and sheaves. Various methods of NDE such as ultrasonics, x-ray, magnetic particle, dye penetrant, etc., shall be used as needed.

(b) Check for worn, corroded, cracked, or distorted parts such as pins, bearings, shafts, gears, rollers, and locking and clamping devices. NDE techniques shall be used if cracks are suspected.

(c) Inspect motor brake and load break for excessive wear.

(d) Inspect electrical apparatus for pitting or other signs of deterioration. Visually inspect for signs of overheating.

(e) Inspect hook-retaining nuts or collars, pins, welds, or rivets used to secure retaining members for deformations, cracks, or excessive corrosion. NDE techniques shall be used if cracks are suspected.

(f) Ensure that supporting structure is not deformed or cracked.

(g) Check that warning labels are legible.

(2) Monthly Inspections. At least once per month:

(a) Inspect wire rope monthly (except those on platform systems that shall be inspected at least twice a year), paying particular attention to the following signs of deterioration and damage:

1 Twelve randomly distributed broken wires in one rope lay or four broken wires in one strand in one lay.

2 Individual wires with 1/3 wear of original outside diameter.

3 Kinking, crushing, bird caging, or any other damage resulting in distortion.

4 Evidence of heat damage.

5 End connectors that are cracked, deformed, or with evidence of rope pullout.

6 Corrosion (internal or external) that results in reduction of rope diameter, or at end connectors.

7 Reductions of nominal diameter (measured with a caliper or go/no-go gage) of more than:

a 1/64 inch for diameters of rope up to 5/16 inch.

b 1/32 inch for diameters 3/8 inch to 1/2 inch.

c 3/64 inch for diameters 9/16 inch through 3/4 inch.

d 1/16 inch for diameters 7/8 inch through 1-1/8 inches.

e 3/32 inch for rope diameters greater than 1-1/8 inches.

(b) Inspect welded-link chain monthly by performing the following checks:

1 Raise and lower hoist while loaded. The chain should feed smoothly into and away from the sprockets.

2 If chain binds, jumps, or is noisy, see that it is clean and lubricated. Inspect chain and mating parts for wear and distortion.

3 Clean chain and visually examine for gouges, weld splatter, corrosion, and distorted links. Slacken chain and move adjacent links to one side; look for wear at contact points. If wear is observed, measure chain according to hoist manufacturer's instructions. If instructions are not available, select an unworn, unstretched portion of chain. Suspend chain vertically under tension and measure approximately 14 inches of links with a caliper gauge. Measure the same length in a work section and calculate the percentage of increase in length. If chain exceeds the hoist manufacturer's recommended length or is 1.5 percent longer than the unused chain, replace it.

(c) Inspect roller link chain monthly by performing steps 1, 2, and 3 in Paragraph 403d(2)(b). In addition, perform the following checks:

1 With hoist suspended in normal position, apply a load to eliminate slack in the chain. Check chain for elongation. In the absence of specific instructions from hoist manufacturer, check chain by determining nominal pitch and measuring a 12-inch section that usually travels over chain sprocket. Using a Vernier caliper, check dimension from the edge of one chain pin to the same edge of another pin; determine number of pitches per foot. If elongation exceeds 1/4-inch in 12 inches, replace chain.

2 Check chain for twist. Replace it if twist exceeds 15 degrees in any 5-foot section.

3 Check for camber. Replace chain that has a side bow exceeding 1/4 inch in a 5-foot section.

4 Clean chain annually in an acid-free solvent. Check for pins turned from their original position, rollers that do not turn freely with light finger pressure, joints that cannot be flexed easily by hand, open link plates, corrosion, gouges, and weld splatter. Remove chain from hoist if required for proper cleaning and inspection.

(d) Inspect hooks monthly, except those on platform systems, for deformation or cracks (see Chapter 5).

e. Idle Hoists. Hoists idle for more than 1 month shall be inspected prior to first use according to the requirements of Paragraphs 403c and 403d that were not performed at required intervals and recorded during the idle period.

f. Inspection Reports. After each formal periodic inspection, qualified, authorized personnel shall prepare written, dated, and signed inspection reports. These reports shall include procedure reference and adequacy of the hoist/hoist components. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and be made readily available by the organizational element responsible for hoist inspection.

404 MAINTENANCE

A preventive maintenance program shall be established based on manufacturers' recommendations and/or experience gained from use of the equipment. The program shall include procedures and a scheduling system for normal periodic maintenance items, adjustments, replacements, and repairs. The program shall also ensure that records are kept and unsafe test and inspection discrepancies are documented and corrected.

a. Maintenance Procedures. Before maintenance, adjustments, repairs, and replacements are initiated, the following safety precautions shall be taken:

(1) Move hoist to designated maintenance area.

(2) Turn off all controls and main energy feed system and lockout unless task requires them to be on.

(3) If power has to be on, "Warning," "Out-of-Order," or a like sign shall be placed in a conspicuous location or an operator shall remain at the pendant.

(4) Hoists shall not be operated until all safety devices have been activated and tested/adjusted if involved in the maintenance action.

b. Adjustments. Based upon the manufacturer's documentation and/or experience, adjustments shall be made to ensure that all hoist components function properly, paying particular attention to:

(1) Brakes. (Appropriate precautions should be taken by inspectors, repair personnel, and others who may be potentially exposed to airborne dust fibers from any asbestos friction materials present in braking mechanisms.)

(2) Control system.

(3) Limit switches.

(a) The hoist initial upper limit switch shall be verified by running the empty hook at full speed into the limit switch. It is recommended that the switch be verified at slow speed prior to adjustment.

(b) For hoists used for critical lifts, the final upper limit switch shall be independently verified and adjusted as described above at installation and after modifications that could affect switch operation. The switch can be tested periodically by manually tripping it and verifying that all hoist motion is precluded.

(4) Power plants.

(5) Critical operating mechanisms and safety devices.

c. Repairs and Replacements. Repairs or replacements shall be provided for safe operation. Special attention shall be given to:

(1) Worn or damaged braking components such as friction discs, ratchets, pawls, and pawl springs.

(2) Load-supporting components that are cracked, bent, or worn.

(3) Missing or illegible warning labels.

(4) For repair/replacement requirements for hoist hooks with deformation or cracks, see Chapter 5. If repaired, hoist hooks shall be proof load tested using the associated hoist proof load value.

(5) The need to replace wire rope shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results. Any of the signs of deterioration and damage outlined in Paragraph 403d(2)(a) are sufficient reasons for questioning continued use of the rope.

(6) Replacement rope or chain shall be of the same size, grade, and construction as original furnished by hoist manufacturer. When replaced, disassemble and inspect mating parts for wear, replace mating parts if necessary, and perform a proof load test using the associated hoist proof load value.

405 PERSONNEL CERTIFICATION

a. Program. Only certified (licensed) and trained operators shall be authorized to use/operate powered hoists except for platform hoists where procedural controls can be provided in a technical operating procedure. A training, examination, and licensing program shall be established or made available. For those NASA installations that do not have a training program, all hoist operators shall be trained and certified by a recognized hoist certification organization that normally performs this function. Certification also shall include riggers and flagmen.

b. Levels. Two levels of operator training and proficiency will be established. Operations where critical lifts are involved will require a more rigid operator certification program than those operations that involve more routine lifts that do not involve critical hardware or unique hazards.

(1) Noncritical Lifts. The certification program for noncritical lift operators shall include the following:

(a) Training

1 Classroom training in safety and first aid/emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

2 Hands-on training (for initial certification and as needed).

3 An annual review of the items in Subparagraph (a) above. (This may be conducted informally by local supervisory personnel.)

(b) Examination

1 Physical examination (criteria to be determined by the cognizant medical official using ANSI requirements).

2 Written examination.

3 Operational demonstration (for initial certification only).

(c) Licensing/Operator Certification

1 An organizational element shall be designated to issue operator licenses/operator certification. Provisions shall be made to revoke licenses for negligence, violations of safety requirements, or failure to meet medical standards. Provisions shall be made for periodic checks of operators to verify they have licenses in their possession. The licenses shall indicate the type of hoist the holder is qualified to operate. Alternately, the organizational element may elect to maintain a master list of licensed operators instead of issuing individual licenses, providing copies of the list are readily available to assurance and supervisory personnel at the work site.

2 Renewal of all licenses shall require demonstration of proficiency. Licenses or certifications shall expire at least every 4 years. Renewal procedures will be established by each licensing organization but as a minimum, will include items in Paragraphs 405(b)(1)(a) and (b).

(2) Critical Lifts. Besides the training, examination, licensing, and renewal requirements for noncritical lifts, operators that are being certified to perform critical lifts must be trained in the specific hazards and special procedures associated with the lift. Operators must also demonstrate proficiency and operating finesse with the hoist using a test load as appropriate for the initial certification or alternately be immediately supervised by a certified operator during the first initial lifting period. The licenses will indicate specific hoists for which the operator is certified.

406 OPERATIONS

a. Only certified and trained operators shall be authorized to use/operate lifting devices, including hoist operations, except for platform operators where procedural controls can be provided in a technical operating procedure.

b. The following practices shall be observed during all hoist operations:

(1) When an "Out-of-Order" sign has been placed on the starting controls, the hoist operator shall not power the unit or start operations until required repairs, inspections, and retests have been made.

(2) Before starting a hoist, the operator shall be certain that all personnel are clear of the area. Operators shall not engage in practices that will divert their attention while operating a hoist.

(3) The operator shall test all controls before beginning an operation. If the controls do not operate properly, adjustments or repairs shall be made before operations begin.

