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KSC Safety Practices Procedural Requirements

Excerpts for Use by ISS/Cargo/Payload Items Processing Through KSC

This excerpt consists of the following Chapter:

Chapter 20, "NASA KSC Payload & Cargo Ground Safety Requirements" (Pages 2 – 44)

Plus these Chapters/Sections referred to in Chapter 20:

Section 5.3, "Tools" (Page 45)

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CHAPTER 20: NASA KSC PAYLOAD & CARGO GROUND SAFETY REQUIREMENTS

a. As the Space Shuttle Program (SSP) nears completion, it has become necessary to separate Shuttle/ISS-Specific Requirements from the main body of this KNPR so that this document may be used in the planning of future documents. To bridge the gap between Shuttle/ISS and future programs while still providing KSC Safety Practices Procedural Requirements required through the completion of these programs, Kennedy Handbook (KHB) 1700.7, Space Shuttle Payload Ground Safety Handbook, has been included as this chapter of KNPR 8715.3.

b. The requirements presented in this chapter shall ONLY be applicable to the following groups:

(1) All organizations processing SSP/International Space Station Program (ISSP) payloads or experiments in those areas under the jurisdiction of the Kennedy Space Center. This includes all government organizations (e.g., NASA, DOD, other domestic, or foreign government or alliance organizations) and independent foreign or domestic enterprises.

(2) Contractors in direct support of the above organizations.

(3) Other organizations or agencies providing direct personnel and equipment interface to payload or payload GSE support.

(4) Any of the above organizations required to support SSP/ISSP payload post-landing operations at any landing site.

c. If disagreement exists between the requirements of this chapter and those present in the other chapters of this KNPR, the requirements in this chapter shall supersede those requirements ONLY as applicable to the aforementioned groups.

d. The purpose of this chapter is to present the SSP/ISSP payload ground safety procedures and the criteria applicable to payload/GSE design and to ground processing from arrival to liftoff and during post landing activities to qualify SSP/ISSP payloads and associated GSE for safety certification by the payload organization to the Launch Site Safety Office (LSSO).

e. NASA policy is to achieve a consistent level of safety by applying reasonable criteria, giving the SSP payload or the International Space Station Program (ISSP) and ground support equipment (GSE) designer, operator, processor, and user the requirements to develop effective, efficient ground processing procedures usable at all SSP/ISSP and cargo processing locations. The requirements to assure payload mission success are the responsibility of the payload organization and are not within the scope of this document.

f. This chapter establishes the minimum NASA ground processing safety procedures, criteria, and requirements for SSP/ISSP payloads and associated payload organization provided GSE. It provides the detailed safety requirements for ground operations and payload/GSE design not contained in NSTS 1700.7B "Safety Policy and Requirements for Payloads Using the Space Transportation System," the NSTS 1700.7B ISS Addendum, “Safety Policy and Requirements for Payloads Using the Space Station,” and SSP 50021, “Flight Safety Requirements.”

g. This document does not apply to facility GSE, non-SSP/ISSP program elements, or flight safety. Additionally, this chapter does not apply to equipment under the jurisdiction of SSP 50004, “Ground Support Design Requirements” and the ISSP Support Equipment Control Board

nor to equipment under the control of the KSC Checkout, Assembly and Payload Processing Services (CAPPS) Contractor. Specific implementation of design requirements is sometimes omitted to allow the payload organization flexibility in developing payload/GSE design. The payload organization's implementation of design requirements shall be coordinated with the LSSO.

20.1 RESPONSIBILITIES

The KSC Director has been assigned overall authority for safety for all SSP/ISSP payload activities conducted at KSC.

a. The Director of Safety and Mission Assurance is responsible for implementing the safety policy and criteria for SSP/ISSP payload activities.

b. Delegation

(1) The LSSO is the designated office responsible to the Director of S&MA for implementation of these requirements.

(2) The Launch Site Safety Representative (LSSR) is the designated representative of the LSSO and has been delegated the following authorities:

(a) Monitors LSSO-selected operations and has safety approval authority for procedural deviations.

(b) Gives concurrence to start these selected operations.

(c) May halt any operation deemed unsafe.

20.2 PHASE SAFETY REVIEWS

a. The payload organization personnel are responsible for the safety of their own systems and personnel. They are also responsible to the SSP/ISSP operator and the launch site operator not to compromise the safety of the other SSP/ISSP payloads, the Orbiter, launch site facilities, and personnel.

