HYBRID

National Aeronautics and
Space Administration

NASA-STD 8719.9 Standard for Lifting Devices and Equipment has been superseded by NASA-STD-8719.9A Standard for Lifting Devices and Equipment Revision A 08/13/2015
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STANDARD FOR
LIFTING DEVICES AND EQUIPMENT

NASA TECHNICAL STANDARD

FOREWORD

This standard is approved for use by NASA Headquarters and all NASA Installations and contractors as specified in their contracts. The standard establishes uniform design, testing, inspection, maintenance, operational, personnel certification, and marking requirements for lifting devices and associated equipment used in support of NASA operations. A NASA operation is defined as any activity or process that is under NASA direct control or includes major NASA involvement.

NASA's goal for achieving "best class" status as an organization poised for preventing mishaps requires perfecting our processes in four areas of excellence. These areas are: management commitment and employee involvement; system and worksite hazard analysis; hazard prevention and control; and safety and health training. This standard was developed to address hazard prevention and control as well as safety and health training and expands on NPG 8715.3, "NASA Safety Manual," policy and guidelines for safety assurance. It is a compilation of pertinent requirements from the Occupational Safety and Health Administration (OSHA), American Society of Mechanical Engineers (ASME), American National Standards Institute (ANSI), Crane Manufacturers Association of America (CMAA), and unique NASA requirements. The standard combines the knowledge of all NASA Installations and contractors including NASA operations in host countries, standardizes definitions, clarifies/documents OSHA interpretations, addresses the subject of criticality, and conveys standardized requirements. With the exception of Alternative Standard for Suspended Load Operations contained in Appendix A, this standard is not a substitute for OSHA or local government (including such host country requirements as those in Australia or Spain) requirements which apply to NASA operations in full.

Significant changes in this revision of the standard include the coverage for Mobile Aerial Platforms, Powered Industrial Trucks, and Jacks. Appendices C and D have been added concerning lifting personnel with a crane and using a crane to load test other lifting equipment, respectively. The designation of an installation Lifting Devices and Equipment Manager (LDEM) is also required with this revision.

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 assuring implementation. This document establishes minimum safety requirements; NASA installations are encouraged to assess their individual programs and develop additional requirements as needed.

Requests for information, corrections, or additions to this standard should be directed to the National Aeronautics and Space Administration Headquarters, Director, Safety and Risk Management Division, Code QS, Washington, DC 20546. Requests for general information concerning NASA Technical Standards should be sent to NASA Technical Standards Program Office, ED41, MSFC, AL, 35812. This and other NASA Standards may be viewed and downloaded free-of-charge from our NASA Standards Homepage: http//standards.nasa.gov. This NASA Technical Standard cancels NSS/GO-1740.9, dated November 1991 as updated March 1993.

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REVISION LOG

REVISION	DESCRIPTION	DATE
Initial Issue	NASA-STD-8719.9, NASA Standard for Lifting Devices and Equipment. Significant Changes. Converts document to NASA-STD format. Adds sections on mobile aerial platforms, powered industrial trucks, and jacks. Adds appendices on lifting personnel with a crane and using a crane to load test other lifting equipment. Designation of an installation Lifting Devices and Equipment Manager (LDEM) is also required.	May 9, 2002
Change 1	Document is revalidated without changes other than updates to Cover, Foreword (address), and Revision Log.	October 1, 2007 JWL4
Change 2	Corrected page numbering. Removed expiration date.	September 28, 2012 AEC

A note concerning the history of this document:

The original NASA Safety Standard for Lifting Devices and Equipment was issued as NSS/GO-1740.9 in July 1982. In July 1988 it was revised and Revision A was issued reflecting significant changes related to mobile cranes, hoist supported personnel platforms, personnel lifting buckets, and guidance concerning super critical lifts. In November 1991 it was revised again and Revision B was issued which deleted the guidance on super critical lifts and added the NASA Alternate Standard for Suspended Load Operations. Additional revisions were issued as change pages in March 1993 to expand operational test requirements for special hoist supported personnel lifting devices. When it came time to update the standard again, in addition to the technical changes to the document (synopsized in the Revision Log above) the format and numbering were changed to reflect current practices and conventions for NASA Standards.

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STANDARD FOR LIFTING DEVICES AND EQUIPMENT

1. SCOPE

1.1 Scope. This standard applies to overhead and gantry cranes (including top running monorail, underhung, and jib cranes) mobile cranes, derricks, hoists, winches, special hoist supported personnel lifting devices, hydra-sets, load measuring devices, hooks, slings and rigging, mobile aerial platforms, powered industrial trucks, and jacks. This document does not include coverage for front-end loaders and elevators.

1.2 Purpose. This standard establishes NASA's minimum requirements for the design, testing, inspection, maintenance, personnel certification, and operation of lifting devices and equipment (LDE) described in paragraph 1.1.

1.3 Applicability. Compliance with this standard is mandatory for all NASA-owned and NASA contractor-supplied equipment used in support of NASA operations at NASA installations and NASA operations in host countries. The individual installation Lifting Devices and Equipment Manager (LDEM) and safety organizations are responsible for implementation and enforcement. This document establishes minimum 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. Rented or leased LDE is exempt from this standard only by the decision of the contracting officer, the responsible NASA installation/program safety office, and the LDEM. If determined that rented or leased LDE will be used for a critical lift, this standard applies.

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

1.3.2 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.

1.3.3 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 1.7. 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.

1.3.4 Portions of this standard refer to various national consensus codes/standards for equipment design/hardware requirements (e.g., ASME, CMAA, etc.). Lifting devices and equipment purchased after the initial review required in paragraph 1.3.2 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 and Risk Management Division

with concurrence from the field installations shall decide when the next complete review (as described in paragraph 1.3.2) is warranted.

1.4 Relation to Occupational and Safety Health Administration (OSHA) Requirements. 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 and Risk Management Division, with assistance from the field installations, shall monitor subsequent OSHA requirements for any impact on NASA's safe lifting program.

1.5 Critical and Noncritical Lifting Operations. There are two categories of lifting operations for the purposes of this standard, critical and noncritical.

1.5.1 Critical lifts are lifts where failure/loss of control could result in loss of life, loss of or damage to flight hardware, or a lift involving special high dollar items, such as spacecraft, one-of-a-kind articles, or major facility components, whose loss would have serious programmatic or institutional impact. Critical lifts also include the lifting of personnel with a crane, lifts where personnel are required to work under a suspended load, and operations with special personnel and equipment safety concerns beyond normal lifting hazards. 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 A). Lifting of personnel with a crane shall be in accordance with 29 CFR 1926.550 (see Appendix C).

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 LDEM.

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. During critical lifts there shall be one person present (NASA or contractor) that is designated as responsible for the safety of the operations. That person may be a safety professional, a supervisor, an engineer, or a task leader.

1.5.2 Noncritical lifts typically involve routine 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.

1.5.3 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 1.7. Different levels of risks associated shall be evaluated using the risk determination criteria in NPG 8715.3.

1.6 Recordkeeping and Trend Analysis. A data collection system shall be established at each installation or location to support NASA-wide 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.

1.7 Safety Variances.

1.7.1 If a mandatory requirement cannot be met, a safety variance shall be prepared in accordance with NPG 8715.3.

1.7.2 The NASA variance process does not apply to Federal and applicable State/local regulations (e.g., OSHA, Cal OSHA). Any variance of a Federal or State/local regulation must be approved by the appropriate Federal/State/local agency (e.g., NASA Alternate Safety Standard for Suspended Load Operations approved by OSHA). The NASA Safety and Risk Management Division shall review all proposed safety variances of Federal regulations before submittal for approval.

1.7.3 Example: A variance request to a requirement in this standard that uses the word shall would be routed through the Center Safety Director for concurrence and approved or denied by the Center Director. A copy would then be sent to the NASA Safety and Risk Management Division within 14 days along with detailed rationale for its approval and other documentation.

1.8 Lifting Devices and Equipment Committee.

1.8.1 NASA LDE Committee. Each installation Director shall designate in writing at least one person and an alternate, with appropriate background in lifting devices, lifting operations, lifting equipment industry standards and an understanding of lifting safety, as the installation LDEM, to participate as a member of the NASA LDE Committee. The committee is chaired by the Director, Safety and Risk Management Division, or designee, and is responsible for reviewing proposed changes to this standard and addressing general LDE safety issues. The LDEM is responsible for overall management of the installation LDE program, coordinating with appropriate personnel at their installation on lifting issues and providing the NASA LDE Committee with their installation's position on LDE issues.

1.8.2 Installation LDE Committee. Each installation shall establish a LDE Committee, to ensure this standard is understood and applied across other organizations at the installation and to resolve any issues and provide a forum to exchange information. The Installation LDE Committee shall be chaired by the LDEM, with representation from all organizations at the installation that are responsible for and/or involved with LDE.

1.9 Personnel Performing Nondestructive Testing. Personnel performing lifting devices and equipment nondestructive testing (NDT), including visual inspections, shall be qualified and certified in accordance with written practices meeting the requirements contained

in American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.

2. APPLICABLE DOCUMENTS

2.1 General. The applicable documents cited in this standard are listed in this section for reference only. The specified technical requirements listed in the body of this document must be met whether or not the source document is listed in this section.

2.2 Government Documents.

2.2.1 Specifications, Standards, and Handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issuances in effect on date of invitation for bids or request for proposal shall apply.

DEPARTMENT OF LABOR, OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910, Subpart I, Personal Protective Equipment.

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910.29, Manually Propelled Mobile Ladder Stands and Scaffolds (Towers).

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910.67, Vehicle-Mounted Elevating and Rotating Work Platforms.

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910.178, Powered Industrial Trucks.

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910.179, Overhead and Gantry Cranes.

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910.180, Crawler, Locomotive, and Truck Cranes.

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910.181, Derricks.

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1910.184, Slings.

OCCUPATIONAL SAFETY AND HEALTH STANDARD, 29 CFR 1926.550, Cranes and Derricks.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Specifications Kept Intact (SPECSINTACT), Standard Construction Specification System.

NASA SPECSINTACT, Section 14370, Monorails and Hoists.

NASA SPECSINTACT, Section 14380, Electric Overhead Cranes.

(Copies of OSHA standards are available at: http://www.osha.gov/comp-links.html, copies of NASA Standards are available at http://standards.nasa.gov.)

2.2.2 Other Government Documents, Drawings, and Publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issuances in effect on date of invitation for bids or request for proposal shall apply.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA Procedures and Guidelines 8715.3, NASA Safety Manual.

NASA Procedures and Guidelines 8820.2C, Facility Project Implementation Handbook.

(Copies of NASA directives are available at http://nodis.hq.nasa.gov/Welcome.html.)

2.3 Non-Government Publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issuances in effect on date of invitation for bids or request for proposals shall apply.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.

"Manual of Steel Construction," 400 North Michigan Avenue, Chicago, Illinois 60611.

AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING

SNC-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME), AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A10.22, Safety Requirements for Rope Guided and Nonguided Worker's Hoists.

ANSI/SIA A92.2, Vehicle Mounted Elevating and Rotating Aerial Devices.

ANSI/SIA A92.3, Manually Propelled Elevating Aerial Platforms.

ANSI/SIA A92.5, Boom Supported Elevating Work Platforms.

ANSI/SIA A92.6, Self Propelled Elevating Work Platforms.

ANSI/ISA S84.01, Electrical, Electronic, Programmable Electronic Systems in Safety Applications.

ASME B30.1, Jacks.

ASME B30.2, Overhead and Gantry Cranes.

ASME B30.3, Construction Tower Cranes.

ASME B30.4, Portal, Tower, and Pedestal Cranes.

ASME B30.5, Mobile and Locomotive Cranes.

ASME B30.6, Derricks.

ASME B30.7, Base Mounted Drum Hoists.

ASME B30.8, Floating Cranes and Floating Derricks.

ASME B30.9, Slings.

ASME B30.10, Hooks.

ASME B30.11, Monorails and Underhung Cranes.

ASME B30.12, Handlings Loads Suspended from Rotorcraft.

ASME B30.14, Side Boom Tractors.

ASME B30.16, Overhead Hoists.

ASME B30.17, Overhead and Gantry Cranes.

ASME B30.19, Cableways.

ASME B30.20, Below-the-Hook Lifting Devices.

ASME B30.21, Manually Lever Operated Hoists.

ASME B30.22, Articulating Boom Cranes.

ASME B30.23, Personnel Lifting Systems.

ASME B56.1, Safety Standard for Low Lift and High Lift Trucks.

ASME HST-1, Performance Standard for Electric Chain Hoists.

ASME HST-2, Performance Standard for Hand Chain Manually Operated Chain Hoists.

ASME HST-3, Performance Standard for Manually Lever Operated Chain Hoists.

ASME HST-4, Performance Standard for Overhead Electric Wire Rope Hoists.

ASME HST-5, Performance Standard for Air Chain Hoists.

ASME HST-6, Performance Standard for Air Wire Rope Hoists.

AMERICAN WELDING SOCIETY

D1.1, Structural Welding and Cutting Code.

D1.2, Structural Welding Code – Aluminum.

D14.1, Specifications for Welding Industrial and Mill Cranes.

CRANE MANUFACTURERS ASSOCIATION OF AMERICA (CMAA)

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

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

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA No. 70, National Electric Code.

POWER CRANE AND SHOVEL ASSOCIATION (PCSA)

PCSA, Standards No. 4 and No. 5.

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE J765, Crane Load Stability Test Code.

WIRE ROPE TECHNICAL BOARD

Wire Rope Users Manual

Wire Rope Sling Users Manual

2.4 Order of Precedence. Where this document is adopted or imposed by contract on a program or project, the technical guidelines of this document take precedence, in the case of conflict, over the technical guidelines cited in other referenced documents.

3. DEFINITIONS AND ACRONYMS

3.1 Definitions Used in this Standard

3.1.1 Brake: A device used for retarding or stopping motion.

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

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

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

3.1.5 Critical Lift: A lift where failure/loss of control could result in loss of life, loss of or damage to flight hardware, or a lift involving special, high dollar items, such as spacecraft, one-of-a-kind articles, or major facility components, whose loss would have serious programmatic or institutional impact. Critical lifts also include the lifting of personnel with a crane, lifts where personnel are required to work under a suspended load, and operations with special personnel and equipment safety concerns beyond normal lifting hazards.

3.1.6 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.

3.1.7 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.

3.1.8 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 operate.

3.1.9 Design Load: The value used by the manufacturer as the maximum load 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.”

3.1.10 Design Factor: A numeric term that is broadly used. It is usually expressed as a ratio of the ultimate stress, or yield stress, to the capacity of a component, or to the service load, or its rated capacity. It is also used or includes factors in calculations to quantify variations found in the properties of materials, manufacturing tolerances, operating conditions, and design assumptions.

3.1.11 Design Safety Factor: See Design Factor.

3.1.12 Deviation: A variance that authorizes departure from a particular safety requirement that does not strictly apply or where the intent of the requirement is being met through alternate means that provide an equivalent level of safety with no additional risk.

3.1.13 Dummy Load: A test load, to simulate the real load; typically a test weight.

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

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

3.1.16 Failure Modes 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.

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

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

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

3.1.20 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.

3.1.21 Holding Brake: A brake that automatically prevents motion when power is off.

3.1.22 Hydra-set: Trade name for a closed circuit hydraulically operated instrument installed between hook and payload 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.

3.1.23 Idle Lifting Device: Lifting device that has no projected use for the next 12 months.

3.1.24 Infrequently: For the purpose of this document, the term “infrequently” is used to mean less than once per year.

3.1.25 Jack: A mechanism with a base and load point designed for controlled linear movement.

3.1.26 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.)

3.1.27 Lifting Devices and Equipment: Devices such as overhead and gantry cranes (including top running monorail, underhung, and jib cranes), mobile cranes, derricks, hoists, winches, special hoist supported personnel lifting devices, hydra-sets, load measuring devices, hooks, slings and rigging, mobile aerial platforms, powered industrial trucks, and jacks used for lifting and lowering.

3.1.28 Lifting Devices and Equipment Manager (LDEM): Person responsible for overall management of the installation lifting devices and equipment program, coordinating with appropriate personnel at their installation on lifting issues and providing their installation’s position on lifting devices and equipment safety issues.

3.1.29 Linear Fiber Sling: A sling where load bearing fibers are bundled in a linear fashion.

3.1.30 Load: The total load, including the sling or structural sling, below the hoisting device hook, being raised or moved.

3.1.31 Load Measuring Device: A measuring device below the hook that is part of the load path for lifting operations.

3.1.32 Mobile Aerial Platform: A mobile device that has an adjustable position platform, supported from ground level by a structure.

3.1.33 NASA Operation: Any activity or process that is under NASA direct control or includes major NASA involvement.

3.1.34 Noncritical Lift: A lift involving routine lifting operations 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.

3.1.35 Nondestructive Testing (NDT): The development and application of technical methods to examine materials or components in ways that do not impair future usefulness and serviceability in order to detect, locate, measure, and evaluate flaws; to assess integrity, properties, and composition; and to measure geometrical characteristics.

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

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

3.1.38 Payload: The actual object, below the sling or structural sling, being raised or moved.

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

3.1.40 Personnel Certification: A means to assure an individual is qualified to perform a designated task.

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

3.1.42 Platform Hoist: A dedicated hoist whose only purpose is to raise and lower a platform not carrying personnel.

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

3.1.44 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. Proof load test, as used in this standard, is equivalent to the OSHA rated load test.

3.1.45 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” or “working load limit.” If the device has never been downrated or uprated, this also is the “manufacturer’s rated load.”

3.1.46 Regular Service Lifting Device: Lifting device that is being used one or more times per month.

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

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

3.1.49 Side Load: A load applied at an angle to the vertical plane of the hoist line.

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

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

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

3.1.53 Sling: A lifting assembly and associated hardware used between the actual object being lifted and hoisting device hook.