(4) Hoists shall not be loaded beyond rated load except during authorized tests. Platform systems shall not be loaded beyond maximum load as designated on the platform hoist system.

(5) Hoists shall not be used for handling personnel unless specifically designed for such purpose (see Chapter 7).

(6) Personnel shall not be located under suspended or moving loads unless the operation adheres to the OSHA-approved NASA Alternate Standard for Suspended Load Operations. (See Appendix B.)

(7) An operator shall be at the hoist controls at all times while a load is suspended. Due to the length of some NASA operations, an operator change may be required while a load is suspended. This shall be accomplished via a procedure designed for the specific hoist and operation approved by the installation NASA Safety directorate, ensuring that the hoist controls are manned at all times.

(8) Before each lift or series of lifts, the operator shall functionally test proper operation of the upper limit switch with no load on the hook. Upper limit switches shall not be used as operating controls.

(9) Hoists may be used to load test items such as slings, platforms, or lifting fixtures if specifically identified to do so based on a specified percentage of rated load and a safety analysis approved by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations. This is to ensure that the crane is not damaged due to sudden unloading should the test article fail.

(10) Installed or fixed air or electric powered hoists, excluding platform systems, shall be operated by designated personnel only.

(11) The operator shall ensure that the hoist is within inspection and periodic certification intervals by examination of its tag(s) and/or appropriate documentation.

(12) Outdoor hoisting operations should not commence if winds are above 20 knots steady state.

(13) Hoists shall not be used for side pulls unless specifically designed to do so.

(14) If radio communications are to be used, operators and/or lift supervisors shall test the communication system prior to the operation. Operation shall stop immediately upon communication loss, and shall not continue until communication is restored.

(15) If hand signals are required, only standard signals shall be used according to Appendix C. Hand signals shall be posted in a conspicuous location.

(16) When raising loads that approach the rated capacity of the hoist, the operator shall know the weight of the working load. The operator shall test the holding brakes each time a load approaching the rated load is handled. The brakes shall be tested by raising the load minimally above the surface and holding the load with the brake. The load should be held long enough to allow any dynamics to dampen out.

407 SPECIAL CRITERIA

a. Special precautions shall be taken while handling explosives or Electro Explosive Devices (EEDs). Safety support shall be available. Barricades and warning signs shall be erected to control access. Voltage checks on hoist hooks that will handle explosives or EEDs shall be performed to verify that the measured energy level does not exceed 20 decibels below the maximum safe no-fire energy level in the bridge wire of the associated EED. (Example: For a NASA Standard Initiator with a maximum safe no-fire energy level of 1 watt, the measured energy level shall not exceed 10 milliwatts, which corresponds to 100 millivolts measured across a 1 ohm resistor.) The hoist hook shall be connected to facility ground before connecting to explosives or EEDs. Electrical grounding of the hook and load shall be accomplished prior to lifting operations while handling explosives, EEDs, or electrically sensitive devices/payloads. The grounding shall be measured/verified to be within specification by inspection personnel and recorded prior to the lift. If a ground connection must be disconnected to facilitate operations, an alternate ground should be connected prior to disconnecting the existing ground. The final attachment/detachment must be at least 10 feet from exposed propellant grain, explosives, or EEDs. The use of radio transmissions near explosives shall be evaluated for danger potential prior to the operation.

b. Policy shall be developed and enforced for hoist operation during electrical storms. Operations are generally permitted without restriction within enclosed metal or framed buildings that are properly grounded. Restrictions are necessary for outside operations or for those that cannot tolerate power failure/loss.

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CHAPTER 5: HOOKS

500 GENERAL

This chapter establishes safety standards for the testing, inspection, maintenance, and operation of hooks used with lifting equipment.

501 TESTING

Hooks shall be required to pass the tests of the equipment of which they are a part. Written, dated, and signed test reports shall be prepared together with the test reports for the equipment of which the hooks are a part. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use.

502 INSPECTIONS

a. Hooks shall be inspected during the daily and periodic inspections of the equipment of which they are a part. Hooks shall be examined for wear, deformation, cracks, latch damage, and improper attachment with particular emphasis on the following deficiencies:

   (1) Wear exceeding 10 percent (or as recommended by the manufacturer) of the original sectional dimension.

   (2) A bend or twist exceeding 10 degrees from the plane of the unbent hook.

   (3) An increase in throat opening exceeding 15 percent (or as recommended by the manufacturer).

   (4) Latches that are inoperative or fail to fully close the throat opening because of wear or deformation.

   (5) Cracks, nicks, and gouges (see Paragraph 503b).

b. Visual inspection of painted hooks requires consideration of the coating. Surface variations may indicate heavy or severe service. Such instances may call for stripping the paint to allow for more detailed analysis.

c. Hooks shall be given a NDE using magnafluxing or other method immediately after all rated load and proof load tests and prior to further use of the hook. A visual inspection of hooks used for non-critical lifts (if not attached to a crane) and sling hooks of *5* tons or less is acceptable. All new crane hooks shall undergo a volumetric NDE.

d. Written, dated, and signed inspections reports shall be prepared in conjunction with inspection reports for the equipment of which the hooks

are a part. Inadequacies shall be documented and if determined to be a hazard, corrected prior to further use.

503 MAINTENANCE

a. Hooks with deficiencies as noted in Paragraph 502 shall be removed from service and replaced or repaired. Replacement shall be with original equipment or equal. Repair shall require approval by certified or otherwise qualified personnel. Minor grinding of cracks is not considered a repair providing an approved procedure is used. Hooks will be repaired by certified or otherwise qualified personnel only. Hooks repaired by welding should be derated to reflect the inherent difference in the metal introduced by this process. Hooks must be removed from the crane assembly prior to welding.

b. Cracks, nicks, and gouges shall be repaired by grinding longitudinally, following the contour of the hook, provided that no dimension is reduced more than 10 percent (or as recommended by the manufacturer) of its original value.

c. If repaired, hooks shall be proof load tested using the associated lifting device/equipment proof load value.

d. A system shall be established for tracking/documenting the maintenance and repair history of hooks.

504 OPERATIONS

a. Loads shall be centered in the base (bowl saddle) of the hook, to avoid point loading.

b. Hooks shall not be side or back loaded.

c. Duplex sister hooks shall be equally loaded on both sides, and the pin hole shall not be point loaded or loaded beyond the rated load of the hook except for testing.

CHAPTER 6: HYDRA-SETS

600 GENERAL

This chapter establishes safety standards for the testing, inspection, and operation of Hydra-sets.

601 SAFETY ASPECTS

a. Safety Design Criteria. Hydra-sets used for critical lifts shall have a 5 to 1 factor of safety based on ultimate strength for load bearing elements.

b. Labeling/Tagging of Hydra-Sets.

(1) The rated load shall be plainly marked on each Hydra-set.

(2) Hydra-sets that have the necessary design features, maintenance/inspection, and test intervals to lift critical loads will be marked conspicuously so that the operator and assurance personnel can distinguish that the Hydra-set is qualified for critical lifts.

(3) A standard system of labeling shall be established and used throughout the installation.

(4) A standard tag-out system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance operations, etc.

(5) Certification/recertification tags are required as described in Paragraph 602d.

c. Safety Analysis and Documentation of Hydra-Sets Used for Critical Lifts. A hazard analysis shall be performed on all Hydra-sets used for critical lifts. The analysis shall, as a minimum, determine potential sources of danger, identify most probable failure modes, and recommend resolutions for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, or loss of Hydra-set, facility, or load. The analysis also shall include Hydra-set description, reference documentation, severity assessment, and assessment of passive and structural components. Hazards that are identified shall be tracked (recorded and current status maintained) until final closure is verified. A system of risk acceptance is required for hazards that cannot be eliminated. The hazard analysis shall be done as part of the initial certification process, included in the Hydra-set documentation, and updated as required to reflect and modification and/or changes in operation.

602 TESTING AND INSPECTIONS

Three types of tests are required: proof load tests, periodic load tests, and operational tests. The acceptable tolerance for load test accuracy is + 5/-0 percent unless otherwise specified by design. An inspection shall be performed after each load test and prior to release for service to ensure there is no damage. If cracks are suspected, suitable Nondestructive Evaluation techniques should be used to determine their extent. Tests shall be performed by qualified personnel according to written (specific or general) technical procedures approved by NASA and/or contractor safety representatives.

a. Proof Load Test. Before initial use or after structural repair, test all Hydra-sets at 200 percent of rated load. Proof load tests shall be performed with piston rod fully extended to prevent instrument and seal damage.

b. Periodic Load Test. Load tests shall be performed with the piston rod fully extended to prevent instrument and seal damage. All Hydra-sets shall be tested at 125 percent of rated load at least every 4 years. Tests of Hydra-sets used for critical lifts shall be based on frequency of usage. Hydra-sets used infrequently for critical lifts shall be load tested before each critical lift if it has been over a year since the last test. Hydra-sets used frequently for critical lifts shall be load tested at least once per year.

c. Operational Test and Inspection. The following shall be performed in conjunction with proof load tests and periodic load tests and at least once per year:

   (1) With a test load, at least equal to 50 percent of the Hydra-set's rated capacity but not to exceed 100 percent, operate the unit to approximately the midstroke position. Using a dial indicator or equivalent, verify that the load does not move up or down more than .005 inches in 5 minutes.

   (2) Inspect unit for hydraulic leaks and initiate repairs when required.