NOTE 1: To implement this safety effort, the NASA programs conduct phase safety reviews as implemented by NSTS 13830C, “Payload Safety Review and Data Submittal Requirements,” and SSP 30599, “Safety Review Process.” These procedures provide for an early safety interface to be established between the payload organization and the launch site.

NOTE 2: The phase safety reviews are conducted by a team of representatives from many different backgrounds to provide a broad spectrum of knowledge on the subject of safety. It is their task to advise payload organizations on matters of system safety. Included in this team are representatives of the processing sites. It is their task, in addition to the above, to verify that the payload and its support equipment comply with the requirements of this document.

NOTE 3: NASA normally conducts flight safety reviews for the payload at JSC and a separate ground safety review on ground operations and GSE design at KSC. They may, however, be held concurrently at either site or at a site jointly agreed on by JSC and KSC. These reviews provide for the delivery of safety documentation required by the launch site prior to delivery of

the payload to that site. This documentation is further discussed in section 20.3 of this document. In the past, some payload organizations have not fully understood the extent of these data requirements, and this has created problems. The procedures explained and outlined in this text preclude these problems and bring about a smooth transition from the factory to the launch site, through the launch and, if applicable, through recovery.

b. The documentation requirements of this document and the phase safety reviews shall be based upon the hazardous nature and degree of complexity of the payload systems.

c. When flight payload safety reviews and ground payload reviews are separate reviews, an assessment shall be made by the payload organization to assure hazards identified in each package are assessed for applicability to the other

EXAMPLE: If a ground safety hazard report on inadvertent thruster firing does not exist, the flight safety hazard report must be referenced in the ground safety package and it must contain a discussion of the applicability of the flight safety controls on ground safety.

20.3 DOCUMENTATION

20.3.1 Phase Safety Review Documentation

a. The payload organization shall demonstrate to the LSSO that hazards not eliminated by design exist for valid technical reasons and are not for operational convenience or cost savings.

NOTE: These hazards can cause operational restrictions that could limit personnel numbers, require a specific sequence of operations, or limit operations to specific facilities.

b. The LSSO shall communicate to the payload organization the rationale for any restrictions imposed as early as possible and shall assist the payload organization in determining the course of action which can best serve operational efficiency.

c. The payload organization shall, in accordance with NSTS 13830C or SSP 30599, provide the Ground Safety Review Panel (GSRP) the following data consistent with the program phase:

(1) Block diagrams, schematics, and descriptions of safety-critical subsystems, which includes tables of design and operating parameters for such items as lifting equipment, pressure systems, propellants, tanks, ordnance, and batteries.

(2) Launch site processing plan including timelines for handling, storage, assembly, servicing, and checkout operations.

(3) List of Technical Operating Procedures (TOPs), a synopsis of each procedure, and their preliminary classifications (i.e., hazardous or nonhazardous).

(4) Documentation certifying compliance with ionizing and non-ionizing radiation control requirements.

NOTE: This includes such items as Radio Frequency (RF) personnel hazards and RF susceptibility of Electro-Explosive Devices (EEDs).

(5) Hazard reports addressing both design and operations.

(6) Failure/accident summary reports.

(7) Copies of all noncompliance reports.

(8) Ordnance storage and handling data requirements in accordance with paragraph 20.6.5.7.

(9) A list of all hazardous materials and physical agents. Material Safety Data Sheets (MSDS) as required by the Code of Federal Regulations (CFR 1910.1200) shall be provided to the Launch Site Support Engineer (LSSE) for all materials or agents brought to the ER by the payload organization.

(10) A list of all Plastic Films, Foams, and Adhesives (PFAs) quantity, and location of use.

(11) List of the payload T-0 Umbilical functions.

(12) Critical software commands shall be identified and managed. These critical software commands include commands which, if executed or executed out of sequence, would create a hazardous condition or would remove a safety inhibit.

(13) A Mechanical Damage Control Plan (MDCP) for any Graphite/Epoxy (Gr/Ep) Composite Overwrapped Pressure Vessels (COPVs).

20.3.2 Post Phase III Approval Changes

Changes or modifications which affect any approved phase safety review or launch site documentation shall be provided to the LSSO for review and re-approval.

20.3.3 Launch Site Documentation

20.3.3.1 Payload Organization Launch Site Safety Plan

a. The payload organization Launch Site Safety Plan shall demonstrate the means by which the organization manages and interfaces safety within its organization and how it applies the launch site safety requirements.

b. For NASA and NASA-sponsored payloads, the specifics of the plan contents shall be identified to the payload organization early in the phase safety review process.

c. All plans shall be tailored to the complexity of the payload element and be provided to the LSSO for review and approval at least 30 days prior to first hardware delivery to the launch site.