3.1.54 Special Hoist Supported Personnel Lifting Device: Device specifically designed to lift and lower persons via a hoist. These devices include hoist supported platforms where personnel occupy the platform during movement. These devices do not including elevators, lifting personnel with a crane, mobile aerial platforms, or platforms or others items hoisted unoccupied to a position and anchored or restrained to a stationary structure before personnel occupy the platform.

3.1.55 Standby Lifting Device: Lifting device that is not in regular service but used occasionally or intermittently as required. Intermittent use is defined as a lifting device which has not been used for a period of one month or more, but less than 6 months.

3.1.56 Structural Sling: A rigid or semi-rigid fixture that is used between the actual object being lifted and hoisting device hook. Examples are spreader bars, equalizer bars, and lifting beams.

3.1.57 Surface Nondestructive Testing: Test and inspection methods used to examine the surface of equipment/materials; e.g., magnetic particle and liquid penetrant.

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

3.1.59 Valley Break: A broken wire in a wire rope in which the outside wire of a strand breaks in the immediate vicinity of the point where it contacts a wire or wires of an adjacent

strand, generally at a point not visible when the wire rope is examined externally. One end of the broken wire is long enough to reach from one valley to the next one and the other end of the broken wire generally cannot be seen.

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

3.1.61 Volumetric Nondestructive Testing: Test and inspection methods used to examine the interior of equipment/materials; e.g., ultrasonic and radiographic.

3.1.62 Waiver: A variance that authorizes departure from a specific safety requirement, where a special level of risk has been documented and accepted.

3.1.63 Winch: A stationary motor-driven or hand-powered hoisting machine having a drum around which is wound a rope, chain, or web used for lifting and lowering a load (does not apply to winches used for horizontal pulls).

3.1.64 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.

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

3.2 Abbreviations and Acronyms Used in this Standard

3.2.1	AC	Alternating Current
3.2.2	AGMA	American Gear Manufacturers Association
3.2.3	ANSI	American National Standards Institute
3.2.4	ASME	American Society of Mechanical Engineers
3.2.5	cm	centimeter
3.2.6	CMAA	Crane Manufacturers Association of America, Inc.
3.2.7	DC	Direct Current
3.2.8	FMEA	Failure Modes and Effects Analysis
3.2.9	km/hr	kilometer/hour
3.2.10	LDEM	Lifting Device and Equipment Manager
3.2.11	m	meter
3.2.12	mm	millimeter
3.2.13	mph	mile/hour

3.2.14 NEMA	National Electrical Manufacturers Association
3.2.15 NFPA	National Fire Protection Association
3.2.16 NPG	NASA Procedures and Guidelines
3.2.17 OEM	Original Equipment Manufacturer
3.2.18 OSHA	Occupational Safety and Health Administration
3.2.19 O&SHA	Operating and Support Hazard Analysis
3.2.20 PCSA	Power Crane and Shovel Association
3.2.21 RCM	Reliability Centered Maintenance
3.2.22 SPECSINTACT	Specifications Kept Intact

4. OVERHEAD CRANES

4.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, personnel certification, and operation for overhead and gantry cranes, including underhung, monorail, and jib cranes.

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

4.2.1 Design criteria that should be emphasized during overhead crane design are contained in the documents listed in Section 2.

4.2.2 Labeling/Tagging of Cranes.

a. 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).

b. 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.

c. A standard system of labeling shall be established and used throughout the installation.

d. A standard lockout/tagout 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, or other reasons.

e. Certification/recertification tags are required as described in paragraph 4.3.4.

f. Each overhead crane shall have the directions of its bridge and trolley movements displayed on the underside of the crane. These directions shall correspond to the directions on the operator station. These markings shall be visible from the floor but are not required if the crane is at such a height the markings would be legible without unaided vision.

4.2.3 Safety Analysis and Documentation of Cranes Used for Critical Lifts. A recognized safety hazard analysis, such as fault tree analysis, FMEA, Operating and Support Hazard Analysis (O&SHA), shall be performed on all cranes used for critical lifts. The analysis shall, as a minimum, determine potential sources of danger, identify failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the crane, facility, or load. The analysis shall be done as part of the initial evaluation process for critical lift compliance and prior to use in a critical lift, included in the crane documentation, and updated as required to reflect any changes in operation and/or configuration.

4.2.4 Performance. Crane service classification, load capability, and the desired control characteristics with which the crane handles the load shall be addressed for all designs. Crane service classification requirements shall be based on the worst expected duty the unit will encounter. 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.

4.2.5 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 ASME and CMAA standards for specific design details.

4.2.6 Mechanical.

a. 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.

b. The mechanical design requirements for crane components are as follows:

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

(2) 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.

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

(4) 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.

(5) For cranes used for critical lifts, two holding brakes shall be provided, each capable of bringing a rated load to zero speed and holding it. Holding brakes shall be applied automatically when power to the brake is removed. 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 4.3.3.d. The brake design shall provide for emergency load lowering.

(6) 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.

(7) 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 LDEM and the responsible design engineering organization. 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.

(8) 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.

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

(10) 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.

(11) 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.

(12) Malleable iron clips for wire rope termination shall not be used. Forged steel wire rope clips are acceptable.

(13) 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 ASME requirements. These hoists shall be equipped with at least one self-setting brake, referred to as a holding brake, applied directly to the motor shaft or some part of the gear train. No limit switches are required if proper over-travel restraint is provided.

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

(15) Initial and final upper limit switches (limit control valves) shall be provided and tested for critical air operated hoists as described in paragraph 4.2.7.k. The final upper limit switch (limit control valve) shall exhaust air from the crane hoist, set the brakes, and require reset at the upper limit switch (limit control valve) level.

(16) A minimum clearance of 3 inches (7.6 cm) overhead and 2 inches (5.1 cm) laterally shall be provided and maintained between the crane and all obstructions.

c. 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, and bridge and trolley drives 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 4.2.6.b and the following additional minimum requirements:

(1) 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).

(2) 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.

(3) 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.

(4) Each load-bearing component shall be specified or detailed to lift the maximum imposed loads resulting from zero to rated hook load with appropriate design factors.

4.2.7 Electrical. Electrical design requirements are as follows:

a. 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.

b. 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. This built-up equipment generally uses many commercially available or made-to-order components which are then custom engineered together as an assembly. Built-up equipment should only be used where commercial equipment is not available to meet the user/operational requirements. 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 less reliable than commercial equipment.

c. Wiring and safety devices shall be in accordance with 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.

d. Electrical enclosures shall provide protection for the contained equipment against environmental conditions according to the class rating established by NEMA.

e. In addition to overload protection required by the National Electrical Code, under-voltage and phase reversal should be considered.

f. 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 (main breaker preferred). A positive lockout to the controls shall be provided to ensure the safety of maintenance personnel.

g. 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.

h. 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 unplanned directional shifts, and/or loss of control are unacceptable.

i. 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 4.8 for handling explosives or Electro-Explosive Devices (EED's).

j. 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 that have not been modified to provide a remote emergency stop, handling procedures shall be developed and implemented to minimize the risk.

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

(1) 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.

(2) 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.

(3) 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.

(4) 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.

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

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

n. Cranes shall be designed fail-safe in the event of a power outage.

4.3 Testing. Three types of tests are required for cranes: proof load tests, periodic 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 periodic 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. 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. Surface or volumetric

NDT of critical components shall be used to validate the existence or absence of cracks or other load test effects indicated by this inspection. The periodic load test requirement may be fulfilled by a concurrently performed proof load test.

4.3.1 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 acceptable tolerance for proof load test accuracy is -5/+0 percent.

4.3.2 Periodic 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 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 periodic load test accuracy is +5/-0 percent.

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

a. Load hoisting, lowering at various speeds (maximum safe movement up and down as determined by the LDEM and the responsible safety, engineering, operations, and maintenance organizations), and braking/holding mechanisms. Holding brakes shall be tested to verify stopping capabilities and demonstrate the ability to hold a rated load (see paragraph 4.3.3.d). The load should be held long enough to allow any dynamics to dampen out.

b. Trolley and bridge travel (maximum safe movement in all directions with varying speeds as determined by the LDEM and the responsible safety, engineering, operations, and maintenance organizations).

c. 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 4.5.2.c).

d. Cranes used for critical lifts are required to be equipped with two holding brakes (hoist), each capable of bringing a rated load to zero speed and holding it (see paragraph 4.2.6.b(5)). If a worm gear is used as a holding brake, it shall be tested to ensure it is able to hold a static load and stop a dynamic load. 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:

(1) 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.

(2) Alternately, each brake shall be tested for its ability to stop and hold a rated load in both the raising and lowering modes. (CAUTION: It

must be possible to quickly reenergize the out-of-circuit brake or provide other safety measures to perform this test safely.)

(3) Other methods as approved by the LDEM with concurrence from the responsible safety, engineering, operations, and maintenance organizations.

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

4.3.4 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 periodic load test, cranes shall be given a permanently affixed tag, posted on the crane or an appropriate location, identifying the equipment and stating the next required periodic load test date or load test expiration date.

4.4 Inspection.

4.4.1 Inspections, as described below, shall be performed on all cranes and crane accessories. Inspections shall be performed according to this section, the manufacturers' recommendations, and ASME B30.2. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, tagged out and corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

4.4.2 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 4.4.5).

4.4.3 Cranes in regular service (used at least once a month) shall be inspected as required in paragraphs 4.4.4 and 4.4.5. Idle and standby cranes shall be inspected according to paragraph 4.4.6.

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

a. Check operating and control mechanisms for proper function.

b. 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 for floor operated cranes and cab operated cranes or for which there is safe access via crane inspection walkways for cab operated cranes.

c. Without disassembling, visually inspect all functional operating and control mechanisms, including brakes where visible, for excessive wear and contamination by excessive lubricants or foreign matter.

d. Visually inspect hooks for cracks and deformities (see Section 7).

e. 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.

f. Visually inspect hoist chains for excessive wear or distortion.

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

a. Monthly Inspections (Frequent Inspections). At least once per month:

(1) Perform daily inspection requirements described in paragraph 4.4.4.

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

(3) Perform a thorough inspection of all ropes paying particular attention to the signs of deterioration and damage outlined in paragraph 4.5.3.c.

(4) Inspect for visible deformation or cracks in hooks (see Section 7).

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

(1) Requirements for monthly inspections (frequent inspections) described in paragraph 4.4.5.a.

(2) Deformed, cracked, or corroded members and welds and loose bolts or rivets in crane structure and runway. Various methods of nondestructive testing such as ultrasonics, radiography, magnetic particle, or liquid penetrant, shall be used as needed.

(3) Cracked or worn sheaves and drums.

(4) Wear or cracks in pins, bearings, shafts, gears, followers, and locking and clamping devices. Surface or volumetric NDT shall be used to validate the existence or absence of cracks indicated by this inspection.

(5) 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.

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

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

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

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

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

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

(12) Evidence of overheating.

4.4.6 Idle and Standby Cranes. Idle and standby cranes shall be inspected prior to first use according to the requirements of paragraphs 4.4.4 and 4.4.5 unless these daily inspections and formal periodic inspections were performed at required intervals and recorded during the idle/standby period.

4.4.7 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.

4.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance shall be established to increase the probability the crane will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any crane found in an unsafe operating condition shall be tagged out and removed from service until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

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

a. Move crane to an area where maintenance will not interfere with other operations.

b. 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.

c. 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.

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

4.5.2 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:

a. Brakes. Appropriate precautions shall 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.

b. Control system.

c. Limit switches.

(1) 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.

(2) 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.

d. Power plants.

e. Critical operating mechanisms and safety devices.

4.5.3 Repair/Replacements.

a. For repair/replacement requirements for crane hooks with deformation or cracks, see Section 7. If repaired, crane hooks shall be proof load tested using the associated crane proof load value.

b. Structural members that are cracked, bent, broken, excessively worn, or corroded shall be evaluated by the responsible engineering organization to determine if they should be replaced or repaired. Use proper material and weld/repair procedures according to manufacturers' specifications and ANSI/AWS D14.1. Any structural repairs/replacements shall be performed with the proper approval/concurrences required by OSHA, the applicable ASME standards, and the manufacturers' requirements. Procedures will be conducted by properly qualified personnel.

c. 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

rejection of the rope (see Wire Rope Users Manual for additional information on wire rope inspections):

(1) In running ropes, twelve randomly distributed broken wires in one rope lay or four broken wires in one strand in one lay or one valley break.

(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 (0.4 mm) for diameters of rope up to 5/16 inch (8.0 mm).

(b) 1/32 inch (0.8 mm) for diameters 3/8 inch (9.5 mm) to 1/2 inch (13.0 mm).

(c) 3/64 inch (1.2 mm) for diameters 9/16 inch (14.5 mm) through 3/4 inch (19.0 mm).

(d) 1/16 inch (1.6 mm) for diameters 7/8 inch (22.0 mm) through 1-1/8 inches (29.0 mm).

(e) 3/32 inch (2.4 mm) for diameters greater than 1-1/8 inches (29.0 mm).

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

4.6 Personnel Certification.

4.6.1 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. The operator certification program will be reviewed at least annually to assure that the contents, training material, testing, and examination elements are up-to-date with current methods and techniques; and that any “lessons-learned” are adequately addressed. Riggers (see Section 10) and personnel performing NDT (see paragraph 1.9) shall

be certified in their discipline. Training shall be provided to observers and flagmen. All participants in the lifting operation shall have clearly defined roles and responsibilities.

4.6.2 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.

a. Noncritical Lifts. The certification program for noncritical lift operators shall include the following:

(1) Training

(a) Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

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

(c) An annual review of the items in paragraph 4.6.2.a(1) above. (This may be conducted informally by local supervisory personnel.)

(2) Examination

(a) Physical examination (criteria to be determined by the cognizant medical official and should comply with ASME B30.2).

(b) Written examination.

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

(d) Proficiency examination for recertification.

(3) Licensing/Operator Certification

(a) 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.

(b) Renewal of all licenses shall require demonstration of proficiency or approval of supervision that proficiency is adequate

and current. 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 4.6.2.a.(1) and 4.6.2.a.(2).

b. 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.

4.7 Operations. Cranes shall be operated according to this section, the manufacturers' recommendations, and ASME B30.2. The following practices shall be followed for crane operations:

a. 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 1.5.1.c).

b. 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 safety analysis of the equipment, facility, load, human factors, and interfaces as a whole in support of the lifting operation.

c. 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.

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

e. Cranes shall not be used to load test items such as slings, platforms, or lifting fixtures unless specifically identified to do so based on a specified percentage of rated load, and a safety analysis approved by the LDEM and the responsible safety, engineering, operations, and maintenance organizations. Test procedures shall be approved by the responsible safety, engineering, operations, and maintenance organizations. This is to ensure that the crane is not damaged due to sudden unloading should the test article fail. Appendix D, crane/hoist requirements to load test other lifting equipment, shall be followed.

f. Cranes shall not be used for side pulls unless specifically designed to do so.

g. 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.

h. The operator shall ensure that the crane is within inspection and testing intervals by examination of the periodic recertification test tags and/or documentation. The operator shall adhere to all tags placed on the crane controls.

i. 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.

j. The operator shall establish safety zones before initiating operations. Safety zones should have appropriate barriers (rope, cones, or other) established prior to lift. Personnel on the crane should be minimized during crane movement. Any personnel on the crane shall be made aware of and avoid pinch points at their respective location.

k. 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.

l. 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.

m. The operator shall know the weight of the working load. When raising loads that approach 75% of the rated capacity of the crane, the operator shall test the holding brakes. 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.

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

o. If hand signals are required, only standard signals shall be used according to Appendix B. Hand signals shall be posted in a conspicuous location.

p. 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.

q. 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.

r. 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.

s. 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.

t. Person(s) shall not ride the hook or load at anytime. If conventional means of reaching a worksite such as an aerial platform, ladder, stairs, or scaffold would be more hazardous or not possible because of structural design or worksite conditions, 29 CFR 1926.550 and ASME B30.23 shall be followed for lifting of personnel with a crane, which is considered a critical lift (see Appendix C).

u. 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 A).

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

w. 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.

x. 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, ensuring that the crane controls are manned at all times.

y. 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.

z. 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.

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

ab. Outdoor hoisting operations should not commence if winds are above 20 knots (23 mph, 37 km/hr) steady state or if gusts exceed 35 knots (40 mph, 65 km/hr). Consideration shall also be given to sail area and weather conditions such as lightning or snow before commencing operations.

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

ad. Wire rope should be used in accordance with the Wire Rope Users Manual.

4.8 Special Criteria.

4.8.1 Handling Explosives or Electro-Explosive Devices (EED's). Special precautions shall be taken while handling explosives or EED's.

a. DOT-packaged explosives shall be handled in accordance with approved hazardous operating procedures. Barricades and warning signs shall be erected to control access.

b. Explosives and EED's that are not within DOT-approved containers shall be handled in accordance with approved hazardous operations procedures. In addition to system configuration controls, these procedures shall ensure the following requirements are met:

(1) Voltage checks on crane hooks that will handle explosives or EED's shall be performed prior to the start of operations; all crane motions shall be checked.

(2) For static sensitive systems, the crane hook shall be connected to facility ground before connecting to explosives or EED's. Electrical grounding of the hook and load shall be accomplished prior to lifting operations. 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 (3 m) from exposed propellant grain, explosives, or EED's.

(3) The danger potential for radio transmissions near explosives shall be evaluated prior to the operation.

(4) Personnel limits, protective clothing, warning signs and barricades shall be used as required.

(5) Safety surveillance requirements shall be followed.

4.8.2 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.

5. MOBILE CRANES AND DERRICKS

5.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, personnel certification, and operation of mobile cranes and derricks.

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

5.2.1 Design criteria that should be emphasized during mobile crane and derrick design are contained in the documents listed in Section 2.