   (3) Inspect for structural damage and corrosion of the piston rod.

d. Test Reports and Periodic Recertification Tags. After each load test and/or inspection, written, dated, and signed reports shall be prepared. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be kept on file by the responsible owner organization for a minimum of two test cycles and shall be made readily available. Following the periodic load test, all Hydra-sets shall have a permanently affixed tag, identifying the equipment and stating the next required periodic load test date or the certification expiration date.

603 MAINTENANCE

A preventive maintenance program shall be established based on manufacturers' recommendations and/or experience gained from use of the equipment. The program shall include procedures and a scheduling system for normal periodic maintenance items, adjustments, replacements, and repairs. The program also shall ensure that records are kept and unsafe test and inspection discrepancies are documented and corrected.

604 OPERATOR CERTIFICATION

a. A training and operator certification program that specifically addresses the properties of Hydra-sets and operational procedures needed to retain positive control of the same during close mating operations shall be implemented. Elements of the initial training and certification program will include a review of the above procedures, hands-on training, and an operational demonstration.

b. Licensing/operator certification will be issued every 4 years. Renewal will require demonstration of proficiency.

605 OPERATIONS

a. When seals are replaced, an operational test and inspection shall be performed.

b. Hydra-sets shall be stored in their appropriate handling containers when not in use.

c. Hydra-sets shall be clearly and permanently marked with rated load value.

d. Prior to use, the operator shall ensure the Hydra-set is within the inspection and periodic recertification intervals by examination of the certification tag(s) and/or documentation.

e. Hydraulically controlled Hydra-sets are preferred over pneumatically controlled Hydra-sets where close mating operations or accurate control of distances is required. Pneumatically controlled Hydra-sets shall not be used for these operations unless the following items are incorporated:

(1) Installation of a fail-safe check valve in the Hydra-set. This is installed on the Hydra-set pneumatic feedline and "locks up" the Hydra-set in the event of a drop or loss of pneumatic control system pressure. A procedure shall be developed and implemented to ensure that the valve is set to an appropriate sensitivity. Normally, the valve is set at the mid-point of its range, which is satisfactory for most operations. However, depending on the specifics of the lift, it may be necessary to reset the valve using a dummy load as outlined in the manufacturer's recommended procedures.

(2) Installation of a fast acting safety shutoff valve downstream of the load regulator that is used to provide positive control of the Hydra-set when no motion is desired.

(3) Installation of electronic remote position indicators that warn operators of small movements of the hung load. However, these should only be installed if they will not adversely affect the operation or contamination control features of existing Hydra-sets.

(4) Implementation of a training and operator certification program that specifically addresses the unique properties of pneumatically controlled Hydra-sets and operational procedures needed to retain positive control of the same during critical lift operations.

CHAPTER 7: SPECIAL HOIST SUPPORTED PERSONNEL LIFTING DEVICES

700 GENERAL

This chapter establishes minimum safety standards for the design, testing, maintenance, inspection, and operation of special hoist supported personnel lifting devices. These requirements are intended to provide for the safety of personnel using this equipment and of the property and operations that this equipment supports. This chapter applies to unique devices whose operation includes the lifting and lowering of persons via hoist. This does not apply to platforms or other items that are hoisted unoccupied to a position and anchored or restrained to a stationary structure, before personnel occupy the platform. This chapter does not apply to elevators that are covered by ANSI A17.1, “Elevators, Dumbwaiters, Escalators, and Moving Walks.” Also, this chapter does not apply to ground supported personnel lifts (e.g., manlifts, aerial devices, scissors lifts, etc., covered by ANSI A90 and A92 series standards) or powered platforms.

701 SAFETY ASPECTS

a. Generally, anytime personnel must be raised or lowered with hoisting equipment, ANSI A17.1 should be used. Only when unique project requirements dictate that the elevator standard cannot be applied, must special equipment be procured for raising and lowering personnel.

b. In some cases, standard- or custom-designed equipment can be obtained from manufacturers regularly engaged in the design and construction of personnel lifting devices. This equipment must comply with applicable industry and government standards such as ANSI and OSHA and must be tested, maintained, and inspected to their requirements and as required. When industry standards do not apply to a specific project requirement, then a system with an equivalent level of safety must be provided as outlined herein with appropriate concurrence of the applicable design, operations, and safety engineers.

c. A hazard analysis and a Failure Mode and Effects Analysis (FMEA) shall be performed on all personnel lifting devices. The analysis shall, as a minimum, determine potential sources of danger and recommend resolutions for those conditions found in the hardware/facility/environment/human relationship that could cause injury, loss of lift, or damage to property or impact to operations that this equipment supports. The analysis also shall include a system description, reference documentation, severity assessment, and assessment of certain passive and structural components. Hazards that are identified shall be tracked (recorded and current status maintained) until final closure is physically verified. A system of risk acceptance is required for hazards that cannot be eliminated. The analysis shall be done as part of the initial certification process, included in the lifting device documentation, and

updated as required to reflect any changes in operation and/or configuration.

d. General design requirements. The design shall produce a personnel lifting device that will lift, lower, sustain, and transport personnel safely. The structure, mechanism, and material shall be of sufficient strength to meet operational and testing requirements and shall comply with applicable industry and government standards as a minimum and in addition, the requirements outlined in this chapter. Besides the requirements in Chapter 4, Paragraphs 401d, 401e, 401f, and 401g, the following requirements shall be met for all hoist supported personnel lifting devices:

(1) It is the responsibility of design, operations, and safety engineers to ensure that the design, testing, operations, maintenance, and inspection of this equipment comply with the applicable industry and government standards. Most hoist supported personnel lifting devices should comply with applicable industry standards. ANSI A120.1, A39 and A10 series, and OSHA standards establish the configuration, materials, design stresses, safety devices, power and control, test, operation, inspection, and maintenance requirements that should be followed.

(2) When industry standards do not cover a unique project requirement, then a system with an equivalent level of safety must be provided. This system may consist of two separate independent support systems; that is, two separate hoists such that the failure of one hoist, its reeving system, or other component will not cause the stability of the personnel lifting device to be lost or prohibit its movement to a safe location. With this configuration, alternate materials, or higher design stresses than permitted by industry and OSHA standards can be used with concurrence from the appropriate design, operations, and safety engineers. Another option may consist of lifting equipment with at least two holding brakes and additional factors of safety for the hoist load bearing components. All options shall be approved by the installation NASA Safety Directorate and the responsible engineering and operations/maintenance organizations. Operation, maintenance, and inspection requirements shall be developed to provide equivalent certification of equipment as required by industry and OSHA standards and as outlined in this chapter.

(3) A lockout device shall be provided on all hoist supported lifting devices to prevent unauthorized use.

(4) A method for safe egress of personnel or emergency lowering to the ground level or other safe location shall be provided. The emergency lowering shall be clearly marked and accessible from the ground or fixed structure.

(5) An emergency stop device that deenergizes the powered systems and stops the personnel lifting device movement shall be provided to the personnel controlling movement of this personnel lifting device. An additional emergency stop separate from normal operating controls should be considered for personnel at ground level or on a fixed structure to enhance operational safety.

(6) All directional controls shall be designed so that they automatically return to a neutral position when released. Neutral position of controls shall bring the unit to a safe stop and hold the unit in that position until commanded to move to another position.

(7) The rated capacity of the personnel lifting device shall be clearly marked at the entrance-way and warnings, cautions, and restrictions for safe operations shall be provided according to the applicable industry and government standards or ANSI Z35.1, "Accident Prevention Signs."

702 TESTING

Testing of personnel lifting devices shall be completed according to its applicable industry standard and OSHA requirements. The responsible design, operations, and safety engineers shall develop and oversee these tests for each system as required by these standards and as described in this chapter. The following tests shall also be completed (or combined with industry requirements when practical to avoid duplication of efforts).

Three types of tests are required for personnel lifting devices: proof load tests, rated load tests, and operational tests. Proof load tests and operational tests shall be performed prior to first use for new or extensively repaired or altered components directly involved in the hoist or personnel lifting device load path. Repairs or alterations to nonlifting or holding components do not require a load test, although a functional check should be performed to determine if the repairs or alterations are acceptable. The rated load and operational tests shall be performed annually. If a personnel lifting device is upgraded, a proof load test and an operational test shall be performed based on the upgraded rating. The acceptable tolerance for load test accuracy is +5/-0 percent unless otherwise specified by design. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures approved by NASA and/or contractor Safety representatives. An inspection of the personnel lifting device and its components shall be performed after each load test and prior to the device being released for service to ensure there is no damage. This inspection shall include NDE of components that are suspected to be cracked or otherwise affected by the test. The rated load test requirement may be fulfilled by a concurrently performed proof load test.

a. Proof Load Test. Before first use, all new, extensively repaired, extensively modified, or altered personnel lifting devices shall undergo a proof load test at

1.5 times the rated load. A proof load test may also be performed when there is a question in design or previous testing. The load shall be secured to the personnel lifting device and lifted slowly and in an area where minimal damage will occur if the device fails. The load rating of the device shall be clearly marked to be legible from the operator's or user's position and shall not be more than the proof load test weight divided by 1.5.

b. Rated Load Test. Each personnel lifting device shall be tested at least once every year with a load equal to the rated load.

c. Operational Test. Together with proof load and rated load tests, the following shall be performed with a dummy rated load unless otherwise specified:

(1) Perform all hoist functions in an unloaded condition.

(2) Test operation of brakes and limit, locking, and safety devices.

(3) Determine trip setting of limit switches and limiting devices by tests under no load conditions. Conduct tests first by hand, if practical, and then under the slowest speed obtainable. Test with increasing speeds up to the maximum speed. Locate actuating mechanisms so that they will trip the switches or limiting devices in time to stop motion without damaging the hoist.