20.3.3.2 Payload Safety Noncompliance Reports

a. The payload organization shall comply with all the requirements of this chapter or obtain an approved waiver/deviation for each case of inability to comply with a specific safety requirement.

b. Waiver/Deviation requests shall be submitted to the GSRP for evaluation.

c. Payload organizations shall be formally notified of the disposition of the waiver/deviation request.

(1) Each waiver request shall be limited to a specific subsystem or component in a specific application.

(2) The payload organization is responsible for correcting the waived condition prior to the reflight of the payload on another Space Shuttle mission or the flight of subsequent payloads of the same series. If the waived condition is not corrected, a new waiver request is required. The new request shall contain additional rationale, justifying continued noncompliance, and a copy of the original waiver shall be attached.

(3) Waiver requests shall be submitted as soon as the need is identified. Prior to submittal, all waiver requests shall be coordinated with the appropriate governmental sponsor and submitted to the LSSO. The waiver request shall contain the following:

(a) Payload name and the model of the payload or support equipment as applicable.

(b) Specific component and the subsystem in which the component functions shall be identified.

(c) Specific requirement (one per waiver) and document and paragraph number against which the waiver is being sought.

(d) Hazard created by noncompliance to this requirement and a cross-reference to the related hazard report. (The related hazard report shall reference the waiver.)

(e) Reason for noncompliance to this requirement.

(f) Rationale for acceptance of this waiver, including any required support data and drawings, and list possible methods and techniques used in mitigating the hazards.

(g) Waiver request shall be signed by the program manager of the payload organization.

(4) When a deviation is granted, the noncompliance condition may be approved for more than one mission. Deviations shall be applicable where the associated hazard to the Space Shuttle is not affected by manifesting with other SSP/ISSP payloads, location of the payload in the Orbiter, or mission-unique environmental conditions.

NOTE: Noncompliance reports to be considered for a deviation will be those where the design, procedure, configuration, etc., do not comply with the safety requirement in the exact manner specified, but the intent of the requirement has been satisfied and a comparable or higher degree of safety is achieved.

20.3.3.3 Technical Operating Procedures (TOPs)

a. In order to be accomplished in a safe and orderly manner, payload ground operations shall be conducted using detailed step-by-step instructions in TOPs, which are established in Chapter 9 of this KNPR.

NOTE: The Safety Community applies the generic term, Technical Operating Procedures (TOPs), to all test or operations procedures. The term "TOPs" only implies that the procedure must meet minimum content and processing standards. In practice, procedures will carry the nomenclature of the system under which they are developed such as Operations and

Maintenance Instructions (OMIs) of the Operations and Maintenance Documentation (OMD) system, test procedures (TPs) of the Universal Documentation System (UDS)/Air Force Satellite Control Facility (AFSCF) Support Documentation Guide or Detailed Operations Procedures (DOP) for Inertial Upper Stage (IUS) procedures. The host organization prescribes the system to be used.

b. All TOPs designated hazardous by the LSSO or by the payload organization are required to be approved by the LSSO and published 10 calendar days prior to use (7 days prior to use for revisions).

NOTE: Draft or preliminary procedures should be submitted to the LSSO when available.

c. Where procedures are used to control hazards identified in the hazard reports, a listing of those procedures and the applicable step numbers which control the hazard shall be identified in the Phase III data package.

NOTE: Hazardous classification of procedures is provided in paragraph 20.4.3.

20.4 OPERATIONAL CONSIDERATIONS

20.4.1 Failure Tolerance

a. The interaction of payload, GSE, launch site facilities and operator monitoring/intervention shall tolerate a minimum number of credible failures and/or operator errors as determined by the hazard level analyses.

b. When the technical requirements do not provide for failure tolerance, the adequacy of the controls shall be determined during the safety review process.

NOTE: This applies when failure to perform a function or the inadvertent performance of a function results in a hazardous event. The requirements contained in this section are intended to provide the proper failure tolerance for GSE when used alone or in conjunction with a payload and/or facility. Verification of compliance with the technical requirements of this document will normally demonstrate the intent of this paragraph.

20.4.2 Personnel Policies

a. Payload organizations shall provide a description of their Training/Certification Program to the LSSO as part of the payload organization Launch Site Safety Plan.

b. This program shall specify the personnel training required and the certification procedures employed to establish acceptable skill levels for all personnel involved in the ground processing of SSP/ISSP payloads and GSE.

c. Ground processing shall be performed only by persons certified in the discipline required for that process.