5.2.2 Labeling/Tagging of Mobile Cranes and Derricks.

a. 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. 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).

b. 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.

c. A standard system of labeling shall be established and used throughout the installation.

d. A standard lockout/tagout 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, or other reasons.

e. Certification/recertification tags are required as described in paragraph 5.3.4.

5.2.3 Safety Analysis and Documentation of Mobile Cranes and Derricks Used for Critical Lifts. A recognized safety hazard analysis such as fault tree analysis, FMEA, O&SHA 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 failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the crane/derrick, facility, or load. The analysis shall be done as part of the initial evaluation process for critical lift compliance and prior to use in a critical lift, included in the equipment documentation, and updated as required to reflect any changes in operation and/or configuration.

5.2.4 Performance. Load capability and the desired controlled characteristics with which the crane/derrick handles the load shall be addressed for all designs. 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.

5.2.5 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 ASME and PCSA standards for specific design details.

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

a. They shall meet all applicable requirements of OSHA, ASME, and PCSA.

b. 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.

c. Gearing shall be designed and manufactured to comply with the latest AGMA gear standards.

d. 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.

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

f. 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.

g. For mobile cranes and derricks used for critical lifts, two holding brakes shall be provided, each capable of bringing a rated load to zero speed and holding it. The brakes shall be designed so that they can be tested as required in paragraph 5.3.3.f. This may be accomplished by the following means:

(1) When brakes and clutches are used to control the motion of the hoist drum, two independent means of braking shall be provided: a service brake and an emergency brake. The service brake shall be capable of functioning with power, and the emergency brake shall set in the event of a power failure.

(2) For load hoists equipped with an mechanically linked hydraulic motor/brake combination, the use of a counterbalance valve that locks the hydraulic fluid when the valve is in the neutral position is an acceptable braking means. If a free fall clutch is present in the hoist design between the hydraulic motor and planetary disc, then a second, independent holding or control brake is required.

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

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

j. 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.

k. 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.

l. Each load bearing component shall be designed to sustain the maximum imposed loads with appropriate design factors.

5.2.7 Electrical. Electrical design requirements are as follows:

a. Wiring and safety devices shall be in accordance with the NFPA National Electrical Code.

b. Electrical enclosures shall provide protection for the contained equipment against environmental conditions.

c. In addition to overload protection required by the National Electrical Code, undervoltage and phase reversal should be considered.

d. 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 unplanned directional shifts and/or loss of control are unacceptable.

e. 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 5.8 for handling explosives or EED's.

f. Mobile crane anti-two-blocking features shall be in accordance with ASME B30.5.

5.3 Testing. Three types of tests are required for mobile cranes and derricks: proof load tests, periodic 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, or crane cab do not require a load test, although a functional check should be performed to determine if the repairs or alterations are acceptable. The periodic 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. 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. Surface or volumetric NDT of critical components shall be used to validate the existence or absence of cracks or other load test effects indicated by this inspection. The periodic load test requirement may be fulfilled by a concurrently performed proof load test.

5.3.1 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 practical working radius (and maximum working radius for new cranes and derricks only), without interfering with crane structure 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. Proof load tests conducted by the manufacturer prior to delivery are acceptable if the necessary load test papers are provided to verify the extent and thoroughness of the test on that specific item. The acceptable tolerance for proof load test accuracy is -5/+0 percent.

5.3.2 Periodic 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 practical working radius, without interfering with crane structure, according to the manufacturer's load chart. Cranes/derricks used 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 periodic 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 periodic load test accuracy is + 5/-0 percent.

5.3.3 Operational Test. Together with proof load and periodic load tests, the following shall be performed with a dummy rated load, unless otherwise specified, and as determined by the LDEM and the responsible safety, engineering, operations, and maintenance organizations:

a. Load hoisting, lowering at various speeds with the boom at the minimum radius (maximum safe movement up and down as determined by the LDEM and the responsible safety, engineering, operations, and maintenance organizations), and braking/holding mechanisms. Holding brakes shall be tested to verify stopping capabilities and demonstrate the ability to hold a rated load (see paragraph 5.3.3.f). The load should be held long enough to allow any dynamics to dampen out.

b. Boom hoisting and lowering through full safe operating range as determined by the LDEM and the responsible safety, engineering, operations, and maintenance organizations.

c. Swinging and traveling mechanisms.

d. Boom extension and retraction mechanism on telescoping boom cranes.

e. 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.

f. Cranes and derricks used for critical lifts are required to be equipped with two holding brakes (hoist), each capable of bringing a rated load to zero speed and holding it (see paragraph 5.2.6.g). If a worm gear is used as a holding brake, it shall be tested to ensure it is able to hold a static load and stop a dynamic load. 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:

(1) 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.

(2) Alternately, each brake shall be tested for its ability to stop and hold a rated load in both the raising and lowering modes. (CAUTION: It must be possible to quickly reenergize the out-of-circuit brake or provide other safety measures to perform this test safely.)

(3) Other methods may be used as approved by the LDEM with concurrence from the responsible safety, engineering, operations, and maintenance organizations.

g. 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 periodic 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 5.3.3.f) 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.

5.3.4 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 periodic load test, mobile cranes/derricks shall be given a permanently affixed tag, posted on the crane/derrick or an appropriate location, identifying the equipment and stating the next required periodic load test date or load test expiration date.

5.4 Inspection.

5.4.1 Inspections, as described below, shall be performed on all mobile cranes/derricks and accessories. Inspections shall be performed according to this section, the manufacturers' recommendations, and ASME B30.5. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, tagged out and corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

5.4.2 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 5.4.5).

5.4.3 Mobile cranes and derricks in regular service (used at least once a month) shall be inspected as required in paragraphs 5.4.4 and 5.4.5. Idle and standby cranes shall be inspected according to paragraph 5.4.6.

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

a. Check operating and control mechanisms for proper function.

b. 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.

c. Without disassembling, inspect all functional operating and control mechanisms, including brakes where visible, for excessive wear and contamination by excessive lubricants or foreign matter.

d. Inspect hooks for cracks and deformities (see Section 7).

e. Inspect rope reeving for proper travel and drum lay.

f. Inspect hoist chains for excessive wear or distortion.

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

a. Monthly Inspections (Frequent Inspections). At least once per month:

(1) Perform daily inspection requirements described in paragraph 5.4.4.

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

(3) Perform a thorough inspection of all ropes paying particular attention to the signs of deterioration and damage outlined in paragraph 5.5.3.

(4) Inspect for visible deformation or cracks in hooks (see Section 7).

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

(1) Requirements for monthly inspections (frequent inspections) described in paragraph 5.4.5.a.

(2) Deformed, cracked, or corroded members and welds and loose bolts or rivets in crane structure. Various methods of NDT such as ultrasonics, radiography, magnetic particle, liquid penetrant, etc., shall be used as needed.

(3) Cracked or worn sheaves and drums.

(4) Excessive wear or cracks in pins, bearings, shafts, gears, followers, and locking and clamping devices. Surface or volumetric NDT shall be used to validate the existence or absence of cracks indicated by this inspection.

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

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

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

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

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

(10) Evidence of overheating.

5.4.6 Idle and Standby Cranes/Derricks. Idle and standby cranes/derricks shall be inspected prior to first use according to the requirements of paragraphs 5.4.4 and 5.4.5 unless these monthly and annual inspections were performed at required intervals and recorded during the idle/standby period.

5.4.7 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.

5.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance shall be established to increase the probability the mobile crane/derrick will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any mobile crane or derrick found in an unsafe operating condition shall be tagged out and removed from service until repaired.

All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

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

a. Move to an area where maintenance will not interfere with other operations.

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

5.5.2 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:

a. Brakes. Appropriate precautions shall 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.

b. Control system.

c. Power plants.

d. Critical operating mechanisms and safety devices.

e. Operator mechanical and electrical controls.

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

a. For repair/replacement requirements for hooks with deformation or cracks, see Section 7. If repaired, hooks shall be proof load tested using the associated mobile crane/derrick minimum working radius proof load value.

b. Structural members that are cracked, bent, broken, excessively worn, or corroded shall be evaluated by the responsible engineering organization to determine if they should be repaired or replaced. Proper material and weld/repair procedures will be used according to ANSI/AWS D14.1 and manufacturer specifications. Any structural repairs/replacements shall be performed with the proper approval/concurrences required by OSHA, the applicable ASME standards, and the manufacturers' requirements. Procedures will be conducted by properly qualified personnel.

c. 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 rejection of the rope (see Wire Rope Users Manual for additional information on wire rope inspections):

(1) In running ropes, six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay or one valley break. In rotation resistant ropes, two randomly distributed broken wires in thirty rope diameters. In standing ropes, more than two broken wires in one lay in sections beyond end connections or any broken wires at an end connection.

(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 (0.4 mm) for diameters of rope up to 5/16 inch (8.0 mm).

(b) 1/32 inch (0.8 mm) for diameters 3/8 inch (9.5 mm) to 1/2 inch (13.0 mm).

(c) 3/64 inch (1.2 mm) for diameters 9/16 inch (14.5 mm) through 3/4 inch (19.0 mm).

(d) 1/16 inch (1.6 mm) for diameters 7/8 inch (22.0 mm) through 1-1/8 inches (29.0 mm).

(e) 3/32 inch (2.4 mm) for diameters greater than 1-1/8 inches (29.0 mm).

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

5.6 Personnel Certification.

5.6.1 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. The operator certification program will be reviewed at least annually to assure that the contents, training material, testing, and examination elements are up-to-date with current methods and techniques; and that any “lessons-learned” are adequately addressed. Riggers (see Section 10) and personnel performing NDT (see paragraph 1.9) shall

be certified in their discipline. Training shall be provided to observers and flagmen. All participants in the lifting operation shall have clearly defined roles and responsibilities.

5.6.2 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.

a. Noncritical Lifts. The certification program for noncritical lift operators shall include the following:

(1) Training

(a) Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

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

(c) An annual review of the items in paragraph 5.6.2.a(1) above. (This may be conducted informally by local supervisory personnel.)

(2) Examination

(a) Physical examination (criteria to be determined by the cognizant medical official and should comply with ASME B30.5).

(b) Written examination.

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

(d) Proficiency examination for recertification.

(3) Licensing

(a) 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.

(b) Renewal of all licenses shall require demonstration of proficiency or approval of supervision that proficiency is adequate

and current. 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 5.6.2.a(1) and 5.6.2.a(2).

b. 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.

5.7 Operations. Cranes/derricks shall be operated according to this section, the manufacturers' recommendations, and ASME B30.5. The following practices shall be followed for crane/derrick 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.

b. 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 1.5.1.c).

c. 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 safety analysis of the equipment, facility, load, human factors, and interfaces as a whole in support of the lifting operation.

d. 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.

e. For critical lifts, the load shall not exceed 75 percent of the crane's/derrick's rated capacity.

f. 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.

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

h. Cranes/derricks shall not be used to load test items such as slings, platforms, or lifting fixtures unless specifically identified to do so based on a specified percentage of rated load, and a safety analysis approved by the LDEM and the responsible safety, engineering, operations, and maintenance organizations. Test procedures shall be approved by the responsible safety, engineering, operations, and maintenance organizations. This is to ensure that the crane/derrick is not damaged due to sudden unloading should the test article fail. Appendix D, crane/hoist requirements to load test other lifting equipment, shall be followed.

i. Cranes/derricks shall not be side loaded, used to drag loads sideways, or used to pull loads unless specifically designed to do so by the OEM as indicated in the load chart. Side loading of the boom shall be limited to freely suspended loads.

j. 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.

k. The operator shall ensure that the crane/derrick is within inspection and testing intervals by examination of the periodic recertification tags and/or documentation. The operator shall adhere to all tags placed on the crane controls.

l. 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.

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

n. 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.

o. The operator shall know the weight of the working load. When raising loads that approach 75% of the rated capacity of the crane, the operator shall test the holding brakes. 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.

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

q. If hand signals are required, only standard signals shall be used according to Appendix B. Hand signals shall be posted in a conspicuous location.

r. 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.

s. 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.

t. 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.

u. 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.

v. Person(s) shall not ride the hook or load at anytime. If conventional means of reaching a worksite such as an aerial platform, ladder, stairs, or scaffold, would be more hazardous or not possible because of structural design or worksite conditions, 29 CFR 1926.550 and ASME B30.23 shall be followed for lifting of personnel with a crane, which is considered a critical lift (see Appendix C).

w. 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 A).

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

y. 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.

z. 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, ensuring that the crane controls are manned at all times.

aa. 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.

ab. 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.

ac. 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.

ad. Mobile cranes shall be level. When the load to be handled and the operating radius require the use of outriggers, or any time when outriggers are used, the outrigger beams shall be fully extended or deployed per load rating chart specifications. Additionally, the outriggers shall be set to remove the machine weight from wheels if required by the OEM per load rating chart. Blocking under outrigger beams is not permitted. Blocking under outrigger floats, when used, shall be strong enough to prevent crushing, bending, or shear failure and of sufficient thickness, width, and length as to completely support the float, transmit the load to the supporting surface, and prevent shifting or toppling under load.

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

af. Outriggers shall be used when the 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.

ag. 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.

ah. 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.

ai. 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.

aj. 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.

ak. 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.

al. Ropes shall not be handled on a winch head without the knowledge of the operator.

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

an. 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.

ao. 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.

ap. 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.

aq. Machines shall not be fueled with engines running.

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

as. 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:

(1) For lines rated 50kV or below, minimum clearance between lines and any part of crane or load shall be 10 feet (3 m).

(2) For lines rated over 50kV, minimum clearance between lines and any part of crane or load shall be 10 feet (3 m) plus 0.4 inch (10 mm) for each 1kV over 50kV, or twice the length of the line insulator, but never less than 10 feet (3 m).

(3) 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.

(4) In transit, with no load and boom lowered, the clearance between lines and any part of crane shall be a minimum of 4 feet (1.2 m), for lines rated 0.75kV or below. For lines rated over 0.75kV, the clearance shall be 4 feet (1.2 m) plus 0.17 inch (4.3 mm) for each 1kV over 0.75kV. Refer to ASME B30.5 for more details.

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

(6) Crane boom tips shall have two red flags, minimum of 12 inches (30.5 cm) x 12 inches (30.5 cm) each.

at. 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.

au. 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.

av. Outdoor hoisting operations should not commence if winds are above 20 knots (23 mph, 37 km/hr) steady state or if gusts exceed 35 knots (40 mph, 65 km/hr). Consideration shall also be given to sail area and weather conditions such as lightning, or snow before commencing operations.

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

ax. Wire rope should be used in accordance with the Wire Rope Users Manual.

5.8 Special Criteria.

5.8.1 Handling Explosives or Electro-Explosive Devices (EED's). Special precautions shall be taken while handling explosives or EED's.

a. DOT-packaged explosives shall be handled in accordance with approved hazardous operating procedures. Barricades and warning signs shall be erected to control access.

b. Explosives and EED's that are not within DOT-approved containers shall be handled in accordance with approved hazardous operations procedures. In addition to system configuration controls, these procedures shall ensure the following requirements are met:

(1) Voltage checks on crane hooks that will handle explosives or EED's shall be performed prior to the start of operations; all crane motions shall be checked.

(2) For static sensitive systems, the crane hook shall be connected to facility ground before connecting to explosives or EED's. Electrical grounding of the hook and load shall be accomplished prior to lifting operations. 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 EED's.

(3) The danger potential for radio transmissions near explosives shall be evaluated prior to the operation.

(4) Personnel limits, protective clothing, warning signs and barricades shall be used as required.

(5) Safety surveillance requirements shall be followed.

5.8.2 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.

6. HOISTS AND WINCHES

6.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, personnel certification, and operation of hoists and winches used for lifting and lowering a load (does not apply to winches used for horizontal pulls). These standards apply to electric, air-powered, and manual hoists and winches, including platform hoists, whose only purpose is to raise and lower a platform, not carrying personnel. This does not include hoists connected to platforms used to raise or lower personnel. For these, see Section 9, Special Hoist Supported Personnel Lifting Devices.

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

6.2.1 Design criteria that should be emphasized during hoist design are contained in the documents listed in Section 2.

6.2.2 Labeling/Tagging of Hoists and Winches.

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

b. Hoists and winches 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 or winch is qualified for critical lifts.

c. A standard system of labeling shall be established and used throughout the installation.

d. A standard lockout/tagout 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, or other reason.

e. Certification/recertification tags are required as described in paragraph 6.3.4.

6.2.3 Safety Analysis and Documentation for Hoists and Winches used for Critical Lifts. A recognized safety hazard analysis such as fault tree analysis, FMEA, O&SHA shall be performed on all hoists and winches used for critical lifts. The analysis shall, as a minimum, determine potential sources of danger, identify failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the hoist, winch, facility, or load. The analysis shall be done as part of the initial evaluation process for critical lift compliance and prior to use in a critical lift, included in the hoist or winch documentation, and updated as required to reflect any changes in operation and/or configuration.

6.2.4 Performance. Duty cycle, load capability, and the desired control characteristics with which the hoist or winch handles the load shall be addressed for all designs. Duty cycle requirements shall be based on the worst expected duty the unit will encounter. 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.

6.2.5 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.

6.2.6 Mechanical.

a. 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 or winch 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 and winches are built to order.

b. The mechanical design requirements for hoist and winch components are as follows:

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

(2) Electric and air operated hoists and winches 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) For powered (electric and air) hoists and winches used for critical lifts, two holding brakes shall be provided, each capable of bringing a rated load to zero speed and holding it. Holding brakes shall be applied automatically when power to the brake is removed. 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 6.3.3.e. The brake design shall provide for emergency load lowering.