(4) After testing in the unloaded state, apply the test load to check for proper load control. Test load hoisting, lowering at various speeds (maximum safe movement up and down as determined by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations), and braking/holding mechanisms (holding brakes shall be tested to verify stopping capabilities and demonstrate the ability to hold a rated load). The load should be held long enough to allow any dynamics to dampen out.

(5) For hoist supported personnel lifting devices equipped with two means of braking (see Paragraph 701d(2)). The operational test must demonstrate each brake's ability to stop and hold a rated load. This can be done in one of the following ways:

(a) Each brake's ability to hold shall be statically tested (under no load) with 150 percent of the rated load hoisting torque at the point of brake application.

(b) Alternately, each brake shall be tested for its ability to stop a rated load moving at full speed in the down direction. (CAUTION: It must be possible to quickly reenergize the out of circuit brake or provide other safety measures to perform this test safely.)

(c) Other methods as specified by the installation NASA Safety directorate and the responsible engineering and operations/maintenance organizations.

(6) The operational test for a modified hoist supported personnel lifting device can be tailored to test only those portions of the equipment that were modified, only if the rated load and operational test interval has not expired.

d. Test Reports and Periodic Recertification Tags. After each test, designated personnel shall prepare written, dated, and signed test reports including procedure reference. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be kept on file by the owner organization for a minimum of two test cycles and shall be made readily available. Following the rated load test, personnel lifts shall be given a permanently affixed tag identifying the equipment and stating the next required rated load test date or certification expiration date.

703 INSPECTION

a. Daily and periodic safety inspections are required for personnel lifting devices. Inspections shall be completed according to its applicable industry standard and OSHA requirements and shall be performed on all personnel lifting devices. The responsible design, operation, and safety engineers shall develop and oversee the inspections for each system as required by these standards and as described herein. Inspections also shall be completed (or combined with industry requirements where practical to avoid duplication of efforts). Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, corrected prior to further use. Inspections shall be made by designated personnel according to approved technical operating procedures.

b. All new, extensively repaired, or modified personnel lifting devices shall be given a daily and a periodic inspection prior to first use. For component repair on personnel lifts, only the inspections that apply to the repaired portion need to be performed prior to first use unless a periodic inspection interval expires during the downtime (see Paragraph 703e).

c. Personnel lifts in regular service (used at least once a month) shall be inspected as required in Paragraphs 703d and 703e. Idle personnel lifting devices shall be inspected according to Paragraph 703f.

d. Daily Inspection. These inspections shall be performed prior to first use each day the personnel lifting device is used, and shall include the following:

(1) Check for defects such as cracked welds, damaged control cables, loose wire connections, and wheel or roller damage.

(2) Check functional operating and control mechanisms and guard rails for maladjustments that could interfere with normal operations.

(3) Check hose and fittings, tanks, valves, drain pumps, gear casings, and other components of fluid systems for deterioration and leaks.

(4) Without disassembling, inspect all functional operating and control mechanisms for excessive wear and contamination by excessive lubricants or foreign matter.

(5) Inspect hooks for cracks and deformities (see Chapter *5).*

(6) Inspect rope reeving for proper travel and drum lay.

(7) Inspect hoist chains for excessive wear or distortion.

e. Periodic Inspection. These inspections shall be performed at varying intervals, depending on activity, severity of service, environment, and criticality.

(1) Annual Inspections. Inspect for:

(a) Deformed, cracked, or corroded members and welds and loose bolts or rivets in personnel lift structure. Various methods of NDE such as ultrasonics, x-ray, magnetic particle, dye penetrant, etc., shall be utilized as needed.

(b) Cracked or worn sheaves and drums.

(c) Excessive wear or cracks in pins, bearings, shafts, gears, followers, and locking and clamping devices. NDE techniques shall be used if cracks are suspected.

(d) Excessive wear in hoist brake and clutch system parts, linings, pawls, and ratchets.

(e) Excessive wear in chain drive sprockets and stretch in the chain.

(f) Abnormal performance in power plant(s) and compliance with applicable safety requirements, such as locations of guards on belts.

(g) Evidence of a malfunction in braking and locking devices.

(h) Evidence of a malfunction in any safety device.

(i) Pitting or other signs of deterioration in electrical apparatus.

(j) Evidence of overheating.

(2) Monthly Inspections.

(a) Inspect for wear, twist, distortion, or stretch of hoist chains.

(b) Inspect wire rope for:

1 Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay.

2 Individual outside wires with wear of 1/3 the original diameter.

3 Kinking, crushing, bird caging, or any other damage resulting in distortion.

4 Evidence of heat damage.

5 End connectors that are cracked, deformed, or with evidence of rope pullout.

6 Corrosion internal or external, that results in reduction of rope diameter, or at end connectors.

7 Reductions of nominal diameter (measured with a caliper or go/no-go gage) of more than:

a 1/64 inch for diameters of rope up to 5/16 inch.

b 1/32 inch for diameters 3/8 inch to 1/2 inch.

c 3/64 inch for diameters 9/16 inch through 3/4 inch.

d 1/16 inch for diameters 7/8 inch through 1-1/8 inches.

e 3/32 inch for rope diameters greater than 1-1/8 inches.

8 Two broken wires at an end connection.

(c) Visible deformation or cracks in hooks (see Chapter 5).

(d) When wire ropes or chains are replaced or hooks repaired, a proof load test of the hook, rope, or chain shall be performed prior to use.

f. Idle and Standby Personnel Lifting Devices. Personnel lifting devices idle for more than 1 month shall be inspected prior to first use according to the requirements of Paragraphs 703a and 703b that were not performed at required intervals and recorded during the standby period.

g. Inspection Reports. After each formal periodic inspection, qualified authorized personnel shall prepare written, dated, and signed inspection reports, including procedure reference and adequacy of components. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and be made readily available by the organizational element responsible for personnel lift inspection.

704 MAINTENANCE

A preventive maintenance program shall be established based on manufacturers' recommendations and/or experience gained from use of the equipment. The program shall include procedures and a scheduling system for normal periodic maintenance items, adjustments, replacements, and repairs. The program also shall ensure that records are kept and unsafe test and inspection discrepancies are documented and corrected. The need to replace wire rope or chain shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results. Any of the signs of deterioration and damage provided in Paragraphs 703e(2)(a) and 703e(2)(b) are sufficient reasons for questioning continued use.

705 PERSONNEL CERTIFICATION

Operators shall be trained and certified before operating a personnel lifting device. A training, examination, and licensing program shall be established or made available. For those NASA installations that do not have a training program, all personnel lifting device operators shall be trained and certified by a recognized certification organization that normally performs this function. The basic certification program will include the following:

a. Training.

(1) Classroom training in safety and first aid/emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

(2) Hands-on training (for initial certification and as needed).

(3) An annual review of Items (1) and (2) above. (This may be conducted informally by local supervisory personnel.)

b. Examination.

(1) Physical examination (criteria to be determined by the cognizant medical official using ANSI requirements).

(2) Written examination.

(3) Operational demonstration (for initial certification only).

c. Licensing. An organizational element shall be designated to issue operator licenses. Provisions shall be made to revoke licenses for negligence, violations of safety requirements, or failure to meet medical standards. Provisions shall be made for periodic checks of operators to verify they have licenses in their possession. The licenses shall indicate the type of personnel lifting device the holder is qualified to operate. Alternately, the organizational element may elect to maintain a master list of licensed operators instead of issuing individual licenses, providing copies of the list are readily available to assurance and supervisory personnel at the work site.

d. Renewal. Licenses or certifications will expire at least every 4 years. Renewal procedures will be established by each licensing organization, but as a minimum, will include items in Paragraphs 705a and b.

706 OPERATIONS

a. Hoist support personnel lifting devices shall be operated according to applicable industry standards, government requirements, and manufacturers' instructions. The following practices shall be observed when using hoist supported personnel lifting devices:

(1) Determine that the proposed personnel lifting operation is either the least hazardous method or the only method available to position personnel so that an operation can be accomplished.

(2) Before use, the operator shall have read and understood the manufacturer's operating instructions and safety rules, have been trained and licensed according to Paragraph 705, and have read and understood all decals and warnings on the device.

(3) Before use, the operator shall inspect the personnel lifting device per the daily inspection requirements. The operator shall perform a pre-operational check to demonstrate operational readiness. If controls do not operate properly, the operator is responsible for notifying the supervisor. Repairs and adjustments shall be made before operations begin.

(4) Before the personnel lifting device is used, the operator shall survey the area for applicable hazards such as overhead obstructions and high-voltage conductors, debris, bumps and loose obstructions, dropoffs and holes, ditches, untamped earth fills, obstructed path of travel, unstable footing, and other possible hazardous conditions. The operator shall establish appropriate safety zones before initiating operations.

(5) Detailed technical operating procedures describing personnel lifting device operation, emergency steps, communication requirements, and special requirements shall be prepared. There must be a formal system for review, approval, and update to maintain valid operating procedures. Emergency procedures shall be developed for contingency actions such as power loss, brake failure, or other emergencies.

(6) A personnel lifting device shall not be loaded beyond its rated load (capacity) except for required testing.

(7) The operator shall ensure that the personnel lifting device is within inspection and testing intervals by examination of the periodic recertification tags and documentation.

(8) Necessary clothing and personnel belongings shall be stored so as not to interfere with access or operations. Tools, oil can, waste, extra fuses, and other necessary articles shall be stored properly, and shall not be permitted to lie loose during the personnel lift. Operators shall be familiar with the operation and care of the fire extinguishers provided.