20.4.2.1 Training

a. Safety and health inputs to training programs shall be tailored to the task categories involved and included in lesson plans and examinations.

b. Safety training of operating personnel shall be the responsibility of the payload organization.

c. The payload organization shall meet the applicable facility and operating site requirements.

NOTE: It should be noted that there are certain launch site safety training requirements which are necessary in the process of obtaining area badging permits.

d. Safety training shall include the following:

(1) Hazard types, recognition, causes, and effects.

(2) Prevention and control measures.

(3) Safe operating procedures.

(4) Checklists.

(5) Safeguards and safety devices.

(6) Personal protective equipment (PPE).

(7) Monitoring and warning devices.

(8) Emergency and contingency procedures.

20.4.2.2 Certification

The payload organization shall provide a list, to the LSSO prior to commencement of hazardous operations, of all personnel authorized to participate in hazardous operations; certifying each individual's training and qualification by system to perform a specific hazardous operation.

20.4.2.3 Physical Examination

a. Personnel performing selected hazardous operations shall have up-to-date physical examinations which meet the requirements of the cognizant medical office.

NOTE: Examples of personnel who require these examinations include ordnance workers, crane operators, propellant handlers, Propellant Handlers Ensemble (PHE) operators, and personnel working with certain types of ionizing and non-ionizing radiation.

b. The individual examination records shall be furnished to cognizant medical office.

NOTE: The requirements necessary to satisfy this examination may be obtained from the cognizant medical office.

20.4.2.4 Safety Enforcement

a. The payload organization shall describe the means by which occupational and operational safety requirements of the launch site and this chapter are enforced in the Launch Site Safety Plan (LSSP) (see section 20.3.3.1).

b. The LSSP shall address how violations of safety requirements are handled within the organization and what measures will be taken to preclude further violations.

20.4.3 Hazardous Operations

a. A ground processing activity shall be classified as hazardous based on the following considerations:

(1) Energy is involved and loss of control could result in injury to personnel or damage to equipment.

(2) A significant change from ambient condition will occur; e.g., increase or decrease of oxygen content, pressure, or temperature.

(3) Presence of hazardous materials or physical agents which presents potential exposure to personnel.

b. The LSSR shall be notified of all hazardous or LSSO-designated procedures at least 24 hours prior to their performance.

c. Concurrent hazardous operations within the same hazard control area shall require the approval of the LSSR or LSSO.

20.4.4 Safety Inspection

a. LSSR and payload organizations shall perform joint systematic safety inspections of the facility, working environment, related GSE, and any work in progress which could cause accidental injury to personnel or damage to hardware.

b. Primary emphasis shall include payload/GSE, critical processing equipment, facility maintenance status and associated equipment locations, and facility ingress/egress provisions and routing.

c. Discrepancies identified from any of the inspections shall be corrected by the appropriate organization prior to conducting hazardous operations or bringing hazardous materials into the area.

d. These safety inspections shall be performed on payload processing facilities at the following minimum times:

(1) Prior to payload/GSE installation in the facility.

(2) Immediately after installation of payload/GSE.

(3) Immediately before the start of LSSO selected hazardous operations.

(4) After any facility or equipment modification which may affect hazard potential.

20.4.5 Safety Equipment

a. The payload organization shall ensure that personnel protection is provided when engineering controls alone are not adequate to provide sufficient employee protection.

b. Payload processing activities which are considered normal to general industry shall be in compliance with the requirements of accepted industrial safety practices.

c. The payload organization shall review, with the LSSO and health officials, those operations not specifically identified which might require PPE.

d. The LSSO and Health Officials shall approve all PPE.

20.4.6 Tools

Tools shall be handled per the requirements in section 5.3 of this KNPR.

20.4.7 Photography

a. The use of photographic lighting equipment (e.g., flashbulbs, strobe lights, and photofloods) shall be restricted within 100 feet of the Orbiter/payload whenever they are loaded with any propellant, within 100 feet of a propellant storage tank, and within 10 feet of exposed solid propellants.

b. Photo equipment used above a payload shall be tethered and the light sources shielded to prevent debris from falling onto the payload.

c. The payload organization shall obtain LSSO approval to use photographic equipment in these and other hazardous atmosphere locations.

20.5 PERSONNEL SAFETY

The payload organization shall ensure a safe and healthful working environment through good design, effective training, and appropriate PPE.

20.5.1 Human Factors

Potential hazards resulting from the human interface shall be addressed by the payload organization during the Phase Review Process.