(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 and winches 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 and winch 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 and winches are acceptable for critical and noncritical lift applications. They shall comply with applicable ASME requirements. These hoists shall be equipped with at least one self-setting brake, referred to as a holding brake, applied directly to the motor shaft or some part of the gear train. No limit switches are required if proper over-travel restraint is provided.

(8) Air operated chain hoists and winches 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 and winches as described in paragraph 6.2.7.i. The final upper limit switch (limit control valve) shall exhaust air from the hoist or winch, set the brakes, and require reset at the upper limit switch (limit control valve) level.

(10) Worm gears shall not be used as a holding brake unless the lead angle is sufficient to prevent back driving. Worm gears used as a brake for air and electric powered hoists may be considered as a second holding brake. 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 or winch load path shall be approved, as a minimum, by the LDEM and the responsible design engineering organization. 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) Each load-bearing component shall be specified or detailed to lift the maximum imposed loads resulting from zero to rated hook load with appropriate design factors.

c. 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 hoists/winches 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, and bridge and trolley drives 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 6.2.6.b.

6.2.7 Electrical. Electrical design requirements are as follows:

a. 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.

b. 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. This built-up equipment generally uses many commercially available or made-to-order components which are then custom engineered together as an assembly. Built-up equipment should only be used where commercial equipment is not available to meet the user/operational requirements. 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 less reliable than commercial equipment.

c. Wiring and safety devices shall be in accordance with the NFPA National Electrical Code.

d. Electrical enclosures shall provide protection for the contained equipment against environmental conditions as required by NEMA.

e. In addition to overload protection required by the National Electrical Code, undervoltage and phase reversal should be considered.

f. For powered hoists and winches 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 and winches used for critical lifts require a remote emergency stop. Remote emergency stops are required for hoists and winches 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 and winches required to make critical lifts that have not been modified to provide a remote emergency stop, handling procedures shall be developed and implemented to minimize the risk.

g. 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 (main breaker preferred). A dump valve is acceptable for the emergency stop for a pneumatic hoist.

h. The electrical system shall be designed fail-safe to ensure that a failure of any component will not cause the hoist or winch 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 or winch to slow down or come to a safe stop are acceptable; those that could cause unplanned directional shifts, and/or loss of control are unacceptable.

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

(1) 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.

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

(3) 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.

(4) 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 or winch will not two-block (or otherwise damage wire rope) if the hoist or winch 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.

j. 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 6.8 for handling explosives or EED's.

k. For hoists and winches used for critical lifts, lower limit switches to prevent reverse winding of the wire rope shall be provided.

l. Electrical hoists and winches shall have the capability to be locked out at the main breaker to prevent unauthorized use.

m. Hoists and winches shall be designed fail-safe in the event of a power outage.

6.3 Testing. Three types of tests are required on hoists: proof load tests, periodic 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 and winches. The periodic load and operational tests shall be performed at least every 4 years. For hoists and winches used for critical lifts, these tests shall be based on frequency of usage. Hoists and winches used frequently for critical lifts shall be load tested annually. Hoists and winches used infrequently for critical lifts shall be load tested before each critical lift if it has been more than one year since the last test. If a hoist or winch 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. An inspection shall be performed after each load test and prior to the hoist being released for service to ensure there is no damage. Surface or volumetric NDT shall be used to validate the existence or absence of cracks or other load test effects indicated by this inspection.

6.3.1 Proof Load Test. Before first use and after installation, all new, extensively repaired, modified, or altered hoists and winches 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 acceptable tolerance for proof load test accuracy is -5/+0 percent.

6.3.2 Periodic Load Test. All hoists and winches shall be tested at least once every 4 years with a dummy load equal to the hoist's/winch's rated capacity. Platform hoists shall be tested using the attached platform only. Hoists and winches used for critical lifts shall be load tested at least once per year. Hoists and winches used infrequently for critical lifts shall be load tested before each critical lift if it has been over one year since the last test. The acceptable

tolerance for periodic load test accuracy is + 5/-0 percent. The periodic load test can be fulfilled by a concurrently performed proof load test.

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

a. Perform all hoist functions in an unloaded condition.

b. Test operation of brakes and limit, locking, and safety devices.

c. 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 or winch.

d. After testing in the unloaded state, apply the test load to the hoist or winch to check the proper load control. Test load hoisting, lowering at various speeds (maximum safe movement up and down as determined by the LDEM and the responsible safety, engineering, operations, and maintenance organizations), and braking/holding mechanisms. Holding brakes shall be tested to verify stopping capabilities and demonstrate the ability to hold a rated load (see paragraph 6.3.3.e). The load should be held long enough to allow any dynamics to dampen out.

e. Powered hoists and winches used for critical lifts are required to be equipped with two holding brakes, each capable of bringing a rated load to zero speed and holding it (see paragraph 6.2.6.b(3)). If a worm gear is used as a holding brake, it shall be tested to ensure it is able to hold a static load and stop a dynamic load. 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:

(1) 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.

(2) Alternately, each brake shall be tested for its ability to stop and hold a rated load in both the raising and lowering modes. (CAUTION: It must be possible to quickly reenergize the out of circuit brake or provide other safety measures to perform this test safely.)

(3) Other methods may be used as approved by the LDEM with concurrence from the responsible safety, engineering, operations, and maintenance organizations.

f. The operational test for a modified hoist or winch can be tailored to test only those portions of the equipment that were modified, only if the periodic load and operational test interval has not expired.

6.3.4 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 periodic load test, all hoists and winches shall be given a permanently affixed tag, posted on the hoist or winch or an appropriate location, identifying the equipment and stating the next required periodic load test date or load test expiration date.

6.4 Inspection.

6.4.1 Inspections, as described below, shall be performed on all hoists and winches in regular service. Inspections shall be performed according to this section, the manufacturers' recommendations, and the applicable ASME standard. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, tagged out and corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

6.4.2 All new, extensively repaired, or modified hoists and winches shall be inspected to the requirements of both daily and periodic inspections prior to first use. For component repair on hoists and winches, 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 6.4.5).

6.4.3 Hoists and winches in regular service (used at least once per month) shall be inspected as required in paragraphs 6.4.4 and 6.4.5. Idle and standby hoists/winches shall be inspected according to paragraph 6.4.6.

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

a. Check operating and control mechanisms for proper function.

b. Without disassembling, visually inspect all functional operating and control mechanisms, including brakes where visible, for excessive wear and contamination by excessive lubricants or foreign matter.

c. Inspect load chain for wear, twists, damage links, or foreign matter.

d. Visually inspect hooks for deformation, chemical damage, or cracks (see Section 7).

e. Inspect load bearing components for damage.

f. Inspect running rope or chain for discrepancies.

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

a. Monthly Inspections (Frequent Inspections). At least once per month:

(1) Perform daily inspection requirements described in paragraph 6.4.4.

(2) 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:

(a) In running rope for a base mounted drum hoist, six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay or one valley break. In standing rope for a base mounted drum hoist, three randomly distributed broken wires in one rope lay or two broken wires at an end connection. In running rope for an overhead hoist, twelve randomly distributed broken wires in one rope lay or four broken wires in one strand in one lay or one valley break.

(b) Individual wires with 1/3 wear of original outside 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:

(i) 1/64 inch (0.4 mm) for diameters of rope up to 5/16 inch (8.0 mm).

(ii) 1/32 inch (0.8 mm) for diameters 3/8 inch (9.5 mm) to 1/2 inch (13.0 mm).

(iii) 3/64 inch (1.2 mm) for diameters 9/16 inch (14.5 mm) through 3/4 inch (19.0 mm).

(iv) 1/16 inch (1.6 mm) for diameters 7/8 inch (22.0 mm) through 1-1/8 inches (29.0 mm).

(v) 3/32 inch (2.4 mm) for rope diameters greater than 1-1/8 inches (29.0 mm).

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

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

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

(c) 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 (35.5 cm) 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.

(4) Inspect roller link chain monthly by performing steps a, b, and c in paragraph 6.4.5.a(3). In addition, perform the following checks:

(a) With hoist or winch 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 (30.5 cm) 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 (6.3 mm) in 12 inches (30.5 cm), replace chain.

(b) Check chain for twist. Replace it if twist exceeds 15 degrees in any 5-foot (1.5 m) section.

(c) Check for camber. Replace chain that has a side bow exceeding 1/4 inch (6.3 mm) in a 5-foot (1.5 m) section.

(d) 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.

(5) Inspect hooks monthly, except those on platform systems, for deformation or cracks (see Section 7).

b. Annual Inspections (Periodic Inspections). At least once per year:

(1) Perform monthly inspection (frequent inspection) requirements described in paragraph 6.4.5.a.

(2) Check for loose bolts and rivets and cracked or worn drums and sheaves. Various methods of NDT such as ultrasonics, radiography, magnetic particle, and liquid penetrant shall be used as needed.

(3) Check for worn, corroded, cracked, or distorted parts such as pins, bearings, shafts, gears, rollers, and locking and clamping devices. Surface or volumetric NDT shall be used to validate the existence or absence of cracks or other load test effects indicated by this inspection.

(4) Inspect for 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.

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

(6) Inspect hook-retaining nuts or collars, pins, welds, or rivets used to secure retaining members for deformations, cracks, or excessive corrosion. Surface or volumetric NDT shall be used to validate the existence or absence of cracks or other load test effects indicated by this inspection.

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

(8) Check that warning labels are legible.

6.4.6 Idle and Standby Hoists/Winches. Idle and standby hoists/winches shall be inspected prior to first use according to the requirements of paragraphs 6.4.4 and 6.4.5 unless these daily and formal periodic inspections were performed at required intervals and recorded during the idle/standby period.

6.4.7 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 and winch inspection.

6.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance shall be established to increase the probability the hoist or winch will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any hoist or winch found in an unsafe operating condition shall be tagged out and removed from service until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

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

a. Move hoist or winch to designated maintenance area.

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

c. 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.

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

6.5.2 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:

a. Brakes. Appropriate precautions shall 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.

b. Control system.

c. Limit switches.

(1) 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.

(2) For hoists and winches 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.

d. Power plants.

e. Critical operating mechanisms and safety devices.

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

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

b. Load-supporting components that are cracked, bent, or worn.

c. Missing or illegible warning labels.

d. For repair/replacement requirements for hoist and winch hooks with deformation or cracks, see Section 7. If repaired, hoist and winch hooks shall be proof load tested using the associated hoist or winch proof load value.

e. 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 6.4.5.a are sufficient reasons for questioning continued use of the rope (see Wire Rope Users Manual for additional information on wire rope inspections).

f. Replacement rope or chain shall be at least equal to the same size, grade, and construction as original furnished by the hoist or winch manufacturer. When replaced, perform a proof load test using the associated hoist or winch proof load value.

6.6 Personnel Certification.

6.6.1 Program. Only certified (licensed) and trained operators shall be authorized to use/operate powered hoists and winches 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 and winch operators shall be trained and certified by a recognized hoist certification organization that normally performs this function. The operator certification program will be reviewed at least annually to assure that the contents, training material, testing, and examination elements are up-to-date with current methods and techniques; and that any "lessons-learned" are adequately addressed. Riggers (see Section 10) and personnel performing NDT (see paragraph 1.9) shall be certified in their discipline. Training shall be provided to observers and flagmen. All participants in the lifting operation shall have clearly defined roles and responsibilities.

6.6.2 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.

a. Noncritical Lifts. The certification program for noncritical lift operators shall include the following:

(1) Training

(a) Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

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

(c) An annual review of the items in paragraph 6.6.2.a(1) above. (This may be conducted informally by local supervisory personnel.)

(2) Examination

(a) Physical examination (criteria to be determined by the cognizant medical official).

(b) Written examination.

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

(d) Proficiency examination for recertification.

(3) Licensing/Operator Certification

(a) 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.

(b) Renewal of all licenses shall require demonstration of proficiency or approval of supervision that proficiency is adequate and current. 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 6.6.2.a(1) and 6.6.2.a(2).

b. 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.

6.7 Operations. Hoists and winches shall be operated according to this section, the manufacturers' recommendations, and the applicable ASME standard. The following practices shall be followed for hoist and winch operations:

a. Operators will adhere to all tags placed on the hoist or winch controls.

b. Before starting a hoist or winch, 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.

c. 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.

d. Hoists and winches 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.

e. Hoists and winches shall not be used for handling personnel unless specifically designed for such purpose (see Section 9).

f. 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 A).

g. An operator shall be at the hoist or winch 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, ensuring that the hoist or winch controls are manned at all times.

h. 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.

i. Hoists and winches shall not be used to load test items such as slings, platforms, or lifting fixtures unless specifically identified to do so based on a specified percentage of rated load and a safety analysis approved by the LDEM and the responsible safety, engineering, operations, and maintenance organizations. Test procedures shall be approved by the responsible safety, engineering, operations, and maintenance organizations. This is to ensure that the hoist or winch is not damaged due to sudden unloading should the test article fail. Appendix D, crane/hoist requirements to load test other lifting equipment, shall be followed.

j. Installed or fixed air or electric powered hoists and winches, excluding platform systems, shall be operated by designated personnel only.

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

l. Outdoor hoisting operations should not commence if winds are above 20 knots (23 mph, 37 km/hr) steady state or if gusts exceed 35 knots (40 mph, 65 km/hr). Consideration shall also be given to sail area and weather conditions such as lightning or snow before commencing operations.

m. Hoists and winches shall not be used for side pulls unless specifically designed to do so.

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

o. If hand signals are required, only standard signals shall be used according to Appendix B. Hand signals shall be posted in a conspicuous location.

p. The operator shall know the weight of the working load. When raising loads that approach 75% of the rated capacity of the hoist or winch, the operator shall test the holding brakes. 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.

q. Wire rope should be used in accordance with the Wire Rope Users Manual.

6.8 Special Criteria.

6.8.1 Handling Explosives or Electro-Explosive Devices (EED's). Special precautions shall be taken while handling explosives or EED's.

a. DOT-packaged explosives shall be handled in accordance with approved hazardous operating procedures. Barricades and warning signs shall be erected to control access.

b. Explosives and EED's that are not within DOT-approved containers shall be handled in accordance with approved hazardous operations procedures. In addition to system configuration controls, these procedures shall ensure the following requirements are met:

(1) Voltage checks on crane hooks that will handle explosives or EED's shall be performed prior to the start of operations; all crane motions shall be checked.

(2) For static sensitive systems, the crane hook shall be connected to facility ground before connecting to explosives or EED's. Electrical grounding of the hook and load shall be accomplished prior to lifting operations. 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 (3 m) from exposed propellant grain, explosives, or EED's.

(3) The danger potential for radio transmissions near explosives shall be evaluated prior to the operation.

(4) Personnel limits, protective clothing, warning signs and barricades shall be used as required.

(5) Safety surveillance requirements shall be followed.

6.8.2 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.

7. HOOKS

7.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, and operation of hooks used with lifting equipment.

7.2 Safety and Design Criteria. 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), nonlubricated bearings, or permanently lubricated sealed bearings should be provided. 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. Hooks on cranes used for lifting people shall be a lockable type as required by ASME B30.23.

7.3 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.

7.4 Inspection.

7.4.1 Hooks shall be inspected during the daily and periodic inspections of the equipment of which they are a part.

7.4.2 Daily Inspections. These inspections shall be performed each day the lifting equipment is used. Inspect for:

a. Distortion, such as bending, twisting, or increased throat opening.

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

c. Wear, deformation, cracks, nicks, and gouges (see paragraph 7.5.2).

d. Hook attachment and securing means.

7.4.3 Periodic Inspections. These inspections shall be performed at varying intervals depending on activity, severity of service, environment, and criticality. The following inspections shall be performed at least once per year. Inspect for:

a. Requirements for daily inspections as described in paragraph 7.4.2.

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

c. A bend or twist exceeding 10 degrees from the plane of the unbent hook.

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

7.4.4 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.

7.4.5 NDT. Hooks shall be given a surface NDT (see paragraphs 3.1.35 and 3.1.57) immediately after all periodic load and proof load tests and prior to further use of the hook. Cracks are not acceptable. Linear indications greater than 1/8 inch long whose length is equal to or greater than three times its width are not acceptable. A visual inspection of hooks used for noncritical 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 NDT (if determined necessary by the LDEM and the responsible design engineering organization) followed by a proof load test in accordance with ASME B30.10 followed by a surface NDT. Personnel performing NDT shall be qualified and certified in accordance with paragraph 1.9.

7.4.6 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.

7.5 Maintenance.

7.5.1 Hooks with deficiencies as noted in paragraph 7.4 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.

7.5.2 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.

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

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

7.6 Operations. The following practices shall be followed when using hooks:

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.

8. HYDRA-SETS AND LOAD MEASURING DEVICES

8.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, and operation of Hydra-sets and load measuring devices.

8.2 Safety and Design Aspects.

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

8.2.2 Labeling/Tagging of Hydra-Sets and Load Measuring Devices.

a. The rated load shall be plainly marked on each Hydra-set and load measuring device (unless permanent part of lifting device).

b. Hydra-sets and load measuring devices 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 and load measuring device (unless permanent part of lifting device) are qualified for critical lifts.

c. A standard system of labeling shall be established and used throughout the installation.

d. A standard lockout/tagout 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, or other reason.

e. Certification/recertification tags are required as described in paragraph 8.3.5.

8.2.3 Safety Analysis and Documentation of Hydra-Sets Used for Critical Lifts. A recognized safety hazard analysis such as fault tree analysis, FMEA, O&SHA shall be performed on all Hydra-sets used for critical lifts. The analysis shall, as a minimum, determine potential sources of danger, identify failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the Hydra-set, facility, or load. The analysis shall be done as part of the initial evaluation process for critical lift compliance and prior to use in a critical lift, included in the Hydra-set documentation, and updated as required to reflect any changes in operation and/or configuration.

8.3 Testing. 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. 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 NDT techniques should be used to determine their extent. Tests shall be performed by qualified personnel according to written (specific or general) technical procedures.