(9) Prior to an operation, personnel lifting device operators shall test the communication system. Operation shall stop immediately upon communication loss, and shall not continue until communication is restored.

(10) Operator discipline shall be maintained at all times. There shall be no eating, drinking, or rowdiness, etc., during personnel lifting operations. Personnel shall keep all parts of the body, tools, and equipment inside the work platform periphery during raising, lowering, and traveling operations.

(11) Fall protection is required for personnel using personnel lifting devices. Where possible, personnel should tie off to approved attachment points not on the work cage. Handrails shall not be used as an attachment point.

(12) Personnel required to hold onto a moving platform shall use both hands. Tools and other objects shall be carried in canvas bags or by other methods that free both hands and do not present a snagging hazard. Alternate methods of tool delivery beside personnel lifting devices should be investigated.

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CHAPTER 8: SLINGS

800 GENERAL

This chapter establishes safety standards for the testing, inspection, and operation of slings. This includes slings constructed of wire rope, alloy steel chain, metal mesh, natural or synthetic fiber, and structural slings and associated equipment such as shackles, turnbuckles, eyebolts, etc.

801 SAFETY ASPECTS

a. Safety Design Criteria that should be emphasized during sling design are contained in the documents listed in Paragraph 105. Sling design shall be in accordance with industry standards and meet the applicable requirements of OSHA and ANSI. Sling design shall maintain the minimum design load safety factors listed in Table 8-3.

b. Labeling/Tagging of Slings. Certification/recertification tags are required as described in Paragraph 802e. A system shall be developed to identify slings used in critical lift applications. Completely assembled slings that have the necessary design features and maintenance/inspection, and test intervals to lift critical loads will be marked conspicuously so that the operator and assurance personnel can distinguish that the sling is qualified for critical lifts.

802 TESTING

The following proof load and periodic load tests apply to slings except as noted in Paragraph 802c. Turnbuckles shall be tested at the open position as a minimum. It is recommended that turnbuckles be tested at the open, closed, and midway positions. These tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures approved by NASA and/or contractor Safety representatives. The acceptable tolerance for load test accuracy is +5/-0 percent unless otherwise specified by design. When slings are composed of major components that fall into more than one of the categories listed in Table 8-1, the components shall be tested individually according to applicable requirements and then as a system to the lowest test value (if practical). An inspection shall be performed after each load test and prior to release for service to ensure there is no damage. A periodic load test requirement can be fulfilled by a concurrent proof load test.

a. Proof Load Test. Before first use, all new, extensively modified, repaired or altered slings shall undergo a proof load test at a specified factor of the rated load according to Table 8-1. Proof load tests performed by the manufacturer prior to delivery are acceptable, if the necessary test certification papers are provided to verify the extent and thoroughness of the test on the specific item. A proof load test also may be performed at

a prescribed time when there is a question in design or previous testing. All components shall be tested together as a system, if practical.

Table 8-1. Proof Load Test Factors
(Based on Manufacturers' Rated Load)

Equipment	Proof Load Test Factor
Wire Rope Slings	2.0
Alloy Steel Chain Slings	2.0
Metal Mesh Slings	1.5
Natural or Synthetic Rope Slings	1.0
Synthetic Web Slings	2.0
Structural Slings	2.0*
Shackles, Turnbuckles, Eye Bolts, etc.	2.0

* Unless otherwise specified by design, due to material characteristics, geometry, safety factors, etc., but in any case, at least 125 percent of the sling's rate capacity.

b. Periodic Load Test. Slings shall undergo periodic load tests at least every 4 years at a specific load test factor of the design rated load as given in Table 8-2. All components shall be tested together as a system, if practical. For slings used for critical lifts, these tests shall be based on frequency of use. Slings used infrequently for critical lifts shall be load tested before each critical lift if it has been over a year since the last load test. Slings used frequently for critical lifts shall be load tested at least once per year.

Table 8-2. Periodic Load Test Factors
(Based on Manufacturers' Rated Load)

Equipment	Periodic Load Test Factor
Alloy Steel Chain Slings	1.25
Wire Rope Slings	1.25
Metal Mesh Slings	1.25
Structural Slings	1.25
Natural or Synthetic Rope Slings	1.00*
Synthetic Web Slings	1.25
Shackles, Turnbuckles, Eye Bolts, etc.	1.25

* Critical lift rope slings of natural or synthetic material shall not be used beyond 50 percent of the manufacturer's rating to maintain an equivalent safety factor in the load system.

c. Non-Load Test Structural Slings. Due to unique design and usage requirements, a structural sling may be designated as a non-load test structural sling by the installation NASA Safety Director and the responsible engineering and operations/maintenance organizations. Such slings do not require periodic load tests.

d. Sling Rated Load. Rated loads for slings shall be based on the periodic load test weight divided by the periodic load test factor (see Table 8-2). For metal mesh slings, the rated capacity will be noted for vertical basket and choker hitch configurations. For natural or synthetic rope slings, used in noncritical lifts, a 50-percent derating for use is recommended. For natural or synthetic rope slings used in critical lifts, a 50-percent derating is required.

e. Test Reports and Periodic Recertification Tags.

(1) Written, dated, and signed reports shall be prepared after each test. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be kept on file by the owner organization for a minimum of two test cycles and shall be made readily available.

(2) Following the load test, all slings shall be given a permanently affixed tag identifying the equipment (part number) and stating the rated capacity based on the load test value and the next periodic load test due date or certification expiration date. For alloy steel chains, size, grade, and reach shall be stated along with the rated load. For natural or synthetic rope slings used for critical lifts, the marked rated load shall be 50 percent of the manufacturer's rated load. The type of material shall also be stated. All load bearing components shall be traceable to the most recent load test. This may be accomplished by clearly marking/coding or tethering all components of the assembly, through configuration control, or other procedures. (NOTE: Load bearing components not traceable to load test/certification will invalidate the load test/certification of the whole assembly.)

803 INSPECTION

Inspections shall be performed on all slings. Visual inspections for cracks, deformations, gouges, galling, kinks, crushed areas, corrosion, and proper configuration shall be performed each day the sling is used, prior to first use. An indepth inspection shall be performed annually or when a sling is suspected to have even a small loss of strength or is repaired. Inspections shall be performed by qualified personnel according to approved technical operating procedures. Inadequacies shall be documented and, if determined to be a safety hazard, corrected prior to further use.

a. Daily Inspections. These inspections shall be performed prior to first use each day the sling is used and shall include the following:

(1) Check for defects such as cracks, deformations, gouges, galling, kinks, crushed areas, and corrosion.

(2) Check for proper configuration (the lifting assembly and associated hardware, as proof load tested).

b. Periodic Inspections. The following inspections shall be performed at least once a year, unless otherwise specified below. The need to replace or repair slings shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results. Any discrepancy (deterioration or damage) is sufficient reason for questioning continued use of the sling.

(1) Alloy Steel Chain

(a) Inspect each link individually to ensure every link hangs freely with adjoining link.

(b) Ensure that wear, corrosion, or deformities at any point on chain do not exceed 20 percent of original dimensions.

(c) Ensure that master links are not deformed.

(2) Wire Rope Slings

(a) Ensure that there are fewer than 10 randomly distributed broken wires in one rope lay or *5* broken wires in 1 strand in 1 lay.

(b) Ensure wear or scraping is less than 1/3 the original diameter of outside individual wires.

(c) Inspect for kinking, crushing, bird caging, or any other distortion of the rope structure.

(d) Inspect for excessive heat damage.

(e) Inspect for cracked, deformed, or worn end attachments.

(f) Inspect for significantly corroded rope or end attachments.

(3) Metal Mesh Slings

(a) Ensure that there are no broken welds or brazed joints along the sling edge.

(b) Ensure that reduction in wire diameter does not exceed *25* percent due to abrasion or 15 percent due to corrosion.

(c) Inspect for lack of flexibility due to distortion of the fabric.

(d) Ensure that there is no more than a 25-percent reduction of the original cross-sectional area of metal at any point around handle eyes.

(e) Inspect for distortion of either handle out of plane, more than 10-percent decrease in eye width, and more than 10-percent increase in the receiving handle slot depth.

(4) Natural and Synthetic Fiber Rope Slings

(a) Inspect for abnormal wear.

(b) Ensure that there is no powdered fiber between stands.

(c) Inspect for broken or cut fibers.

(d) Ensure that there is no rotting or acid or caustic burns.

(e) Inspect for distortion of associated hardware.

(5) Synthetic Webbing Slings

(a) Ensure that there are no acid or caustic burns.

(b) Inspect for melting or charring of any part of surface.

(c) Inspect for snags, punctures, tears, and cuts.

(d) Inspect for broken or worn stitches and rotting.

(e) Ensure that wear or elongation does not exceed amount recommended by the manufacturer.

(6) Structural Slings

(a) Verify overall that there is no evidence of damage, gouges in metal, loose bolts, rivets, connections, or deformations such as galling or gouges in pins, eyes, and end connections.

(b) Ensure that there are no bent, deformed, cracked, or excessively corroded support or main members.

(c) Without disassembly, inspect load bearing bolts for evidence of deterioration. Verify that assemblies are intact and that there has been no shifting or relative motion of parts.

(d) Inspect attachment and lifting lugs for visual deformation and evidence of local yielding.

(e) Ensure that there are no elongated attachment or lifting holes.

(f) Inspect around fasteners for local yielding and deformation.