20.5.2 Human Error

a. Controls shall be instituted to prevent a hazardous condition which may result from human error (e.g., mismating a connector, throwing the wrong switch, misreading a gauge, etc.).

b. Controls shall be instituted via design rather than procedural control where feasible.

c. All equipment controls shall be labeled.

20.5.3 Noise

a. The payload organization shall implement a hearing conservation program to provide hearing protection for any noise levels of 85 decibels A-scale (dBA) or greater, regardless of the length of exposure.

b. Where noise levels occur on intervals of 1 second or less, they shall be considered continuous.

c. If such controls fail to reduce sound levels to below 85 dBA, PPE shall be provided and used.

d. Exposure to impulsive or impact noise shall not exceed 140 decibels (dB).

20.5.4 Hazardous Materials

The payload organization shall assure through design/procedural controls that payload/ground processing GSE and operations will not expose personnel to hazardous materials in excess of the limits specified by the cognizant health officials.

20.5.5 Physical

a. Accidental contact with sharp surfaces or protrusions shall be prevented by the use of ductile materials, energy absorbing devices, shields, rounded corners, and flush-mounted features.

NOTE: Sharp surfaces or protrusions include edges, crevices, points, burrs, wire ends, screw heads, corners, brackets, rivets, braided cable, cable swages, cable strands, clamps, pins, latches, lap joints, bolt ends, lock nuts, etc., which if contacted, could injure operating personnel.

b. Hazards shall not be created by the inaccessibility of flight or ground hardware.

c. Physical access for safety critical operations or maintenance functions shall be provided.

d. Protrusions which create a hazard (e.g., hoses, wave guides, cables, brackets, etc.) which cannot be eliminated by design shall be made to be removable during service or maintenance functions.

e. Moving parts (e.g., fans, belt drives, turbine wheels, and similar components) that could cause personnel injury or equipment damage due to inadvertent contact or entrapment of floating objects shall be provided with guards or other protective devices.

f. Wherever possible, equipment requiring adjustment during its operation shall have external adjustment provisions and provide electrical shock protection when applicable.

g. GSE shall be designed to minimize the requirement for operations and maintenance personnel to wear protective clothing during normal operations and maintenance.

h. Valves, gauges, levers, bolts, nuts, and any other item required to be moved, turned, manipulated, or monitored by personnel in protective equipment shall be sized to facilitate operation.

i. Suitable provisions to prevent damaging the protective equipment and to prevent personnel fatigue and discomfort shall be included in the GSE design.

NOTE: Such items should be located to optimize access to the item while the operator is in a standing position. Sufficient clearance should be provided to preclude brushing against other surfaces.

j. All GSE designs shall include a center-of-gravity analysis to ensure that the GSE/flight hardware does not tip, fall, slide, or allow for any type of sudden load shift.

20.5.6 Temperature

a. The payload organization shall protect personnel from equipment which generates high or low temperatures greater than 45 degrees Centigrade (C) (113 degrees Fahrenheit) or less than 0 degrees C (32 degrees Fahrenheit).

b. This equipment shall be shielded, insulated, isolated, and/or oriented away from personnel and labeled to warn them of the danger.

20.6 PAYLOADS AND GROUND SUPPORT EQUIPMENT (GSE)

20.6.1 Biomedical Subsystems

The payload operator shall provide complete handling procedures for all hazardous biomedical subsystems.

NOTE: Hazardous biomedical subsystems consist of medical experiment equipment designed to obtain data on man's adaptation and performance in the space environment. They also consist of scientific equipment designed to obtain experimental data on the effects of space environments on microorganisms, plants, and animal life.

20.6.2 Electrical

All electrical equipment shall meet the requirements of this section to preclude hazardous conditions.

20.6.2.1 Electrical Requirements

a. Electrical connectors shall be designed to make it physically impossible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be created.

b. Connectors for energized circuits shall be of "scoop-proof" design so a partial inadvertent mismate will not provide temporary, undesirable pin-to-pin contact.

c. Electrical equipment shall not cause ignition of adjacent materials.