8.3.1 Hydra-set Proof Load Test. Before first use, all new, extensively repaired, modified, or altered Hydra-sets shall undergo a proof load at 200 percent of rated load. Proof

load tests shall be performed with piston rod fully extended to prevent instrument and seal damage.

8.3.2 Hydra-set 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 100 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 more than one year since the last test. Hydra-sets used frequently for critical lifts shall be load tested at least once per year.

8.3.3 Hydra-set Operational Test. The following shall be performed in conjunction with proof load tests and periodic load tests and at least once per year:

a. 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.

b. Inspect unit for hydraulic leaks and initiate repairs when required.

c. Inspect for structural damage and corrosion of the piston rod.

8.3.4 Load Measuring Device Periodic Load Test. Before first use, all new, extensively repaired, modified, or altered load measuring devices shall undergo a load test at rated capacity. All load measuring devices shall be tested at rated capacity at least once every 4 years. Load measuring devices used for critical lifts shall be load tested at least once per year. Load measuring devices used infrequently for critical lifts shall be load tested before each critical lift if it has been more than one year since the last test. Calibration of load measuring devices satisfies the load test requirement.

8.3.5 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 and load measuring devices (unless permanent part of lifting device) shall have a permanently affixed tag or label, identifying the equipment and stating the next required periodic load test date or the load test expiration date.

8.4 Inspection.

8.4.1 Inspections, as described below, shall be performed on all Hydra-sets. Inspections shall be performed according to this section and the manufacturers' recommendations. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, tagged out and corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

8.4.2 All new, extensively repaired, or modified Hydra-sets shall be given a daily and a periodic inspection prior to first use. For component repair on Hydra-sets, 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 8.4.5).

8.4.3 Hydra-sets in regular service (used at least once a month) shall be inspected as required in paragraphs 8.4.4 and 8.4.5. Idle and standby Hydra-sets shall be inspected according to paragraph 8.4.6.

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

a. Check operating and control mechanisms for proper function.

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

c. Visually inspect for corrosion, damage, cracks, and deformities.

d. Inspect hydraulic system for deterioration and leakage.

e. Check for loose hardware.

8.4.5 Periodic Inspections. Periodic inspections are the same as paragraph 8.4.4. Periodic inspections shall be performed at least once per year or more frequently if required by the manufacturer. Periodic inspections consist of visual inspection by an appointed person and require dated documented records.

8.4.6 Idle and Standby Hydra-sets. Idle and standby Hydra-sets shall be inspected prior to first use according to the requirements of paragraphs 8.4.4 and 8.4.5 unless these daily and periodic inspections were performed at required intervals and recorded during the idle/standby period.

8.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance shall be established to increase the probability the Hydra-set or load measuring device will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any Hydra-set or load measuring device found in an unsafe operating condition shall be tagged out and removed from service until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

8.6 Personnel Certification.

8.6.1 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.

8.6.2 Licensing/operator certification will be issued every 4 years. Renewal shall require demonstration of proficiency or approval of supervision that proficiency is adequate and current.

8.7 Operations. The following shall be followed for Hydra-set operations:

a. When Hydra-set 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 and load measuring devices (unless permanent part of lifting device) shall be clearly and permanently marked with rated load value.

d. Prior to use, the operator shall ensure the Hydra-set and load measuring device (unless permanent part of lifting device) are within the inspection and periodic recertification intervals by examination of the load test tag(s), load test label(s), and/or documentation. The operator shall adhere to all tags on the controls.

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.

9. SPECIAL HOIST SUPPORTED PERSONNEL LIFTING DEVICES

9.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, personnel certification, 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 section applies to devices specifically designed to lift and lower persons via hoist, including hoist supported platforms where personnel occupy the platform during movement. 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 section does not apply to elevators that are covered by ASME A17.1, "Elevators, Dumbwaiters, Escalators, and Moving Walks." Also, this section does not apply to mobile aerial platforms (e.g., manlifts, aerial devices, scissors lifts, or other devices, covered by ANSI/SIA A92 series standards). See Section 11 for Mobile Aerial Platforms.

9.2 Safety and Design Aspects.

9.2.1 Generally, any time personnel must be raised or lowered with hoisting equipment, ASME 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. 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.

9.2.2 Labeling/Tagging of Special Hoist Supported Personnel Lifting Devices.

a. The rated load/applicable capacity ratings shall be clearly marked on the personnel lifting device. 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.

b. A standard system of labeling shall be established and used throughout the installation.

c. A standard lockout/tagout system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance, or other reasons.

d. Certification/recertification tags are required as described in paragraph 9.3.4.

9.2.3 Safety Analysis and Documentation of Special Hoist Supported Personnel Lifting Devices. A recognized safety hazard analysis such as fault tree analysis, FMEA, O&SHA shall be performed on all special hoist supported personnel lifting devices. The analysis shall, as a minimum, determine potential sources of danger, identify failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-

environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the lifting device, facility, or load. The analysis shall be done as part of the initial evaluation process for critical lift compliance and prior to use in a critical lift, included in the lifting device documentation, and updated as required to reflect any changes in operation and/or configuration.

9.2.4 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 section. Besides the requirements in Section 6, paragraphs 6.2.4, 6.2.5, 6.2.6 and 6.2.7, the following requirements shall be met for all hoist supported personnel lifting devices:

a. 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. ASME 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.

b. 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. The option selected shall be approved by the LDEM with concurrence from the responsible safety, engineering, operations, and maintenance organizations. Operation, maintenance, and inspection requirements shall be developed to provide equivalent verification of equipment as required by industry and OSHA standards and as outlined in this section.

c. 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.

d. 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.

e. 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.

9.3 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 section. 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, periodic 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 periodic 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. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures. 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. Surface or volumetric NDT of critical components shall be used to validate the existence or absence of cracks or other load test effects indicated by this inspection. The periodic load test requirement may be fulfilled by a concurrently performed proof load test.

9.3.1 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.

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

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

a. Perform all hoist functions in an unloaded condition.

b. Test operation of brakes and limit, locking, and safety devices.

c. 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.

d. 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 LDEM and the responsible safety, engineering, operations, and maintenance organizations) and braking/holding mechanisms. Holding brakes shall be tested to verify stopping capabilities and

demonstrate the ability to hold a rated load (see paragraph 9.3.3.e). The load should be held long enough to allow any dynamics to dampen out.

e. For hoist supported personnel lifting devices equipped with two means of braking (see paragraph 9.2.4.b) 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:

(1) 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.

(2) 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.)

(3) Other methods may be used as approved by the LDEM with concurrence from the responsible safety, engineering, operations, and maintenance organizations.

f. 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.

9.3.4 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 periodic load test, personnel lifts shall be given a permanently affixed tag identifying the equipment and stating the next required periodic load test date or load test expiration date.

9.4 Inspection.

9.4.1 Inspections, as described below, 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, tagged out and corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

9.4.2 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 9.4.5).

9.4.3 Personnel lifts in regular service (used at least once a month) shall be inspected as required in paragraphs 9.4.4 and 9.4.5. Idle and standby personnel lifting devices shall be inspected according to paragraph 9.4.6.

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

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

b. Check operating mechanisms, control mechanisms, and guard rails for proper function.

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

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

e. Inspect hooks for cracks and deformities (see Section 7).

f. Inspect rope reeving for proper travel and drum lay.

g. Inspect hoist chains for excessive wear or distortion.

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

a. Monthly Inspections (Frequent Inspections). At least once per month:

(1) Perform requirements for daily inspections as described in paragraph 9.4.4.

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

(3) Inspect wire rope for:

(a) In running rope, six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay or one valley break. In standing rope, two randomly distributed broken wires in one rope lay or two broken wires at an end connection or one valley break.

(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:

(i) 1/64 inch (0.4 mm) for diameters of rope up to 5/16 inch (8.0 mm).

(ii) 1/32 inch (0.8 mm) for diameters 3/8 inch (9.5 mm) to 1/2 inch (13.0 mm).

(iii) 3/64 inch (1.2 mm) for diameters 9/16 inch (14.5 mm) through 3/4 inch (19.0 mm).

(iv) 1/16 inch (1.6 mm) for diameters 7/8 inch (22.0 mm) through 1-1/8 inches (29.0 mm).

(v) 3/32 inch (2.4 mm) for rope diameters greater than 1-1/8 inches (29.0 mm).

(h) Two broken wires at an end connection.

(4) Inspect for visible deformation or cracks in hooks (see Section 7).

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

(1) Requirements in 9.4.5.a Monthly Inspections (Frequent Inspections).

(2) Deformed, cracked, or corroded members and welds and loose bolts or rivets in personnel lift structure. Various methods of NDT such as ultrasonics, radiography, magnetic particle, or liquid penetrant shall be utilized as needed.

(3) Cracked or worn sheaves and drums.

(4) Excessive wear or cracks in pins, bearings, shafts, gears, followers, and locking and clamping devices. Surface or volumetric NDT shall be used to validate the existence or absence of cracks indicated by this inspection.

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

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

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

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

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

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

(11) Evidence of overheating.

c. Other Inspections. 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.

9.4.6 Idle and Standby Personnel Lifting Devices. Idle and standby personnel lifting devices shall be inspected prior to first use according to the requirements of paragraphs 9.4.4 and 9.4.5 unless these monthly and annual inspections were performed at required intervals and recorded during the idle/standby period.

9.4.7 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.

9.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive and predictive maintenance shall be established to increase the probability the personnel lifting device will function in the required manner over its design life cycle with a minimum of maintenance. 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 9.4.5.a and 9.4.5.b are sufficient reasons for questioning continued use (see Wire Rope Users Manual for additional information on wire rope inspections). Any personnel lifting device found in an unsafe operating condition shall be tagged out and removed from service until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

9.6 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:

9.6.1 Training.

a. Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

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

c. An annual review of items in paragraphs 9.6.1.a and 9.6.2.b above. (This may be conducted informally by local supervisory personnel.)

9.6.2 Examination.

a. Physical examination (criteria to be determined by the cognizant medical official).

b. Written examination.

c. Operational demonstration (for initial certification only).

d. Proficiency examination for recertification.

9.6.3 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.

9.6.4 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 9.6.1 and 9.6.2.

9.7 Operations. Hoist support personnel lifting devices shall be operated according to applicable industry standards, government requirements, and manufacturers' instructions. The following practices shall be followed for hoist supported personnel lifting device operations:

a. 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.

b. 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 9.6, and have read and understood all decals and warnings on the device.

c. 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. The operator shall adhere to all tags placed on the controls.

d. 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.

e. 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.

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

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

h. 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.

i. 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.

j. Operator discipline shall be maintained at all times. There shall be no eating, drinking, or rowdiness 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.

k. 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.

l. 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.

m. Wire rope should be used in accordance with the Wire Rope Users Manual.

10. SLINGS AND RIGGING

10.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, personnel certification, and operation of slings. This includes slings constructed of wire rope, alloy steel chain, metal mesh, synthetic rope, synthetic web, linear fiber, structural slings, and associated equipment such as shackles, turnbuckles, and eyebolts.

10.2 Safety and Design Aspects.

10.2.1 Design Criteria that should be emphasized during sling design are contained in the documents listed in Section 2. Sling design shall be in accordance with industry standards and meet the applicable requirements of OSHA and ASME. Sling design shall maintain the minimum design factors listed in Table 10-1.

Table 10-1 Minimum Design Factors for Slings

Equipment	Design Load Safety Factor
Alloy Steel Chain Slings	5
Wire Rope Slings	5
Metal Mesh Slings	5
Synthetic Rope Slings	5
Synthetic Web Slings	5
Linear Fiber Slings	5
Structural Slings	Lesser of 3 times yield or 5 times ultimate
Shackles, D-rings, Turnbuckles, Eye Bolts, Lifting Lugs, Safety Hoist Rings, etc.	5

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

10.2.2 Labeling/Tagging of Slings. Certification/recertification tags are required as described in paragraph 10.3.5. 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.

10.3 Testing. The following proof load and periodic load tests apply to slings except as noted in paragraph 10.3.3. 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. The acceptable tolerance for load test accuracy is +5/-0 percent. When slings are composed of major components that fall into more than one of the categories listed in Table 10-2, 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. The load shall be held for a minimum of 3 minutes for load tests.

10.3.1 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 10-2. Proof load tests performed by the manufacturer prior to delivery are acceptable, if the necessary load test 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. Prior to first use, all lifting interfaces such as eyebolts, D-rings, and lifting lugs permanently attached to the load shall be proof load tested if feasible. For lifting interfaces, when deemed unfeasible by the responsible design organization and accepted by the user organization, based on possible overloading of structural members not required during lifting or other considerations, this proof load test can be eliminated. However, design analysis and inspection shall be used to verify the integrity of the interface.

Table 10-2 Proof Load Test Factors
(Based on Manufacturers' Rated Load)

Equipment	Proof Load Test Factor
Alloy Steel Chain Slings	2.0
Wire Rope Slings	2.0
Metal Mesh Slings	2.0
Synthetic Rope Slings	2.0
Synthetic Web Slings	2.0
Linear Fiber Slings	2.0
Structural Slings	2.0*
Shackles, D-rings, Turnbuckles, Eye Bolts, Lifing Lugs, Safety Hoist Rings, etc.	2.0

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

10.3.2 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 10-3. All components shall be tested together as a system, if practical. Slings used for critical lifts shall be load tested at least once per year. 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. Lifting interfaces such as eyebolts, D-rings, and lifting lugs permanently attached to the load are exempt from periodic load testing.

Table 10-3 Periodic Load Test Factors
(Based on Manufacturers' Rated Load)

Equipment	Periodic Load Test Factor
Alloy Steel Chain Slings	1.00
Wire Rope Slings	1.00
Metal Mesh Slings	1.00
Synthetic Rope Slings	1.00*
Synthetic Web Slings	1.00
Linear Fiber Slings	1.00
Structural Slings	1.00
Shackles, D-rings, Turnbuckles, Eye Bolts, Lifting Lugs, Safety Hoist Rings, etc.	1.00

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

10.3.3 Non-Load Test Slings. Due to unique design and usage requirements, a sling may be designated as a non-load test sling by the LDEM, with concurrence from the affected/responsible program/project office, the responsible safety, design engineering, systems engineering, operations, and maintenance organizations. Such slings do not require periodic load tests. Inspections shall be conducted in accordance with paragraph 10.4. This non-load test designation shall be formally documented by each installation and the sling marked accordingly to designate it as a non-load test sling.

10.3.4 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 10-3). For metal mesh slings, the rated capacity will be noted for vertical basket and choker hitch configurations. For synthetic rope slings, used in noncritical lifts, a 50-percent derating for use is recommended. For synthetic rope slings used in critical lifts, a 50-percent derating is required.

10.3.5 Test Reports and Periodic Recertification Tags.

a. 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.

b. 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 load test expiration date. For alloy steel chains, size, grade, and reach shall be stated along with the rated load. For 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 will invalidate the load test of the whole assembly.)

10.4 Inspection.

10.4.1 Inspections, as described below, shall be performed on all slings. Inspections shall be performed according to this section, the manufacturers' recommendations, and ASME B30.9. 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, tagged out and corrected prior to further use.

10.4.2 All new, extensively repaired, or modified slings shall be given a daily and a periodic inspection prior to first use. For component repair on slings, 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 10.4.5).

10.4.3 Slings in regular service (used at least once a month) shall be inspected as required in paragraphs 10.4.4 and 10.4.5. Idle and standby slings shall be inspected according to paragraph 10.4.6.

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

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

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

10.4.5 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 (see Wire Rope Users Manual for additional information on wire rope inspections):

a. Alloy Steel Chain

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

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

(3) Ensure that master links are not deformed.

b. Wire Rope Slings

(1) 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.

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

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

(4) Inspect for excessive heat damage.

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

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

c. Metal Mesh Slings

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

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

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

(4) 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.

(5) 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.

d. Synthetic Rope Slings

(1) Inspect for abnormal wear.

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

(3) Inspect for broken or cut fibers.

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

(5) Inspect for distortion of associated hardware.

e. Synthetic Web and Linear Fiber Slings

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

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

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

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

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

(6) Perform all inspections provided for by the sling manufacturer. This may include red fibers used as a wear indicator, or a fiber optic sling damage indicator, or some other NDT method designed into the sling.

f. Structural Slings

(1) 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.

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

(3) 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.

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

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

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

(7) 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 by performing a surface NDT.

(8) Inspect pin bores for deformation, local yielding, scoring, galling, brinelling, and diameters not within design tolerances. Verify that there are no cracks by performing a surface NDT.

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

(a) Visual inspection of all welds.

(b) Ultrasonics, radiography, magnetic particle, liquid penetrant, or eddy current as appropriate for critical welds as identified on the design drawings. Inspect a minimum of 1/2 inch on each side of the weld to ensure the heat affected zone is included. Verify that there are no cracks.

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

(11) Inspect hooks for deformations or cracks (see Section 7).

g. Rejected Slings. 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.

10.4.6 Idle and Standby Slings. Idle and standby slings shall be inspected prior to first use according to the requirements in paragraphs 10.4.4 and 10.4.5 unless these daily and periodic inspections were performed at required intervals during the idle/standby period.

10.4.7 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).

10.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance shall be established to increase the probability the sling will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any sling found in an unsafe operating condition shall be tagged out and removed from service until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions. The need to repair or replace slings shall be determined by a certified or otherwise qualified person based on an evaluation of inspection results.

10.6 Personnel Certification.

10.6.1 Program. Only certified (licensed) and trained riggers are authorized to perform rigging tasks for lifting devices, equipment, and/or operations. A comprehensive training, examination, and licensing program shall be established or made available. For those NASA installations/initiatives or sponsored programs and activities that do not have a training program, these requirements may be provided by a third party that is proficient in the principles of rigging. The rigging certification program will be reviewed at least annually to assure that the contents, training material, testing, and examination elements are up-to-date with current methods and techniques; and that any "lessons-learned" are adequately addressed. Personnel performing NDT shall be qualified and certified in accordance with paragraph 1.9. Training shall be provided to observers and flagmen. All participants in the lifting operation shall have clearly defined roles and responsibilities.