(g) Remove and inspect load bearing slip pins for deformation, evidence of bending, abnormal defects such as galling, scoring, brinelling, and diameters not within design tolerances. Verify that there are no cracks. Dye penetrant, magnaflux, x-ray, or ultrasonics shall be used when required by design requirements or when cracks are suspected.

(h) Inspect pin bores for deformation, local yielding, scoring, galling, brinelling, and diameters not within design tolerances. Verify that there are no cracks. Dye penetrant or ultrasonics shall be used when required by design requirements or when cracks are suspected.

(i) Inspect welds for cracks, evidence of deformation, deterioration, damage, or other defects by:

1 Visual inspection of all welds.

2 Ultrasonics, x-ray, magnetic particle, dye penetrant, or eddy current as appropriate for critical welds as identified on the design drawings and welds where cracks are suspected.

(j) Inspect all parts, particularly bare metal, for corrosion. Corrosion-protect all surfaces with strippable vinyl that are not to be painted, lubricated, or coated. Do not paint over uninspected areas, or cracks, deformations, deterioration, or other damage until engineering assessment has been made.

(k) All slings rejected during inspection shall be marked. An engineering assessment will be made to determine if the sling is repairable. Non-repairable slings will be destroyed as soon as possible to avoid unintentional use.

(l) Inspect hooks for deformations or cracks (see Chapter 5).

c. Idle Slings. Slings that are idle will be inspected prior to use to fulfill the requirements in Paragraph 803a and 803b that may have expired during the idle time.

d. Inspection Reports. Written, dated, and signed inspection reports shall be prepared after each periodic inspection. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be filed and made readily available by the organizational element responsible for inspecting sling(s).

804 MAINTENANCE

A preventive maintenance program shall be established based on manufacturers' recommendations and/or experience gained from use of the equipment. The program shall include procedures and a scheduling system for normal periodic maintenance items, adjustments, replacements, and repairs. The program shall also ensure that records are kept and unsafe test and inspection discrepancies are documented and corrected. The need to repair or replace slings shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results.

805 OPERATIONS

a. The following safety practices shall be followed when using slings:

(1) Select a sling of suitable rated capacity, use proper hitch, and attach the sling securely to the load. For critical lifts, rope slings of natural or synthetic construction shall not be used beyond 50 percent their rated load. (The minimum safety factors for determining rated load are provided in Table 8-3.)

(2) Avoid kinks, loops, or twists in the legs.

(3) Start lift slowly to avoid shock loading the slings.

(4) Do not pull a sling from under a load when the load is resting on the sling. Block the load up to remove the sling.

(5) Do not shorten a sling by any means. Knotting and wire rope clips are prohibited.

(6) Keep metallic slings lubricated/painted to prevent corrosion.

(7) Slings shall not be loaded over the rated load except as required for periodic load tests.

(8) Particular attention shall be given to preventing corrosion. Slings shall be stored such that they will not be damaged by moisture, heat, sunlight, or chemicals. Nylon shall not be used in an acid or

phenolic environment. Polyester, polypropylene, and aluminum shall not be used in a caustic environment.

(9) Precautions shall be taken to ensure proper sling assembly and that the proper configuration is maintained.

(10) The user shall ensure that the sling is within the inspection and periodic recertification intervals and that all load bearing components are traceable to the most recent load test by examination of the tags and/or documentation.

(11) Sling repair shall maintain the minimum design load safety factors based on ultimate material strength. These factors are listed in Table 8-3.

Table 8-3. Minimum Safety Factors for Slings

Equipment	Design Load Safety Factor
Alloy Steel Chain	5
Wire Rope	5
Metal Mesh	5
Manila Rope	5
Nylon Rope	9
Nylon Web	5
Polyester Rope	9
Polypropylene Rope	6
Structural	3 times yield and 5 times ultimate

Note: Design load safety factor based on ultimate material strength, except for structural slings.

APPENDIX A

ACRONYMS AND DEFINITIONS

ANSI: American National Standards Institute.

Brake: A device, other than a motor, used for retarding or stopping motion by friction or power means.

Certification: That situation when the lifting device or equipment maintenance, test, or other operational checks have been performed and are current.

CMAA: Crane Manufacturers Association of America, Inc.

Control Braking Means: A method of controlling speed by removing energy from the moving body or by imparting energy in the opposite direction.

Crane: A machine for lifting and lowering a load and moving it horizontally, with the hoisting mechanism an integral part of the machine.

Critical Weld: A weld where the single failure of which could result in injury to personnel or damage to property or flight hardware by dropping or losing control of the load.

Derrick: An apparatus with a mast or member held at the head by guys or braces, with or without a boom and that uses a hoisting mechanism and operating ropes for lifting or lowering a load.

Designated Person: Any person who has been selected or assigned (in writing) by the responsible NASA organizational element or the using contractor as being qualified to perform specific duties. A licensed operator may serve as a designated person for the equipment he/she is licensed to handle.

Design Load: The value used by the manufacturer as the maximum load that around which the device or equipment is designed and built based on specified design factors and limits. This is also the load referred to as the "Manufacturer's Rated Load."

Deviation: A variance that authorizes departure from a particular safety requirement, were the intent of the requirement is being met through alternate means that provide an equal or greater level of safety.

Eddy Current Brake (control braking means): A method of controlling or reducing speed by means of an electrical induction load brake.

Emergency Stop (E-Stop): A manually operated switch or valve to cut off electric power or release fluid power independently of the regular operating controls.

Failure Mode and Effects Analysis (FMEA): A systematic, methodical analysis performed to identify and document all identifiable failure modes at a prescribed level and to specify the resultant effect of the modes of failure.

Frequently: For the purpose of this document, the term “frequently” is used to mean once or more per year.

Hazard: Any real or potential condition that can cause injury or death to personnel, or damage to or loss of equipment or property.

Hoist: A machinery unit device used for lifting and lowering a load.

Hoist Supported Personnel Lifting Device: Lifting equipment such as a platform, bucket or cage supported by hoist(s) that is designed, built, tested, maintained, inspected, and certified as having sufficient reliability for safely lifting and lowering personnel.

Holding Brake: A friction brake that is automatically applied and prevents motion when power is off.

Hydra-set: Trade name for a closed circuit hydraulically operated instrument installed between hook and load that allows precise control of lifting operations and provides an indication of the applied load. It will be used in the general sense in this standard as a means of identifying precision load positioning devices.

Licensed Operator: Any person who has successfully completed the examination for crane, hoist, or heavy equipment operator and has been authorized to operate such equipment. (NOTE: This term includes certified and/or authorized operator.)

Load: The actual object being raised or moved.

Nondestructive Evaluation (NDE): Test and inspection methods used to determine the integrity of equipment that do not involve destruction of the test object. Examples are ultrasonic, magnetic particle, eddy current, X-ray, dye penetrant, etc.

NSIS: NASA Safety Information System.

OEM: Original Equipment Manufacturer.

Operational or Working Load: A value representing the weight of the load actually being handled plus the load attaching equipment (slings, Hydra-set, spreader bars, etc.).

Operational Test: A test to determine if the equipment (limit switches, emergency stop controls, brakes, etc.) is functioning properly.

OSHA: Occupational Safety and Health Administration.

Periodic Load Test: A load test performed at predetermined intervals with load greater than the rated load, but less than the proof load.

Personnel Lift: For the purposes of this document, a working platform that will lift, lower, sustain, and transport people.

Proof Load: The specific load or weight applied in performance of a proof load test and is greater than the rated load.

Proof Load Test: A load test performed prior to first use, after major modification of the load path or at other prescribed times. This test verifies material strength, construction, and workmanship and uses a load greater than the rated load.

PSCA: Power Crane and Shovel Association.

Rated Load or Safe Working Load or Rated Capacity: An assigned weight that is the maximum load the device or equipment shall operationally handle and maintain. This value is marked on the device indicating maximum working capacity. This is also the load referred to as "safe working load." If the device has never been downrated or uprated, this also is the "manufacturer's rated load."

Rated Load Test: A load test performed at predetermined intervals with a load equal to the rated load.

Remote Emergency Stop (Remote E-Stop): An emergency stop remotely located from the regular operator controls.

Safety Factor: A ratio of ultimate strength, breaking strength, or yield strength to maximum permissible stress. It is not "reserve strength" that can be used to justify exceeding permissible stresses or exceeding the design load.

Side Pull: That portion of the hoist pull acting horizontally when the hoist lines are not operating vertically.

Side Load: A load applied at an angle to the vertical plane of the boom.

Single Failure Point: A single item or component whose failure would cause an undesired event such as dropping a load or loss of control.

Shall: The word "shall" indicates that the rule is mandatory and must be followed.

Should: The word "should" indicates that the rule is a recommendation, the advisability of which depends on the facts in each situation.

Sling: A lifting assembly and associated hardware used between the load and hoisting device hook.

Structural Sling: A rigid or semi-rigid fixture that is used between the load and hoisting device hook. Examples are spreader bars, equalizer bars, lifting beams, etc.

Tagline: A line used to restrain or control undesirable motion of a suspended load.

User-Operated Crane: A crane maintained by one group (contractor) and operated by a different group (contractor).

Variance: Documented and approved permission to perform some act contrary to established requirements.

Waiver: A variance that authorizes departure from a particular safety requirement, where an increase level of risk has been accepted.

Winch: A device used for hauling or pulling in a horizontal direction by means of a drum or barrel around which a rope or chain is wrapped or is shortened.

Wire Rope Slings: Wire ropes made into forms, with or without fittings, for handling loads and so made as to permit the attachment of an operating rope.

Working Load: If the device has never been downrated or uprated, this also is the "manufacturer's rated load."