NOTE: The requirements for explosion/hazard proofing at the launch site are identified in paragraphs 20.7.2.3 and 20.7.2.4.

d. Malfunction of the payload or GSE circuitry shall not induce overload into the Orbiter, GSE, or facility electrical systems.

e. Electrical equipment shall be designed to provide personnel protection from accidental contact with alternating current (AC) voltages in excess of 30 volts root mean square (rms) or 50 volts direct current (DC) or any lower voltage that could cause injury.

f. Construction of the payload and electrical GSE shall assure all conductive external parts and surfaces are at ground potential at all times.

g. Cables extending across work areas shall be protected against damage from personnel activity or equipment use.

h. Switches/controls which can create hazardous conditions if inadvertently operated shall be guarded, shielded, or otherwise protected against inadvertent switching.

i. Electrical fuse and switch boxes shall be labeled on the outside or inside cover to show the voltage present, rated fuse capacity, and equipment that the circuit controls.

j. Non-bypassable interlocks shall be used to prevent possible shock whenever a voltage in excess of 500 volts is exposed upon opening an access door, cover, or plate.

k. All electrical GSE shall meet the requirements of the "National Electrical Code (NEC), National Fire Protection Association 70 (NFPA 70)."

l. Dead-end wires shall be completely insulated.

m. Three-phase power sequencing shall be verified in each KSC processing facility prior to connection.

n. Battery charging/conditioning shall be accomplished in the battery laboratories unless approval is granted from the LSSO to accomplish the charging elsewhere.

o. Battery charging equipment shall be continuously monitored by personnel.

p. Charging/conditioning performed in hazardous locations shall comply with paragraph 20.7.2.

NOTE: The payload organization should consider incorporating voltage and current limiters, fuses, diodes, and temperature and pressure monitors in the charging/conditioning electrical GSE.

q. The payload shall be assessed to determine if the loss of power during any phase of ground processing is a hazard to personnel or equipment. If so, an alternate or backup power source may be required.

20.6.2.2 Grounding, Bonding, and Shielding

a. The design, construction, and installation of equipment shall be such that all external parts, surfaces, and shields are at ground potential at all times.

b. Grounding and bonding schemes shall ensure proper interfacing between equipment and facility.

c. Power cords on GSE shall provide a non-current carrying ground conductor unless the unit is double insulated.

d. Grounding/bonding connections of GSE shall be designed to minimize the possibility of inadvertent disconnection.

e. Solder shall not be used for external connections.

f. Threaded fasteners shall use lock washers.

g. GSE external bonding straps and jumpers shall be capable of carrying the maximum expected fault current.

NOTE: Additional grounding requirements for ordnance and propellant operations are included in the applicable sections.

20.6.2.3 Electrical Maintenance Operations

Maintenance operations on energized electrical circuits are normally prohibited. Maintenance operations shall be performed in accordance with accepted industrial practice. In addition, the following shall be included:

a. Any accessible capacitor circuitry which presents a hazard to personnel shall be discharged prior to performing maintenance.

b. Protective equipment such as nonconducting fuse pullers, rubber gloves, nonconductive matting, etc., shall be used when working on energized circuits which could cause personal injury.

c. Procedures for tagging and lockout of control switches and circuit breakers shall be provided.

d. All grounds shall be verified to be intact.

e. Worn, abraded, or defective insulating material shall be repaired or replaced.

f. Only fuses of proper voltage and current ratings shall be used in circuits. No other material shall be used in place of a fuse.

20.6.2.4 Electrical Control of Hazardous Functions

a. Where electrical GSE is used to control a potentially hazardous function, it shall be designed to be failure tolerant.

b. Acceptable failure tolerance shall be determined by the LSSO during the safety review process.

c. Where feasible, failure tolerance shall be implemented through design control rather than procedural control.

NOTE: Design control can be implemented by eliminating the potential hazard (e.g., the current-limiting features in EED bridgewire checkers), providing a fail safe design (e.g., current-

limiting fuses) or requiring multiple component failures and/or operator actions prior to a hazardous event occurring.

20.6.2.5 Energized Electrical Equipment

a. Energized equipment shall be manned or connected to the manned facility emergency power shut-off system.

b. The electrical equipment shall be powered down during non-working hours.

c. All electrical equipment located outside a hazardous processing area shall be inhibited from supplying power to electrical equipment located within the hazardous processing area during non-working hours.

d. Electrical equipment that must remain energized for hazardous operations (e.g., maintaining spacecraft thruster solenoid valves in an opened or closed state) shall be equipped with an uninterrupted power source such as a battery backup.

e. Battery charging operations shall occur in an approved charging facility.

f. Battery charging requirements for batteries that cannot be removed from flight hardware shall be assessed on a case-by-case basis.

20.6.3 Pressure/Vacuum Systems

Pressurized systems contain fluids above atmospheric pressure. Vacuum systems contain fluids below atmospheric pressure. Pressure system elements include tanks, accumulators, lines (e.g., piping, tubes, and hoses), fittings, gauges, filters, valves, regulators, and other components.