10.6.2 The certification program for rigging operations shall include the following and may be included in the operator training for the individual lifting device training and certification . If the general rigging is included in the specific lifting device certification and training program, sufficient rigging details shall be included in the training, testing and "hands-on" examination portion of that lifting device training program to assure that each individual understands and demonstrates proficiency in the required rigging techniques and methods.

The following shall be addressed in the qualification of individuals for "rigging certification."

a. Training

(1) Classroom training in rigging safety, techniques, and methods, pre-use inspection, slings, and attachment devices (for initial certification and as needed).

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

(3) An annual review by supervision or other designated personnel of each individual's performance as a rigger or operator/rigger to assure adequate proficiency in performing the necessary rigging tasks in a

manner consistent with the principals, methods, and techniques associated with safe rigging practices.

b. Examination

(1) Physical examination (criteria to be determined by the cognizant medical official based upon the related requirements associated with performing rigging tasks).

(2) Written examination.

(3) Operational (practical) demonstration test (for initial certification only or to address new techniques or methods as required). Each individual shall demonstrate the ability to adequate determine and/or apply load weight, center of gravity and apply special articulating devices essential to the safe and successful lift operation. Riggers must demonstrate the ability to apply proper rigging principals, methods, and techniques using simulated loads of various weights, sizes, and configurations.

c. Rigger Licensing/Certification

(1) An organization element shall be designated to issue rigger licenses/certifications. Provisions shall be made to suspend/revoke licenses or certifications for violation of safety requirements, failure to meet medical requirements, or acts of negligence in rigging. A program element to assure current rigger certification status of persons performing rigging tasks shall be established and implemented. The method of licensing is the responsibility of the organization element that is designated to issue the rigger licenses/certifications. Generally this will involve the use of “License/Certification Cards” issued to each individual or maintaining a master list of licensed/certified riggers that is readily available to assurance and supervisory personnel.

(2) Renewal of all rigger licenses/certifications shall require demonstration of proficiency or approval of supervision that proficiency is adequate and current. Licenses/certifications will expire at least every 4 years. Renewal procedures and requirements will be established by the organizational element responsible for issuing rigger licenses/certifications and will include those requirements established in paragraphs 10.6.2 a. and 10.6.2 b.

10.7 Operations. Slings shall be operated according to this section, the manufacturers’ recommendations, and ASME B30.9. The following practices shall be followed for sling operations:

a. Select a sling of suitable rated capacity, use proper hitch, and attach the sling securely to the load. For critical lifts, rope slings of synthetic construction shall not be used beyond 50 percent of their rated load. (The minimum design factors for determining rated load are provided in Table 10-1.)

b. Avoid kinks, loops, or twists in the sling legs.

c. Start lift slowly to avoid shock loading the slings.

d. 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.

e. Slings shall be shortened only by methods approved by the sling manufacturer or a qualified person.

f. Eyes in wire rope bridles, slings, or bull wires shall not be formed by wire rope clips or knots.

g. The following materials and techniques shall not be used in slings or rigging hardware to hoist personnel or loads: natural rope, wire rope clips, the fold back metal pressed sleeve or clip technique.

h. Keep metallic slings lubricated/painted to prevent corrosion.

i. Slings shall not be loaded beyond rated load except for required testing.

j. 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.

k. Precautions shall be taken to ensure proper sling assembly and that the proper configuration is maintained. Slings shall be used according to design and/or manufacturers' instructions.

l. 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.

m. Sling repair shall maintain the minimum design factors based on ultimate material strength. These factors are listed in Table 10-1.

n. Slings shall be padded or protected from the sharp edges of their loads.

o. Wire rope slings should be used in accordance with the Wire Rope Sling Users Manual.

p. For lifting, safety hoist rings are strongly recommended for use instead of eye bolts.

11. MOBILE AERIAL PLATFORMS

11.1 General. This section establishes minimum standards for the design, testing, maintenance, inspection, personnel certification, and operation of mobile aerial platforms. This section applies to those platforms covered by ANSI/SIA A92.2 (Vehicle Mounted Elevating and

Rotating Aerial Devices), A92.3 (Manually Propelled Elevating Aerial Platforms), A92.5 (Boom Supported Elevating Work Platforms), and A92.6 (Self-Propelled Elevating Work Platforms).

11.2 Safety and Design Aspects. High quality off-the-shelf OEM type equipment is acceptable if it is designed, maintained, and operated according to this standard.

11.2.1 Design criteria/general design requirements that should be emphasized for mobile aerial platforms are contained in ANSI/SIA A92.2, A92.3, A92.5, and A92.6. It is the responsibility of the applicable engineering, operations/maintenance, and safety organizations to ensure the design, testing, maintenance, inspection, and operation of this equipment complies with this standard, the manufacturers' recommendations, and ANSI/SIA.

11.2.2 Labeling/Tagging of Mobile Aerial Platforms.

a. The rated load/applicable capacity ratings shall be clearly marked on the mobile aerial platform.

b. A standard system of labeling shall be established and used throughout the installation.

c. A standard lockout/tagout system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance, or other reasons.

d. Certification/recertification tags are required as described in paragraph11.3.4.

11.2.3 Safety Analysis and Documentation of Mobile Aerial Platforms. A recognized safety hazard analysis such as fault tree analysis, FMEA, O&SHA shall be performed on all mobile aerial platforms used for lifts where failure/loss of control could result in loss of or damage to flight hardware. The analysis shall, as a minimum, determine potential sources of danger, identify failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the mobile aerial platform, facility, or load. The analysis shall be done as part of the initial activation process, included in the equipment documentation, and updated as required to reflect any changes in operation and/or configuration.

11.3 Testing. Testing of mobile aerial platforms shall be performed according to this section, the manufacturers' recommendations, and the applicable ANS/SIA standard. Three types of tests are required for mobile aerial platforms: proof load tests, periodic 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 in the mobile aerial platform load path. Repairs or alterations to nonlifting or nonholding components do not require a load test, although a functional check should be performed to determine if the repairs or alterations are acceptable. The periodic load and operational tests shall be performed annually. The acceptable tolerance for load test accuracy is +5/-0 percent. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures. An inspection of the mobile aerial platform and its components shall be performed after each load test and prior to the platform being released for service to ensure

there is no damage. The periodic load test requirement may be fulfilled by a concurrently performed proof load test.

11.3.1 Proof Load Test. Before first use, all new, extensively repaired, or altered mobile aerial platforms shall undergo a proof load test in accordance with the manufacturers' instructions and the applicable ANSI/SIA standard. A proof load test may also be performed when there is a question in design, previous testing, or to ensure system integrity. The load shall be lifted slowly in an area where minimal damage will occur if the platform fails.

11.3.2 Periodic Load Test. Each mobile aerial platform shall be tested at least once every year with a load equal to the rated load.

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

a. Perform all functions in an unloaded condition, including operation of limit switches and tilt alarm/shutoff. Where possible, use ground control station. When required to use the platform control station, operate close to ground level.

b. Perform load test at maximum boom radius over the rear, if applicable. Hold the load for a minimum of 5 minutes and verify drift does not exceed that specified by the responsible engineering organization.

c. The operational test for a modified mobile aerial platform can be tailored to test only those portions of the equipment that were modified/repaired, only if the rated and operational test interval has not expired.

11.3.4 Test Reports and Periodic Recertification Tags. After each test, designated personnel shall prepare written, dated, and signed test reports. Inadequacies shall be documented and, if determined to be a hazard, corrected prior to further use. These reports shall be kept on file for a minimum of two test cycles and shall be made readily available. Following the periodic load test, mobile aerial platforms shall be given a permanently affixed tag identifying the equipment and stating the next required periodic load test date or load test expiration date.

11.4 Inspection.

11.4.1 Inspections, as described below, shall be performed on all mobile aerial platforms. Inspections shall be performed according to this section, the manufacturers' recommendations, and the applicable ANSI/SIA standard. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, tagged out and corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

11.4.2 All new, extensively repaired, or modified mobile aerial platforms shall be inspected to the requirements of both daily and periodic inspections prior to first use. For component repair on mobile aerial platforms, 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 11.4.5).

11.4.3 Mobile aerial platforms in regular service (used at least once a month) shall be inspected as required in paragraphs 11.4.4 and 11.4.5. Idle and standby platforms shall be inspected according to paragraph 11.4.6.

11.4.4 Daily Inspections. These inspections shall be performed each day the mobile aerial platform is used and shall include the following:

a. Check safety devices for malfunction.

b. Check operating and control mechanisms for proper function.

c. Inspect for defects such as cracked welds, damaged control cables, and loose cable/wire connections.

d. Inspect hydraulic or pneumatic systems for observable deterioration or leakage and check hydraulic system for proper oil level if suspect.

e. Inspect electrical equipment for signs of malfunction, signs of deterioration, and dust and moisture accumulation.

f. Inspect chains or wire rope for wear or distortion.

11.4.5 Periodic Inspections. These inspections shall be performed at varying intervals depending on activity, severity of service, and environment. The following inspections shall be performed at least once per year or more frequently if required by the manufacturer or the applicable ANSI/SIA standard. Inspect for:

a. Requirements for daily inspections described in paragraph 11.4.4.

b. Deformed, cracked, or corroded members and loose bolts or rivets in the aerial platform structure. Various methods of NDT such as ultrasonics, radiographic, magnetic particle, and liquid penetrant shall be utilized as needed.

c. Worn, cracked, or distorted parts, such as pins, bearings, shafts, gears, couplings, rollers, and locking devices.

d. Wear in chain drive sprockets and stretch in the chain.

e. Hydraulic and pneumatic relief valve settings as required by the manufacturer.

f. Hydraulic system for proper oil level.

g. Hydraulic and pneumatic fittings, hoses, and tubing for evidence of leakage, abnormal deformation, or abrasion.

h. Compressors, pumps, motors, and generators for loose fasteners, leaks, unusual noises or vibrations, loss of operating speed, and heating.

i. Hydraulic and pneumatic valves for cracks in the valve housing, leaks, and sticking spools.

j. Hydraulic and pneumatic cylinders and holding valves for malfunction and visible damage.

k. Hydraulic and pneumatic filters for cleanliness and the presence of foreign material in the system indicating other component deterioration.

l. Condition and tightness of bolts and other fasteners.

m. Legible and proper markings of controls, ratings, and instructions.

11.4.6 Idle and Standby Mobile Aerial Platforms. Idle and standby mobile aerial platforms shall be inspected prior to first use according to the requirements of paragraphs 11.4.4 and 11.4.5 unless these daily and periodic inspections were performed at required intervals and recorded during the idle/standby period.

11.4.7 Inspection Reports. After each formal periodic inspection, qualified 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 mobile aerial platforms.

11.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive and predictive maintenance shall be established to increase the probability the mobile aerial platform will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any mobile aerial platform found in an unsafe operating condition shall be removed from service until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

11.6 Personnel Certification. Only certified (licensed) and trained operators shall be authorized to operate mobile aerial platforms (except for manually propelled platforms where training can be provided). A training, examination, and licensing program shall be established or made available. For those NASA installations that do not have a training program, all mobile aerial platform operators shall be trained and certified by a recognized certification organization that normally performs this function. The basic certification program will include the following:

11.6.1 Training.

a. Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

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

c. An annual review of items listed in paragraphs 11.6.1a and 11.6.1.b above. (This may be conducted informally by local supervisory personnel).

d. Training for working at heights and the proper use of fall protection equipment.

11.6.2 Examination.

a. Physical examination (criteria to be determined by the cognizant medical official).

b. Written/oral examination.

c. Operational demonstration.

d. Proficiency examination for recertification.

11.6.3 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 mobile aerial platform 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.

11.6.4 Renewal. Licenses or certifications will expire at least every 4 years. Renewal shall require demonstration of proficiency or approval of supervision that proficiency is adequate and current. Renewal procedures will be established by each licensing organization, but as a minimum, will include items in paragraphs 11.6.1 and 11.6.2.

11.7 Operations. Mobile aerial platforms shall be operated according to this section, the manufacturers' recommendations, and the applicable ANSI/SIA standard. The following practices shall be followed for mobile aerial platform operations:

a. Determine that the proposed mobile aerial platform operation is the desired operation after comparing hazards, productivity, and manpower requirements associated with other methods of access.

b. Before each use, the operator shall have read and understood the manufacturer's operating instructions and safety rules, have been trained and licensed according to paragraph 11.6, and have read and understood all decals and warnings on the equipment.

c. Before each use, the operator shall perform a pre-operational check to demonstrate operational readiness, including all limit switches and outrigger drift switches, if applicable, but excluding the tilt alarm/shutoff. If controls do not operate properly, the operator is responsible for notifying the supervisor. Repairs and adjustments shall be made before operations begin. The operator shall adhere to all tags on the controls.

d. Before each use, 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.

e. The equipment shall not be loaded beyond its rated load (capacity) except for required testing.

f. The operator shall ensure the equipment is within inspection and testing intervals by examination of the periodic recertification tags and/or documentation.

g. Operator discipline shall be maintained at all times. There shall be no eating, drinking, or rowdiness during mobile aerial platform operations. Personnel shall keep all parts of the body, tools, and equipment inside the work platform periphery during raising, lowering, and traveling operations.

h. Fall protection is required for personnel using mobile aerial platforms that can tilt, as covered by ANSI/SIA A92.2 and A92.5.

i. 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 mobile aerial platforms should be investigated.

j. For work on or near electrical distribution and transmission lines, mobile aerial platforms shall be operated in accordance with paragraphs 5.7.as, 5.7.at, and 5.7.au of this standard and the applicable ANSI/SIA standard.

k. Insulated mobile aerial platforms shall be tested and inspected in accordance with ANSI/SIA.

l. Outdoor mobile aerial platform operations should not commence if winds are above 20 knots steady state (23 mph, 37 km/hr) or if gusts exceed 25 knots (29 mph, 46 km/hr) or as recommended by the manufacturer. Consideration shall also be given to weather conditions such as lightning or snow before commencing operations.

m. The requirements of this section apply to all uses of mobile aerial platforms; e.g., movement for storage/repositioning and use of the platform close to ground level.

12. POWERED INDUSTRIAL TRUCKS

12.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, personnel certification, and operation of powered industrial trucks (forklifts). This section applies to those platforms covered by ASME B56.1, “Safety Standard For Low Lift and High Lift Trucks.”

12.2 Safety and Design Aspects. High quality off-the-shelf OEM type equipment is acceptable for critical and noncritical lifts if it is designed, maintained, and operated according to this standard.

12.2.1 Design criteria/general design requirements that should be emphasized for powered industrial trucks are contained in ASME B56.1. It is the responsibility of the applicable engineering, operations/maintenance, and safety organizations to ensure the design, testing, maintenance, inspection, and operation complies with this standard, the manufacturers' recommendations, ASME B56.1, and OSHA 1910.178.

12.2.2 Labeling/Tagging of Powered Industrial Trucks.

a. The rated load/applicable capacity ratings shall be clearly marked on the powered industrial truck.

b. A standard system of labeling shall be established and used throughout the installation.

c. A standard lockout/tagout system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance, mishaps, or other reason.

d. Certification/recertification tags are required as described in paragraph 12.3.4.

12.2.3 Safety Analysis and Documentation of Powered Industrial Trucks. A recognized safety hazard analysis such as fault tree analysis, FMEA, O&SHA shall be performed on all powered industrial trucks used for lifts where failure/loss of control could result in loss of or damage to flight hardware. The analysis shall, as a minimum, determine potential sources of danger, identify failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the powered industrial truck, facility, or load. The analysis shall be done as part of the initial activation process, included in the equipment documentation, and updated as required to reflect any changes in operation and/or configuration.

12.3 Testing. Testing of powered industrial trucks shall be performed according to this section, the manufacturers' recommendations, and the applicable OSHA and ASME standards. Three types of tests are required for powered industrial trucks: proof load tests, periodic load tests, and operational tests. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures. An inspection of the powered industrial truck and its components shall be performed after each load test and prior to the truck being released for service to ensure there is no damage. The acceptable tolerance for load test accuracy is +5/-0 percent unless otherwise specified. The periodic load test requirement may be fulfilled by a concurrently performed proof load test.

12.3.1 Proof Load Test. Proof load tests and operational tests shall be performed prior to first use for new or extensively repaired or altered components directly in the powered industrial truck load path in accordance with the manufacturers' instructions and the applicable ASME standard. Repairs or alterations to non-lifting or non-holding components do not require a load test, although a functional check should be performed to determine if the repairs or alterations are acceptable. A proof load test may also be performed when there is a question in design, previous testing, or to ensure system integrity.

12.3.2 Periodic Load Test. For powered industrial trucks used where failure/loss of control could result in loss of or damage to flight hardware, a periodic load and operational test shall be performed at least once every year with a load equal to the rated load.

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

a. Perform all functions in a loaded condition including tilt operation. Ensure the load is secured and will not move during tilting operations.

b. Hold the load for a minimum of 5 minutes and verify drift does not exceed that specified by the responsible engineering organization.

c. The operational test for a modified powered industrial truck can be tailored to test only those portions of the equipment that were modified/repaired only if the rated and operational test interval has not expired.

12.3.4 Test Reports and Periodic Recertification Tags. After each test, designated personnel shall prepare written, dated, and signed test reports. Inadequacies shall be documented and, if determined to be a hazard corrected prior to further use. These reports shall be kept on file for a minimum of two test cycles and shall be made readily available. Following the periodic load test, powered industrial trucks shall be given a permanently affixed tag identifying the equipment and stating the next required periodic load test date or load test expiration date.