APPENDIX B

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ALTERNATE SAFETY STANDARD FOR
SUSPENDED LOAD OPERATIONS

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U.S. Department of Labor

Assistant Secretary for
Occupational Safety and Health
Washington, D.C. 20210

JUL 15 1991

Mr. George A. Rodney
Associate Administrator for
Safety and Mission Quality
National Aeronautics and Space
Administration
600 Independence Avenue, S.W.
Washington, D.C. 20546

Dear Mr. Rodney:

The Occupational Safety and Health Administration (OSHA) has completed its review of the proposed alternate standard on suspended loads, as required in 29 CFR 1960.17. With this letter, we want to inform you that we have approved the standard. This approval is based on our determination that the alternate standard provides equivalent protection as would compliance with the following standards in specifically identified operations:

- 1910.179(n)(3)(vi) The employer shall require that the operator avoid carrying loads over people.

- 1910.180(h)(3)(vi) The operator should avoid carrying loads over people.

- 1910.180(h)(4)(ii) No person should be permitted to pass under a load on the hook.

One of the OSHA reviewers stated that this standard, ". . . appears to be a very comprehensive approach to a finite task and requires significant amounts of safety management from the preliminary hazard analysis through completion of the lift." It is essential, however, that management ensure that this level of safety management effort continues to effectively protect the exposed employees.

We appreciate the cooperation provided my staff in the many discussions on this alternate standard. Your interest and support for the safety and health of Federal employees is greatly appreciated.

Sincerely,

Gerard F. Scannell
Assistant Secretary

20 OSHA 1971 20 YEARS OF SERVICE TO THE NATION 1991

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ALTERNATE SAFETY STANDARD FOR
SUSPENDED LOAD OPERATIONS

This standard applies to specifically identified operations controlled by the National Aeronautics and Space Administration (NASA) involving both civil service and contractor employees. The standard is an alternate to Code of Federal Regulations 29 CFR 1910.179(n)(3)(vi), 29 CFR 1910.180(h)(3)(vi), and 29 CFR 1910.180(h)(4)(ii). NASA Safety is responsible for its implementation and enforcement.

As an alternative standard developed pursuant to Section 1-201(d) of Executive Order 12196 and 29 CFR 1960.17, it applies only to NASA employees. The Occupational Safety and Health Administration (OSHA) will inspect the working conditions of NASA employees performing these specified operations for compliance with these alternate standard requirements. Although OSHA can not inspect private sector employees working in the same operation with NASA employees for compliance with the alternate standard, it will fully consider the equivalent safeguards specified in this standard for both NASA and contractor employees as the basis for a de minimis violation which is recorded, but not issued.

Suspended Load Operation Definition

An operation is considered a suspended load operation and subject to the requirements of this standard if it meets all three of the following criteria:

1. The operation involves the use of a crane or hoist that supports the weight of a suspended load. (This excludes operations where the load is secured in a holding fixture or on substantial blocks supporting the entire load even though the crane/hoist hook may still be attached.) No distinction is made between a static load and a dynamic load. Rigging, i.e., slings, Hydra-sets, lifting fixtures, shackles, straps, when attached to the hook, is considered part of the load.

2. Personnel involved in the operation have any part of the body directly beneath the suspended load. (This excludes operations where employees have their hands on the sides of a load, i.e., to guide the load.)

3. In the event of a crane/hoist failure, as the load drops it could contact personnel working directly beneath it, with injury or death as a possible result. (This excludes operations where employees have their hands only partially under a load such that a crane or hoist device failure would push their hands out of the way not resulting in injury. This also excludes situations where the falling load would come to rest on hardware that is not suspended before an employee could be injured.)

Requirements

It is recognized that cranes and hoists do not generally meet the support requirements of a system that would allow personnel to work beneath a suspended load. NASA's first hazard avoidance protocol is to design hazards out of the system or operation. Accordingly, it is NASA's intent and goal that all future systems, hardware, and equipment be engineered, designed, installed, and operated to prevent exposing employees to working under loads suspended from cranes and hoists. Due to the uniqueness of NASA activities and the limitations imposed when using present systems, hardware, equipment, and facilities, suspended load operations may be permitted only under specifically approved and controlled conditions. No suspended load operation shall be performed unless all (15) of the following special requirements are met:

(1) All suspended load operations will be approved by the Center/facility NASA Director of Safety based upon a detailed engineering hazards analysis of the operation. The hazards analysis will be prepared by the responsible safety organization and coordinated through appropriate engineering and design offices. The analysis documentation will include the following:

(a) A justification why the operation cannot be conducted without personnel beneath the load. Feasible procedure/design options will be investigated to determine if the work can be accomplished without personnel working under a load suspended from a crane/hoist.

(b) Details of the precautions taken to protect personnel should the load drop. Secondary support systems, i.e., equipment designed to assume support of (catch) the load preventing injury to personnel should the crane/hoist fail, shall be evaluated and used whenever feasible. Secondary support systems will be constructed with a minimum safety factor of 2 to yield.

(c) The maximum number of exposed personnel allowed. Steps shall be taken to limit the number of personnel working under a load suspended from a crane/hoist. Only those essential personnel absolutely necessary to perform the operation will be allowed to work in the safety controlled area.

(d) The time of exposure. Steps shall be taken to ensure that personnel do not remain under the load any longer than necessary to complete the work.

(2) Each operation will be reviewed on a case-by-case basis.

(3) Only those suspended load operations approved by the Center/facility NASA Director of Safety will be permitted, subject to this standard. A list of approved suspended load operations will be maintained by NASA Safety and made available to OSHA personnel upon request.

(4) The operational procedures document (e.g., Operations and Maintenance Instruction, Technical Operating Procedure, Work Authorization Document) will be revised to specify the necessary additional requirements identified by the hazard analysis discussed in Paragraph (1). The procedures will be available on site for inspection during the operation.

(5) During a suspended load operation, if a new procedure not covered by the original analysis is deemed necessary due to unusual or unforseen circumstances, the NASA Center/facility Safety 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. If the new procedure is to be performed on a regular basis, a detailed hazards analysis and approval as outlined in Paragraph (1) are required.

(6) The crane/hoist shall be designed, tested, inspected, maintained, and operated in accordance with the NASA Safety Standard for Lifting Devices and Equipment (NSS/GO-1740.9). Test, inspection, and maintenance procedures will be developed and approved by qualified, responsible NASA engineers. Qualified specialists will perform the procedures and resolve noted discrepancies. NASA Quality Assurance will perform an independent annual inspection of all cranes/hoists involved in suspended load operations. The results of the annual inspections will be maintained and made available to OSHA personnel upon request.

(7) Each crane/hoist involved in suspended load operations shall undergo a Failure Modes and Effects Analysis (FMEA) that shall be approved by the Center/facility NASA Director of Safety. The FMEA will determine Single Failure Points (SFP), assessing all critical mechanical functional components and support systems in the drive trains and critical electrical components.

(a) For those cranes/hoists identified as having no SFP whose failure would result in dropping the load, the total weight of the suspended load shall not exceed the device's rated load.

(b) For those cranes/hoists identified as having a SFP whose failure would result in dropping the load, use of that device for suspended load operations must be approved by NASA Headquarters. Complete documentation on the suspended load operation, including the hazards analysis outlined in Paragraph (1) and the FMEA described above, will be forwarded to NASA Headquarters for evaluation. Approval will be given based upon detailed analysis of the potential hazards and rationale for acceptance. Such cases will never exceed the device's rated load. OSHA shall be notified when NASA Headquarters approves using any crane/hoist identified as having a SFP whose failure would result in dropping the load.

(8) Before lifting the load involved in a suspended load operation, the crane/hoist will undergo a visual inspection (without major disassembly) of components instrumental in assuring that the load will not be dropped (e.g., primary and secondary brake systems, hydraulics, mechanical linkages, and wire rope per NSS/GO-1740.9). Noted discrepancies will be resolved before the operation continues. This pre-lift inspection will be in addition to the inspections required in 1910.179(j) and 180(d).

(9) A trained and licensed operator (certified per NSS/GO-1740.9) shall remain at the crane/hoist controls while personnel are under the load.

(10) Safety controlled areas shall be established with appropriate barriers (rope, cones, etc.). All nonessential personnel shall be required to remain behind the barriers.

(11) Prior to the suspended load operation, a meeting with the crane/hoist operator(s), signal person(s), person(s) who will work under the load, and the person responsible for the task shall be held to plan and review the approved operational procedures that will be followed, including procedures for entering and leaving the safety controlled area.

(12) Communications (voice, radio, hard wired, or visual) between the operator(s), signal person(s), and the person(s) working under the load shall be maintained. Upon communication loss, operations shall stop immediately, personnel shall clear the hazardous area, and the load shall be safed. Operations shall not continue until communications are restored.

(13) Personnel working beneath the load shall remain in continuous sight of the operator(s) and/or the signal person(s).

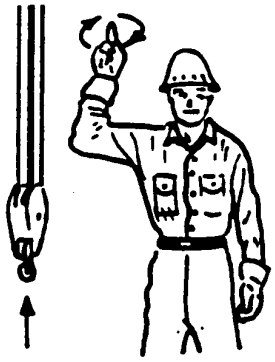
(14) NASA shall conduct periodic reviews to ensure the continued safety of the procedures. As a minimum, NASA will annually evaluate the implementation of this procedure at each Center with operations on the suspended load list.