20.6.3.1 Pressure System Requirements

a. Flight pressure systems shall meet the requirements of NSTS 1700.7B, Chapter 2, Technical Requirements.

b. The following requirements shall be met by both flight and ground pressure systems:

(1) To preclude personnel injury, provisions shall be made for accomplishing remotely controlled pressurization of the flight pressure system.

NOTE: Exception to this requirement is when the conditions of paragraph 20.6.3.6.a do not apply or when the payload operator provides a certification statement of system pressure testing to the LSSO in accordance with paragraph 20.6.3.6.b.

NOTE: Normally, remote pressurization of GSE is not required.

(2) Regulator failure shall not create a hazard to personnel or equipment during ground processing.

(3) All items, including gauges, which come in contact with the service fluid, shall be of compatible material.

(4) All pressure system connectors shall be selected to make it physically impossible to mix fluid media if a hazardous condition can be created by mixing two fluids.

EXAMPLE: Fuels and oxidizers or GN_2 and GHe in an LH_2 system.

20.6.3.2 GSE Containing Pressure Systems

GSE containing pressure systems shall meet the following requirements:

a. Pressure vessels used in GSE systems shall meet the design, test, labeling, marking (it is desired but not necessary to have the pressure vessel code stamped), and operating requirements as specified in "American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Codes," Section VIII, Unfired Pressure Vessels, Division I or Division II, as applicable.

b. If the pressure test is based on a level less than the pressure vessel maximum allowable working pressure (MAWP), the vessel shall be derated to maximum operating pressure (MOP).

c. Pressure vessels shall be registered with the National Board of Boiler and Pressure Vessel Inspectors, or the user shall maintain the design drawings and design and stress calculations for the life of the vessel.

d. GSE pressure systems hardware other than pressure vessels shall be marked as follows:

(1) Pressure system lines (where the function of the line is not immediately apparent) shall be labeled with the MOP, fluid content, and direction of flow.

NOTE: Labeling and, if used, color coding should be in accordance with KSC-STD-SF-0004B, “Safety Standard for Ground Piping Systems Color Coding and Identification.”

(2) Other system components shall be labeled with their manufacturer's name and part number, serial number (if applicable), pressure rating, and direction of flow.

e. Pressure systems components (excluding pressure vessels) shall have a design burst pressure (D.B.) of at least 4 times the MOP of the system (low carbon stainless steels shall have a D.B. of 4.5 times MOP)

NOTE: Pressure systems components (excluding pressure vessels) should conform to either MIL-STD-1522A, "Standard General Requirements for Safe Design and Operation of Pressurized Missile and Space Systems," or JSC SW-E-0002, "Space Shuttle Ground Support Equipment General Design Requirements."

f. Components shall be pressure tested at 1.5 times MOP unless otherwise approved by the LSSO.

g. Regulators shall be selected so that their working pressure falls within the center 50 percent of their total pressure range if susceptible to inaccuracies or creep.

h. Flight and GSE components downstream of a GSE regulator shall be designed to safely operate under full upstream pressure.

NOTE: Open-ended purge systems may be protected by flow restriction orifice devices.

i. If the requirements of section 20.6.3.2.h cannot be met, relief devices shall be provided in accordance with ASME/ANSI codes, and at a minimum shall be provided as follows:

(1) Downstream of last GSE regulator prior to flight hardware interface.

(2) GSE pressure vessels.

(3) Downstream of regulators where upstream pressure exceeds downstream design operating pressure.

(4) Container purge systems using metal tubing or flexhose.

(5) Container purge systems using plastic tubing when the failure of the tube provides sufficient margin of safety to the downstream equipment.

(6) All relief devices shall be relief valves when pressure exceeds 149 psig.

j. Set pressures shall comply with the following:

(1) Pressure relief valves shall be set to relieve at a pressure not to exceed the MAWP of the vessel or the design pressure of the system involved (including flight systems).

(2) The set limits shall be specified in the Operation and Maintenance Requirements and Specifications Document (OMRSD) or other operating and maintenance documents.

(3) The set pressure of relief valves shall always be sufficiently higher than the operating pressure to ensure that the valves will reclose above the operating pressure.

NOTE: See ASME Code, Section VIII, Division 1, paragraph UG-134, and Appendix M, paragraph M-11, and ANSI/ASME B31.3, paragraph 322.6.3.

k. Required relieving capacity shall be determined as follows:

(1) For pressure vessels, the required relieving capacity shall be determined in accordance with the ASME Code, Section VIII, Division 1, paragraph UG-133, or Division 2, paragraph AR-150.