12.4 Inspection.

12.4.1 Inspections shall be performed on all powered industrial trucks. Inspections shall be performed according to this section, the manufacturers' recommendations, and ASME B56.1. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, the truck will be tagged out and the inadequacy corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

12.4.2 All new, extensively repaired, or modified powered industrial trucks shall be inspected to the requirements of both daily and periodic inspections prior to first use. For component repair on powered industrial trucks, 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 12.4.5).

12.4.3 Powered industrial trucks in regular service (used at least once a month) shall be inspected as required in paragraphs 12.4.4 and 12.4.5. Idle and standby powered industrial trucks shall be inspected according to paragraph 12.4.6.

12.4.4 Daily Inspections. These inspections shall be performed by the operator prior to each shift the truck is used. Inspect:

a. Warning and safety devices for malfunction (to include the horn).

b. Condition of tires (if pneumatic tires, check inflation pressures).

c. Lights.

d. Hydraulic system for observable deterioration or leakage and check for proper oil level if suspect.

e. Electrical equipment for signs of malfunction, signs of deterioration, and dust and moisture accumulation.

f. Chains and cables for wear or distortion.

g. Battery, connections, and load test.

h. Control mechanisms.

i. Lift and tilt systems.

j. Load engaging means.

k. Brakes.

l. Steering mechanism.

m. Fuel systems.

n. Engine oil and pressure.

o. Manufacturing plates, tags, or decals in legible condition.

12.4.5 Periodic Inspections. The following inspections shall be performed at least once per year or more frequently as required by the manufacturer, ASME B56.1, users' experience gained, severity of service, environment, and criticality. Inspect:

a. The items listed in paragraph 12.4.4.

b. Forks for damage, deformation, cracks, straightness of blade, fork angle, difference in height of fork tips, positioning lock, and legibility of fork marking.

c. Frame members.

d. Critical welds.

e. Axle stops.

f. Safe operating features or devices designed and approved for hazardous area operations.

g. Motors.

h. Electrical conductors and connections.

12.4.6 Idle and Standby Powered Industrial Trucks. Idle and standby powered industrial trucks shall be inspected prior to first use according to the requirements of paragraphs 12.4.4 and 12.4.5 unless these daily and periodic inspections were performed at required intervals and recorded during the idle/standby period.

12.4.7 Inspection Reports. After each formal periodic inspection, qualified 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 powered industrial trucks.

12.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance shall be established to increase the probability the powered industrial truck will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any powered industrial truck found in an unsafe operating condition shall be tagged out and removed from service until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

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

a. Move the powered industrial truck to a designated area where maintenance activities will not interfere with other operations and there is proper ventilation.

b. When lifting trucks for repair, trucks shall be lifted in a safe, secure, stable manner. The drive wheels will be raised free of the floor or the battery will be disconnected.

c. Chocks or other positive truck positioning devices will be used.

d. Block load engaging means, innermasts(s), or chassis before working on them.

e. Before disconnecting any part of the engine fuel system of gasoline powered trucks with gravity feed fuel systems, take precaution to eliminate any possibility of unintentional fuel escape.

f. Before disconnecting any part of the engine fuel system of LP gas powered trucks, close LP tank valve and run engine until fuel in system is depleted and engine stops.

g. Disconnect the battery before working on the electrical system.

h. The charger connector shall be plugged only into the battery connector and never into the truck connector.

12.5.2 Adjustments. Based upon the manufacturers documentation and/or experience gained, adjustments shall be made to ensure that all powered industrial trucks function properly, paying particular attention to:

a. Brakes.

b. Control systems.

c. Limit switches.

d. Steering mechanisms.

e. Hazardous area operation devices.

f. Motors.

12.5.3 Repair/Replacement.

a. Modifications and additions that affect truck capacity (to include addition of counterweight) and safe truck operation shall not be performed without manufacturer approval.

b. Replacement parts, including tires, shall be interchangeable with the original parts and of a quality at least equal to that provided in the original equipment.

c. Replacement parts are to be installed per manufacturers procedures.

d. No repairs shall be made in Class I, II, and III locations (ref. OSHA 1910.178).

e. Replacement batteries shall be of the service weight that falls within the minimum/maximum range specified on the truck nameplate by the truck manufacturer.

12.6 Personnel Certification. Only certified (licensed) and trained operators shall be authorized to operate powered industrial trucks. A training, examination, and licensing program shall be established or made available. For those NASA installations that do not have a training program, all powered industrial truck operators shall be trained and certified by a recognized certification organization that normally performs this function. The basic certification program will include the following:

12.6.1 Training.

a. Classroom training in safety, lifting equipment emergency procedures, general performance standards, requirements, pre-operational checks, and safety-related defects and symptoms (for initial certification and as needed).

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

c. An annual review of items listed in paragraphs 12.6.1a and 12.6.1.b above. (This may be conducted informally by local supervisory personnel.)

12.6.2 Examination.

a. Physical examination (criteria to be determined by the cognizant medical official and should comply with ASME B56.1).

b. Written/oral examination.

c. Operational demonstration.

d. Proficiency examination for recertification.

12.6.3 Licensing. An organizational element shall be designated to issue operator licenses/certifications. Provisions shall be made to revoke licenses/certifications 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 powered industrial truck 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.

12.6.4 Renewal. Licenses or certifications will expire every 3 years. Renewal shall require demonstration of proficiency or approval of supervision that proficiency is adequate and current. Renewal procedures will be established by each licensing organization, but as a minimum, will include items in paragraphs 12.6.1 and 12.6.2. Renewal or refresher training will be provided to operators within the three year certification period when:

a. The operator has been observed operating the truck in an unsafe manner.

b. The operator has been involved in an accident or near miss incident.

c. The operator has received an evaluation that reveals that the operator is not operating the truck safely.

d. The operator is assigned to drive a different type of truck.

e. A condition in the workplace changes in a manner that could effect safe operation of the truck.

12.7 Operations.

12.7.1 Powered industrial trucks shall be operated according to this section, the manufacturers' recommendations, and ASME B56.1. The following practices shall be followed for powered industrial truck operations:

a. General operating procedures describing powered industrial truck operations, emergency steps, communication requirements, and special requirements including checklists and inspection requirements shall be prepared,

approved and followed for each area powered industrial truck operations are performed and shall include each type of truck. There must be a formal system for review, approval, and update to maintain valid operating procedures.

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

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

d. Before each use, the operator shall survey the area for applicable hazards such as overhead obstructions, debris, bumps and loose obstructions, drop-offs and holes, ditches, obstructed path of travel, unstable ground, and other possible hazardous conditions. The operator shall establish appropriate safety zones before initiating operations.

e. The equipment shall not be loaded beyond its rated load (capacity) except for required testing.

f. The operator shall ensure the equipment is within inspection and testing intervals by examination of the periodic recertification tags and/or documentation. The operator shall adhere to all tags on the controls.

g. Operator discipline shall be maintained at all times. There shall be no eating, drinking, or rowdiness during powered industrial truck operations.

h. Operators shall keep all parts of the body inside the operator compartment during operations.

i. Never put any part of the body into the mast structure or between the mast and truck.

j. Do not start or operate the truck or any of its attachments from any place other than from the operators position.

k. Trucks shall not be driven up to anyone standing in front of an object.

l. Operators shall ensure other personnel are not in the swing radius prior to performing turning maneuvers.

m. Operators shall sound the horn when approaching cross aisles, doorways and other locations where pedestrians may step into the path of truck travel.

n. No person is allowed to stand or pass under the elevated portion of any truck, empty or loaded.

o. Unauthorized personnel shall not be permitted to ride on powered industrial trucks. A safe place to ride shall be provided where riding of trucks is authorized.

p. A powered industrial truck is attended when the operator is less than 25 feet (7.6 m) from the truck and it is in his view.

q. A powered industrial truck is unattended when the operator is more than 25 feet (7.6 m) from the truck or the truck is not in the operator's view.

r. Before leaving the operator's position or dismounting from the truck, while still attending the truck, the operator shall:

(1) Bring the truck to a complete stop.

(2) Place the directional controls in neutral.

(3) Apply the parking brake.

(4) Fully lower the load engaging means.

In addition, when leaving the truck unattended:

(5) Stop the engine or turn off the controls.

(6) If the truck must be left on an incline, block the wheels.

s. The operator shall maintain a safe distance from the edge of ramps, platforms and other similar working surfaces.

t. When powered industrial trucks are driven on and off highway trucks or trailers, the brakes on the highway trucks or trailers shall be applied and wheels chocked or other positive mechanical means shall be used to prevent unintentional truck or trailer movement. Fixed jacks should be placed under trailers not coupled to a tractor.

u. Provision shall be made to prevent railroad cars from being moved during loading and unloading. Wheel stops, hand brakes, or other recognized positive means shall be used to prevent movement of the railroad cars.

v. Operators shall verify sufficient headroom under overhead installations, lights, wiring, pipes, sprinkler systems, or other.

w. An overhead guard shall be used to protect against falling objects.

x. A load backrest shall be used whenever necessary to minimize the possibility of the load or part of it from falling rearward.

y. Only approved industrial trucks shall be used in areas classified as hazardous locations.

z. All accidents involving personnel, building structures, and equipment shall be reported to the supervisor.

aa. Industrial trucks shall not be parked where they block access to fire aisles, stairways, or fire equipment.

ab. Motorized hand trucks shall not be ridden unless they are of the hand/rider design.

ac. Whenever a truck is used to lift personnel and there are no controls that are elevatable with the lifting carriage or forks:

(1) Use a securely attached platform.

(2) Make sure the lifting mechanism is operating smoothly and properly.

(3) Place the mast in a vertical position and never tilt forward or rearward when elevated.

(4) Place the truck controls in neutral and set the brake.

(5) Lift and lower smoothly and with caution.

(6) Watch for overhead obstructions.

(7) Keep hands and feet clear of controls other than those in use.

(8) Move the truck only for minor adjustments in positioning when personnel are on the platform and never more than creep speed.

(9) The operator is to remain in the control position on the truck.

(10) Restraining means such as rails or chains shall be in place and personnel on the platform shall wear a body harness and lanyard or retractable safety device.

(11) Personnel on the platform shall be certified in Fall Protection.

ad. While refueling, the engine shall be stopped and the operator shall not be on the truck.

ae. Spillage of oil or fuel shall be carefully and completely absorbed or evaporated and fuel tank cap replaced before restarting engine.

af. Open flames shall not be used to check electrolyte levels in storage batteries, liquid level in fuel tanks, or the condition of LPG fuel lines and connectors.

12.7.2 Traveling of Powered Industrial Trucks.

a. Truck operators shall observe all traffic regulations including posted speed limits.

b. Truck operators shall yield the right of way to pedestrians and emergency vehicles such as ambulances and fire trucks.

c. Truck operators shall not pass another truck traveling in the same direction at intersections, blind spots, or other dangerous locations.

d. Operators shall slow down and sound the horn, or audible warning device, at cross aisles and other locations where their view is obstructed.

e. Railroad tracks will be crossed at an angle and trucks will not be parked closer than 6 feet to the nearest rail of a railroad track.

f. Truck operators shall keep a clear view of the path of travel and observe for other traffic, personnel, and safe clearances.

g. If the load being carried obstructs forward travel, the operator will travel with the load trailing.

h. Truck operators shall ascend and descend grades slowly, with caution and by the following operations:

(1) Loaded rider trucks shall be driven with the load upgrade when ascending or descending grades in excess of 5%.

(2) Unloaded trucks should be operated on all grades with the load engaging means downgrade.

(3) On all grades the loads and load engaging means shall be tilted back and raised only as far as necessary to clear the road surface.

(4) Travel straight up and down and avoid turning on grades.

i. Trucks shall be operated at a speed that will permit it to be brought to a stop in a safe manner.

j. The truck shall be operated with the load engaging means or load low and where possible, tilted back. The load should not be elevated except during stacking.

k. Starts, stops, turns, or direction reversals shall be in a smooth manner so as not to shift the load or overturn the truck.

l. Horseplay and stunt driving will not be allowed.

m. Operators will slow down for wet and slippery surfaces.

n. Before driving over a dockboard or bridge plate, operators shall be sure it is properly secure and its rated capacity is not exceeded and shall drive across carefully and slowly.

o. Operators shall avoid running over loose objects on the roadway surface.

p. Operators shall reduce speed to a safe level when negotiating turns and shall reduce speed to be consistent with the environment.

q. Seat belts, when provided, shall be used.

r. The operator should stay with the truck if tipover occurs or if the truck falls off a loading dock or ramp. The operator should hold on firmly and lean away from the point of impact.

12.7.3 Loading Powered Industrial Trucks.

a. Handle only stable and safely arranged loads.

b. Handle only loads within the capacity of the truck.

c. Handle loads only with the load engaging means and do not transport loads or miscellaneous items within the operator's compartment or other areas of the truck.

d. When attachments are used, extra care shall be taken in securing, manipulating, positioning, and transporting the load.

e. Trucks equipped with attachments shall be operated as partially loaded trucks when not handling a load.

f. Loads shall be completely engaged with the load engaging means. Forks should be at least 2/3 of the load length.

g. Where tilt is provided, carefully tilt the load backward to stabilize. Caution should be used in tilting with high or segmented loads.

h. Do not tilt forward with load engaging means elevated except to pick up or deposit a load over a rack or stack.

i. When stacking or tiering, use only enough back tilt to stabilize the load.

13. JACKS

13.1 General. This section establishes minimum standards for the design, testing, inspection, maintenance, personnel certification, and operation of jacks used to lift or support flight hardware or where failure/loss of control could result in loss of or damage to flight hardware.

13.2 Safety and Design Aspects. High quality off-the-shelf OEM type equipment is acceptable if it is designed, maintained, and operated according to this standard.

13.2.1 Design criteria/general design requirements for jacks are contained in ASME B30.1. It is the responsibility of the applicable engineering, operations/maintenance, and safety organizations to ensure the design, testing, maintenance, inspection, and operation of this equipment complies with this standard, the manufacturers' recommendations, and ASME B30.1.

a. Control parts shall be designed to provide a means of operation and adjustment, which will minimize exposure of the operator to injury.

b. Jack construction shall incorporate a positive stop or method to prevent over travel. The over travel prevention (or stop) shall not alter the operating characteristics of the jack.

13.2.2 Labeling/Tagging of Jacks.

a. The rated load/applicable capacity ratings shall be clearly and permanently marked on the jack.

b. Mechanical jacks with two ratings (sustaining and lifting) shall be so marked.

c. Hydraulic pressure or lever arm length and force shall be legibly marked on the jack.

d. Marking shall indicate the recommended hydraulic fluid to be used.

e. Double acting hydraulic jacks shall be marked to indicate the need for a relief valve.

f. A standard system of labeling shall be established and used throughout the installation.

g. A standard lockout/tagout system shall be established and used throughout the installation to indicate equipment that is not to be used due to inspection discrepancies, ongoing maintenance, or other reasons.

h. Certification/recertification are required as described in paragraph 13.3.4.

13.2.3 Safety Analysis and Documentation of Jacks. A recognized safety hazard analysis such as fault tree analysis, FMEA, O&SHA shall be performed on all jacks used for lifts where failure/loss of control could result in loss of or damage to flight hardware. The analysis shall, as a minimum, determine potential sources of danger, identify failure modes, and recommend resolutions and a system of risk acceptance for those conditions found in the hardware-facility-environment-human relationship that could cause loss of life, personal injury, and loss of or damage to the jack, facility, or load. The analysis shall be done as part of the initial activation process, included in the equipment documentation, and updated as required to reflect any changes in operation and/or configuration.

13.3 Testing. Testing of jacks shall be performed according to this section, the manufacturers' recommendations, and ASME B30.1. Three types of tests are required for jacks: proof load tests, periodic 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 in the jack load path. Repairs or alterations to nonlifting or nonholding components do not require a load test, although a functional check should be performed to determine if the repairs or alterations are acceptable. The periodic load and operational tests shall be performed annually. The acceptable tolerance for load test accuracy is +5/-0 percent unless otherwise specified. All load and operational tests shall be performed by qualified personnel according to written (specific or general) technical operating procedures. An inspection of the jack and its components shall be performed after each load test and prior to the jack being released for service to ensure there is no damage. The periodic load test requirement may be fulfilled by a concurrently performed proof load test.

13.3.1 Proof Load Test. Before first use, all new, extensively repaired, or altered jacks shall undergo a proof load test at 120% of the rated load and operated to its full length of travel in accordance with the manufacturers' instructions and ASME B30.1. A proof load test may also be performed when there is a question in design, previous testing or to ensure system integrity. The load shall be lifted slowly in an area where minimal damage will occur if the jack fails. For new jacks, manufacturer documentation of performed proof load tests will be acceptable as meeting this requirement.

13.3.2 Periodic Load Test. For jacks used where failure/loss of control could result in loss of or damage to flight hardware, a periodic load and operational test shall be performed at least once every year with a load equal to the rated load.

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

a. Hydraulic jacks shall be operated to full length of travel. Hold the load for a minimum of 5 minutes and verify drift does not exceed that specified by the responsible engineering organization.

b. Mechanical jacks shall be operated to full length of travel. Hold the load for a minimum of 5 minutes and verify no drift.

c. The operational test for a modified jack can be tailored to test only those portions of the equipment that were modified/repaired, only if the rated and operational test interval has not expired.

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

13.4 Inspection.

13.4.1 Safety inspections shall be performed on all jacks. Inspections shall be performed according to this section, the manufacturers' recommendations, and ASME B30.1. Inadequacies discovered during an inspection shall be documented and, if determined to be a hazard, tagged out and corrected prior to further use. Inspections shall be performed by qualified personnel according to approved technical operating procedures.

13.4.2 All new, extensively repaired, or modified jacks shall be inspected to the requirements of both daily and periodic inspections prior to first use. For component repair on jacks, 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 13.4.5).