(15) A list of approved suspended load operations, list of cranes/hoists used for suspended load operations, and copies of the associated hazards analyses will be provided to the OSHA Office of Federal Agency Programs via NASA Headquarters for distribution to the appropriate regional and area OSHA offices. (NASA Headquarters, in conjunction with OSHA, will develop a format for transmittal of this information.) Quarterly updates to the documentation will be provided as needed.

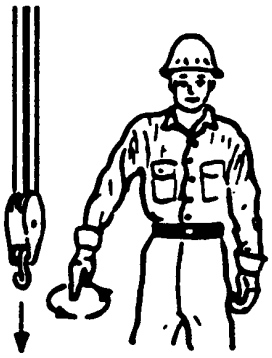
APPENDIX C

HAND SIGNALS

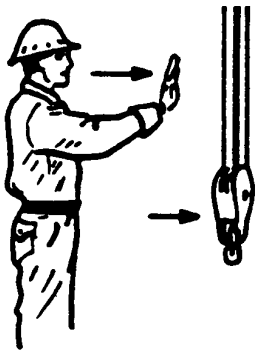
Overhead Cranes



HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle.

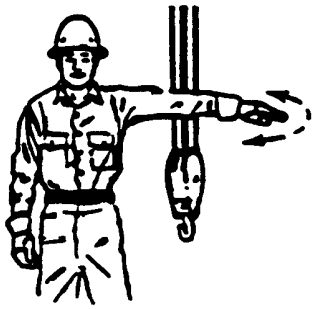


LOWER. With arm extended downward, forefinger pointing down, move hand in small horizontal circles.

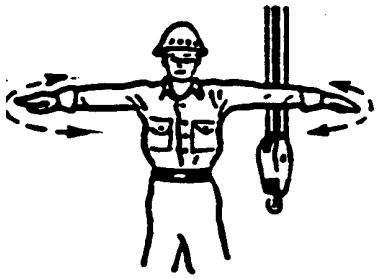


BRIDGE TRAVEL. Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.

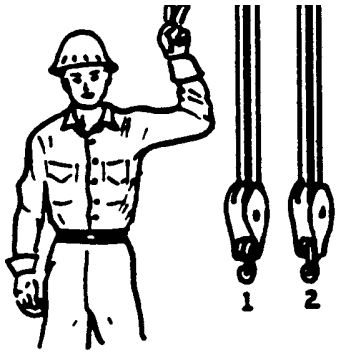
TROLLEY TRAVEL. Palm up, fingers closed, thumb pointing in direction of motion, jerk hand horizontally.



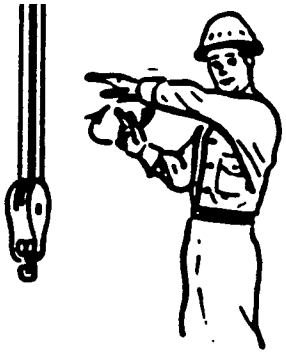
STOP. Arm extended, palm down, move arm back and forth.



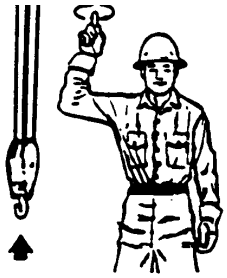
EMERGENCY STOP. Both arms extended, palms down, move arms back and forth.



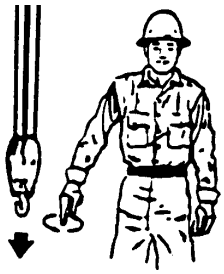
MULTIPLE TROLLEYS. Hold up one finger for block marked “1” and two fingers for block marked “2”. Regular signals follow.



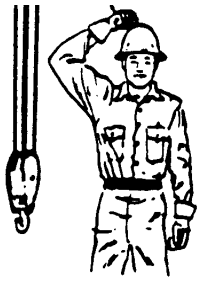
MOVE SLOWLY. Use one hand to give any motion signal and place other hand motionless in front of hand giving the motion signal. (Hoist slowly shown as example.)



HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle.

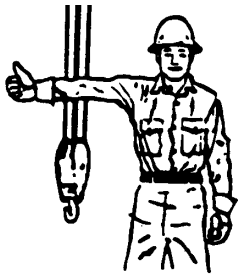


LOWER. With arm extended downward, forefinger pointing down, move hand in small horizontal circles.

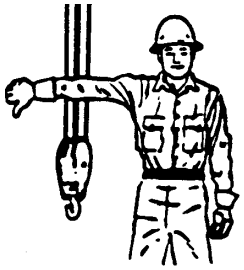


USE MAIN HOIST. Tap fist on head then use regular signals.

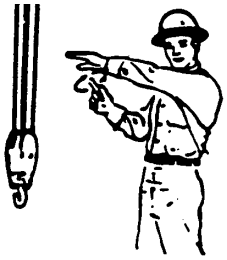
USE WHIP LINE. (Auxiliary Hoist) Tap elbow with one hand, then use regular signals.



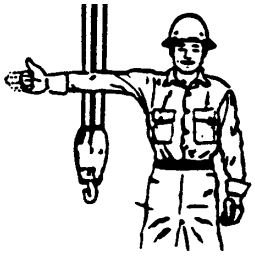
RAISE BOOM. Arm extended, fingers closed, thumb pointing upward.



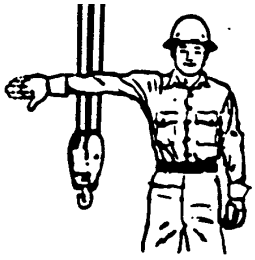
LOWER BOOM. Arm extended, fingers closed, thumb pointing downward.



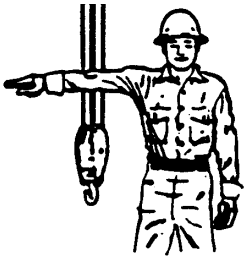
MOVE SLOWLY. Use one hand to give any motion signal and place other hand motionless in front of hand giving the motion signal. (Hoist slowly shown as example.)



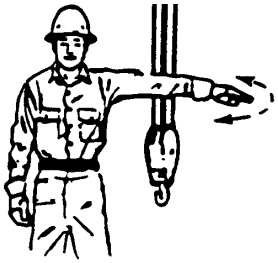
RAISE THE BOOM AND LOWER THE LOAD. With arm extended, thumb pointing up. Flex fingers in and out as long as load movement is desired.



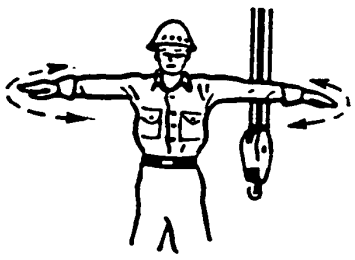
LOWER THE BOOM AND RAISE THE LOAD. With arm extended, thumb pointing down, flex fingers in and out as long as load movement is desired.



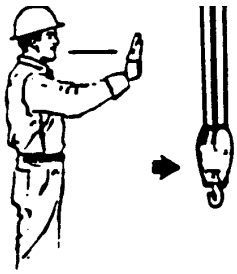
SWING. Arm extended, point with finger in direction of swing of boom.



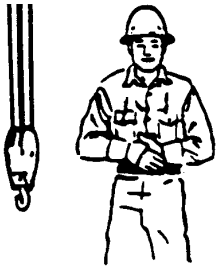
STOP. Arm extended, palm down, move arm back ad forth horizontally.



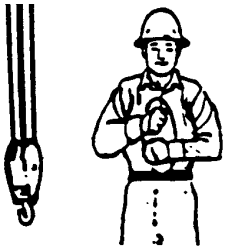
EMERGENCY STOP. Both arms extended, palms down, move arms back and forth horizontally.



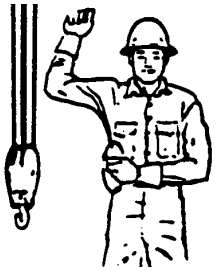
TRAVEL. Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.



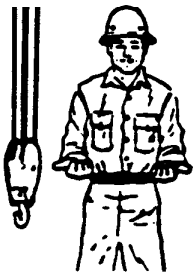
DOG EVERYTHING. Clasp hands in front of body.



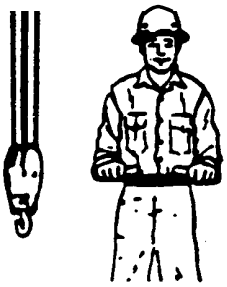
TRAVEL. (Both Tracks) Use both fists in front of body, making a circular motion, about each other, indicating direction of travel; forward or backward. (For land cranes only.)



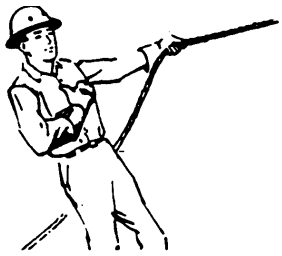
TRAVEL. (One Track) Lock the track on side indicated by raised fist. Travel opposite track in direction indicated by circular motion of either fist, rotated vertically in front of body. (For land cranes only.)



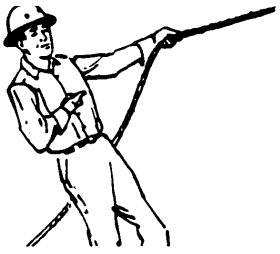
EXTEND BOOM. (Telescoping Booms) Both fists in front of body with thumbs pointing outward.



RETRACK BOOM. (Telescoping Booms) Both fists in front of body with thumbs pointing toward each other.



EXTEND BOOM. (Telescoping Booms) One Hand Signal. One fist in front of chest with thumb tapping chest.



RETRACK BOOM. (Telescoping Booms) One Hand Signal. One fist in front of chest, thumb pointing outward and heel of fist tapping chest.

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