13.4.3 Jacks in regular service (used at least once a month) shall be inspected as required in paragraphs 13.4.4 and 13.4.5. Idle and standby jacks shall be inspected according to paragraph 13.4.6.

13.4.4 Daily Inspections. These inspections shall be performed each day the jack is used. Inspect for (without disassembly):

a. Operating lever and load-bearing surfaces free of slippery material or fluids.

b. Improper engagement or extreme wear of pawl and rack.

c. Chipped, cracked, or worn rack teeth.

d. Defects such as cracked welds, damaged housing.

e. Damaged, bent, or worn threads.

f. Hydraulic systems for observable deterioration or leakage and check hydraulic system for proper oil level if suspect.

g. Scored or damaged plunger.

h. Improper function operation.

i. Free movement of swivel, heads, and caps.

j. Loose bolts or rivets.

k Damaged or improperly assembled accessory equipment.

l. Rack wear or bending.

m. Other items specified in manufacturers' recommendations.

If external conditions indicate possible internal difficulty, notify the supervisor. Repairs and adjustments shall be made before operations begin

13.4.5 Periodic Inspections. Periodic inspections are the same as paragraph 13.4.4. Periodic inspections shall be performed at least once per year or more frequently if required by the manufacturer or ASME B30.1. Periodic inspections consist of visual inspection by an appointed person and require dated documented records. If external conditions indicate possible internal difficulty, notify the supervisor. Repairs and adjustments shall be made before operations begin.

13.4.6 Idle and Standby Jacks. Idle and standby jacks shall be inspected prior to first use according to the requirements of paragraphs 13.4.4 and 13.4.5 unless these daily and periodic inspections were performed at required intervals and recorded during the idle/standby period.

13.5 Maintenance. A maintenance program based on manufacturers' recommendations, integrating proactive, reactive, preventive, and predictive maintenance shall be established to increase the probability the jack will function in the required manner over its design life cycle with a minimum of maintenance. 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. Any jack found in an unsafe operating condition shall be removed from service, tagged out, and not used until repaired. All repairs shall be made by qualified personnel in accordance with the manufacturers' instructions.

13.5.1 Only hydraulic jack fluid which is compatible with the jack manufacturer's specifications shall be used.

13.5.2 Clean and lubricate moving parts requiring lubrication, exposed screw threads, and check for proper delivery of lubricant per manufacturer recommendations.

13.5.3 Jacks exposed to rain, sand, or grit-laden air should be cleaned prior to use.

13.5.4 Jacks should be stored where protected from the elements, abrasive dust, and damage and should be stored in the vertical position.

13.5.5 Replacement parts should be purchased from the original manufacturer or verified as meeting the original manufacturer requirements. A qualified person shall verify replacement parts meet manufacturer requirements and instructions.

13.5.6 Hydraulic jacks exposed to freezing temperatures shall be supplied with an adequate anti-freeze liquid.

13.6 Personnel Certification. Only qualified and designated personnel shall be authorized to perform inspection and/or maintenance operations on jacks. Operators shall be instructed in the proper use of jacks.

13.7 Operations. Jacks shall be operated according to this section, the manufacturers' recommendations, and ASME B30.1. The following practices shall be followed for jack operations:

a. Before the jack is used each day (shift), the operator shall have read and understood the manufacturer's operating instructions and safety rules, and have read and understood all decals and warnings on the equipment.

b. Before the jack is used each day (shift), the operator shall perform a pre-operational check to demonstrate operational readiness, including all limit switches. If controls do not operate properly, the operator is responsible for notifying the supervisor. Repairs and adjustments shall be made before operations begin.

c. Before operating the jack, the operator shall survey the area for applicable hazards such as obstructions, debris, bumps, drop-offs and holes, obstructed path of travel, unstable footing, and other possible hazardous conditions. The operator shall establish appropriate safety zones, if required, before initiating operations.

d. The equipment shall not be loaded beyond its rated load (capacity) except for required testing.

e. The operator shall ensure the equipment is within inspection and testing intervals by examination of the periodic load test tags and/or documentation. The operator shall adhere to all tags on the controls.

f. Verify that there is sufficient swing area for the operating lever.

g. The jack shall be firmly supported at the base under load.

h. The operating lever is the recommended lever and that it is properly seated in its socket.

i. Operators shall not straddle the operating lever of a mechanical jack.

j. Operating levers shall be removed when not in use to avoid accidental dislodging of the jack and reduce the tripping hazard.

k. Measures shall be taken to prevent personnel from working or passing under the load until the load is secured by cribbing, blocking, or other means.

l. Precautions shall be taken to ensure all personnel are clear of the load before lowering.

m. Personnel shall be instructed in the signals and procedures for multiple jack use or special jack lift operations.

n. Off-center loading of jacks shall be avoided.

o. Extenders shall not be used unless authorized by a qualified person.

p. If there is a possibility of slippage of the cap, a block shall be placed in between the cap and the load.

APPENDIX A

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
ALTERNATE STANDARD FOR SUSPENDED LOAD OPERATIONS

U.S. Department of Labor

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

MAR 28 2002

Mr. James D. Lloyd
Director, Safety and Risk Management Division
Office of Safety and Mission Assurance
National Aeronautics and Space Administration
Headquarters Code QS
Washington, D.C. 20546-0001

Dear Mr. Lloyd:

Thank you for your December 20, 2001 letter to the Occupational Safety and Health Administration (OSHA). We apologize for the delay in our response. Due to the October 2001 closing of the Brentwood postal facility in Washington, D.C. and the subsequent sanitizing treatment of the mail, your correspondence was not received until February 4, 2002. A letter dated February 25, 2002 amended your December 20 letter.

You requested that OSHA review and revalidate the revised version of the National Aeronautics and Space Administration's (NASA's) Alternate Standard for Suspended Load Operations. OSHA originally approved this alternate standard on July 15, 1991, in accordance with the requirements of 29 CFR 1960.17. (See enclosed letter.) The approval was based on OSHA's 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.

OSHA Alternate Standard on Suspended Loads Revalidation Letter

The alternate standard is currently a part of NASA's Safety Standard for Lifting Devices and Equipment (NSS/GO-1740.9B). NASA is in the approval process for updating and issuing the safety standard in a new format as the Standard for Lifting Devices and Equipment (NASA-STD-8719.9). NASA intends to include a revised version of the alternate standard on suspended loads as part of NASA-STD-8719.9. The minor revisions NASA proposes to the existing alternate standard are:

- Renumbering of the alternate standard paragraphs to be consistent with the numbering conventions of NASA Technical Standards.

- Changing the references from NSS/GO-1740.9B to NASA-STD-8719.9 to reflect the release of the new NASA Technical Standard.

The revisions you propose to the existing alternate standard were reviewed. It has been determined that they will not affect the existing alternate standard as they are administrative in nature.

Thank you for your interest in occupational safety and health. If you have any questions, please do not hesitate to contact Thomas K. Marple, Director, Office of Federal Agency Programs, at (202) 693-2122.

Sincerely,

John L. Henshaw

Enclosure

OSHA Alternate Standard on Suspended Loads Revalidation Letter

U.S. Department of Labor

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

OCT 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

20SHA
1971 1991

OSHA Alternate Standard on Suspended Loads Validation Letter

A.1 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.

A.2 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 cannot 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.

A.3 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:

A.3.1 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.

A.3.2 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.)

A.3.3 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.)

A.4 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:

A.4.1 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.

A.4.2 Each operation will be reviewed on a case-by-case basis.

A.4.3 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.

A.4.4 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 A.4.1. The procedures will be available on site for inspection during the operation.

A.4.5 During a suspended load operation, if a new procedure not covered by the original analysis is deemed necessary due to unusual or unforeseen circumstances, the NASA 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 A.4.1 are required.

A.4.6 The crane/hoist shall be designed, tested, inspected, maintained, and operated in accordance with the NASA Standard for Lifting Devices and Equipment (NASA-STD-8719.9). 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.

A.4.7 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 A.4.1 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.

A.4.8 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 NASA-STD-8719.9). 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).

A.4.9 A trained and licensed operator (certified per NASA-STD-8719.9) shall remain at the crane/hoist controls while personnel are under the load.

A.4.10 Safety controlled areas shall be established with appropriate barriers (rope, cones, etc.). All nonessential personnel shall be required to remain behind the barriers.

A.4.11 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.

A.4.12 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.

A.4.13 Personnel working beneath the load shall remain in continuous sight of the operator(s) and/or the signal person(s).

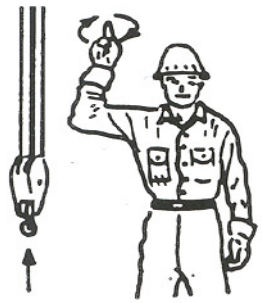
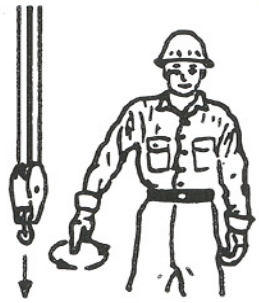
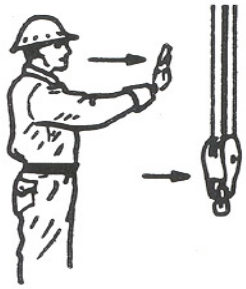
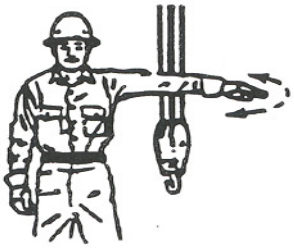
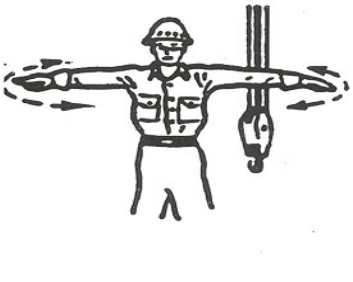
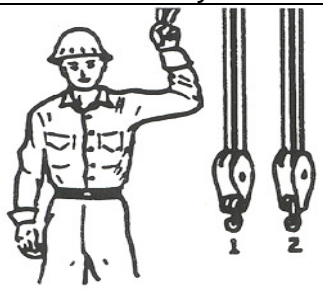
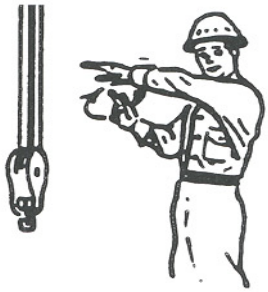
A.4.14 NASA shall conduct periodic reviews to ensure the continued safety of the procedures. As a minimum, NASA will annually evaluate the implementation of this procedure at each Center with operations on the suspended load list.

A.4.15 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.

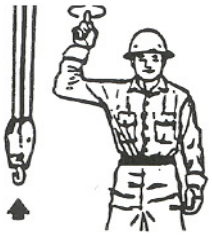
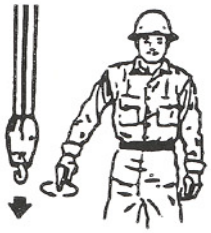
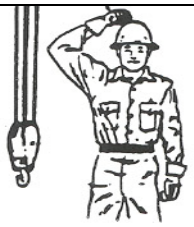
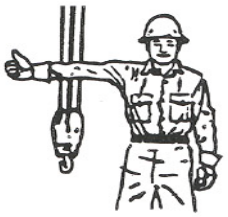
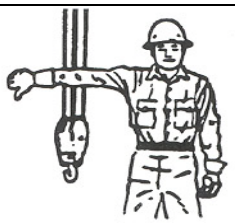
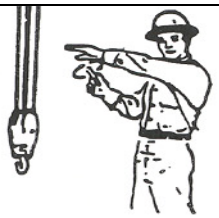
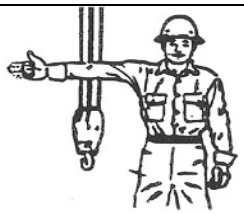
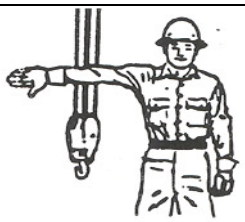
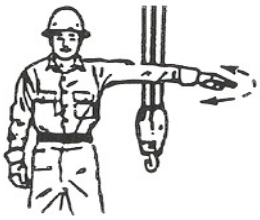
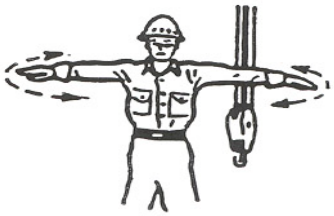
APPENDIX B

HAND SIGNALS

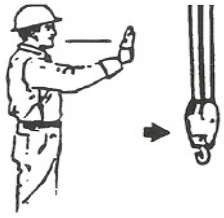
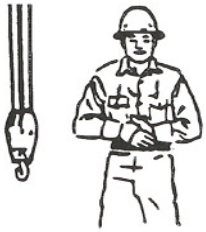
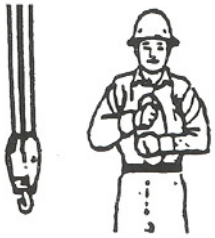
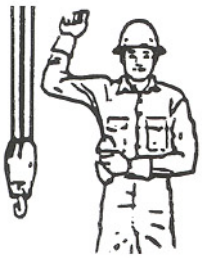
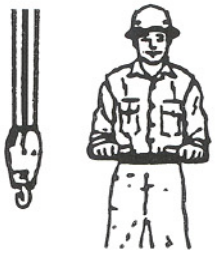
Overhead Cranes

		
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 circle.	**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.)	

Mobile 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 circle.	**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 and forth horizontally.	**EMERGENCY STOP.** Both arms extended, palms down, move arms back and forth horizontally.

Mobile Cranes (Continued)

		
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.	**RETRACT 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.	**RETRACT BOOM.** (Telescoping Booms) One Hand Signal. One fist in front of chest, thumb pointing outward and heel of fist tapping chest.

APPENDIX C

LIFTING PERSONNEL WITH A CRANE

U.S. Department of Labor

Occupational Safety and Health Administration
Washington, D.C. 20210

Reply to the Attention of:

MAY 4 1995

Mr. James D. Lloyd
Director, Safety and Risk Management
Division
Office of Safety and Mission Assurance
National Aeronautics and Space
Administration
Washington, D.C. 20546-0001

Dear Mr. Lloyd:

Thank you for your letter of January 27 regarding lifting personnel with a crane. Please forgive the delay in response.

OSHA does not encourage lifting personnel with cranes; however, if it is the only way, then the requirements in 29 CFR 1926.550 must be followed, no other standards have been promulgated.

Should you have further questions on this or any other issue, please feel free to contact me or my staff at any time.

Thank you for your continued interest in occupational safety and health in the Federal workplace.

Sincerely,

John E. Plummer
Director
Office of Federal Agency Programs

Department of Labor (Occupational Safety and Health Administration) letter concerning Lifting Personnel with Cranes

JAN 27 1995

QS

Mr. John E. Plummer
United States Department of Labor
Occupational Safety and Health
Administration (OSHA)
Federal Agency Programs Office
200 Constitution Avenue, NW
Washington, D.C. 20210

Dear Mr. Plummer:

On occasion NASA has a need to lift personnel with a crane when conventional means of reaching the work site would not be possible. This issue has been the topic of a number of recent discussions between members of my staff and yours. It is understood that the requirements in 29 CFR 1910 do not provide for lifting personnel with a crane. However, there is a recognized safety standard for such operations (used primarily by the construction industry) provided in 29 CFR 1926.550. I am requesting OSHA concurrence to NASA policy for lifting personnel with a crane that would enforce strict adherence to all applicable 29 CFR 1926.550 requirements.

NASA maintains a comprehensive and highly successful crane safety program. NASA requirements for lifting device design, testing, inspection, maintenance, operation, and operator certification meet, and in many cases exceed, OSHA requirements. Our planned approach is to update NASA safety program requirements to include appropriate references to 29 CFR 1926.550 for any operation that would involve lifting personnel with a crane. My office will ensure proper agency-wide implementation through our oversight function.

Any questions should be addressed to Mr. Jonathan B. Mullin of my office at 202-358-0589.

2

Please extend my thanks to your Office of Federal Agency Programs staff for their continued support and willingness to work with us on issues which are critical to the safe accomplishment of NASA's mission.

Sincerely,

ORIGINAL SIGNED BY

James D. Lloyd
Director, Safety and Risk Management Division
Office of Safety and Mission Assurance

bcc:
QS/Chron File

QS/JMullin:ecw:1/12/95x1513:oshalift

NASA Request for OSHA Clarification Concerning Lifting Personnel with Cranes

APPENDIX D

CRANE/HOIST REQUIREMENTS TO LOAD TEST OTHER LIFTING EQUIPMENT

Overhead cranes and hoists should not exceed 50% of their rated capacity and mobile cranes/derricks should not exceed 75% of their rated capacity when used to load test other lifting equipment, unless specifically designed for and dedicated for such use. The following requirements shall be followed when a crane/hoist is used to load test other lifting equipment:

a. Crane/hoist hook and load line(s) shall only be loaded vertically.

b. A certification of the initial proof load test or the current periodic load test shall be supplied with the lifting equipment prior to performing the load test.

c. Items to be tested by an overhead crane shall be freely suspended from the crane hook with the height of the test not to exceed 6 inches above the floor/working surface.

d. Items to be tested by a mobile crane shall be suspended from the crane hook and the height of the test shall not exceed 6 inches, or the lowest reasonable height based on dimension and test article configuration.

e. No overhead crane shall be used to load test items attached to an immovable object.

f. When a mobile crane is used to load test items attached to an immovable object, the boom angle shall be minimized as much as safely possible to prevent the boom from contacting the boom stops when load testing.

g. For lattice boom mobile cranes, the boom shall be adequately restrained to prevent damage to the crane due to sudden unloading should the test article fail.

h. A load-sensing device shall be installed in the lifting assembly.