(2) For piping/tubing systems, the required relieving capacity shall be equal to or greater than the maximum flow capability of the upstream regulator or pressure source and shall prevent the pressure from rising above the limits specified in ANSI B31.3.

NOTE: See ASME Code, Section VIII, Division 1, paragraph UG-133, and Division 2, paragraph AR-150, and ANSI/ASME B31.3, paragraphs 301.2 and 322.6.3.

l. Relief devices shall be located so other components such as shut-off valves cannot render them inoperative.

m. Relief devices and their associated discharge plumbing shall be adequately supported such that their discharge impulse will not cause structural failure.

n. Pressure relief for toxic liquids and/or vapors shall be designed and located so that gases and liquids or vapors will not enter any inhabited areas.

o. Pressure relief for inert gases shall not be discharged into a confined, occupied area where oxygen content could be lowered below acceptable limits.

p. Pressure reliefs for high pressure gases and liquids shall be located such that the discharge will not endanger personnel.

q. Pressure systems shall be equipped with gauges as follows:

(1) Downstream of each regulator.

(2) On any storage system.

(3) On any section of the system where pressure trapped by isolation valves creates a hazard.

r. All pressure gauges shall comply with the following requirements:

(1) Gauges shall be selected so that the operating pressure is not more than 75 percent of the highest graduation.

(2) Pressure gauges shall be of one piece, solid front construction and shall have an optically clear shatterproof window.

NOTE: Gauges should be designed for bolted flush front panel mounting.

(3) Gauges shall have blowout backs to allow unrestricted venting in the event the gauge sensing element ruptures.

(4) All items which come in contact with the service fluid shall be constructed of compatible material. Use of material other than 316SS requires LSSO approval. Bourdon-tube bleed screws may be of any 300SS.

(5) A due date calibration sticker shall be affixed to gauges used for safety-critical monitoring.

(6) Gauges shall be equipped with a bourdon-tube bleeder or equivalent device to facilitate cleaning.

s. All GSE using flexhoses with pressures above 150 psig shall be designed to provide attachments for flexhose restraining devices.

t. Isolation valves shall be designed to permit flow or isolation in both directions at the valve's MAWP.

u. Pressure systems shall be designed so pressure cannot be trapped in any part of the system without bleed capability.

v. Manually operated valves and regulators shall be selected so over-torquing the valve stem or regulator adjustment cannot damage soft seats to the extent seat failure occurs. Designs using uncontained seats are unacceptable.

w. Pressure system elements which are not intended to be reversible shall be designed or marked such that they cannot be connected in a reverse mode.

x. Lines, relief devices, and other pressure system elements shall be routed and/or located to provide for the protection of other systems and personnel.

y. Control stations shall have adequate instrumentation to allow personnel to monitor pressure levels and confirm initiated actions have occurred.

z. Control stations shall be designed so the operator does not have to leave the station to monitor hazard levels.

aa. Systems shall have shut-off valves located as close to the supply vessel as practicable.

bb. Check valves shall be provided where backflow of fluids would create a hazard.

20.6.3.3 Vacuum Systems

See paragraph 20.6.3.7.

20.6.3.4 Flexible Hoses

Flexible hoses consist of an inner liner tube of teflon or other material (compatible with the service fluid) reinforced by layers of wire and/or fabric braid or wrap.

NOTE: Use of flex hoses should be minimized.

Requirements for flexible hoses are as follows:

(1) Connection, disconnection, installation, inspection, maintenance, and testing shall be accomplished in accordance with the manufacturer's specifications and recommendations unless otherwise specified in this document.

(2) Flexible hoses shall be installed so they do not carry any external mechanical load and are not subjected to tension, torsion, or overheating.

(3) All flexible hoses shall have a design burst pressure equal to or greater than 4 times the MAWP.

(4) All flexible hoses pressurized to 150.0 psig (10.34 bars) or greater shall be contained or restrained.

(5) Hose restraint shall be accomplished using a chain or cable securely anchored to a substantial object and to the hose assembly at the following points:

(a) Hose end connector;

(b) Each union or hose splice; and

(c) Intervals not to exceed 6 feet (1.83 meters).

(6) Hose restraint devices and attachment methods shall be approved by the LSSO.

(7) The payload organization shall establish criteria and obtain LSSO approval for periods of inspection and retest. Time in service, type of service, and pressure are factors for determining need of pressure test.

(8) LSSO approval shall be obtained prior to performing pressure testing at the launch site.

(9) All flexible hoses shall be inspected prior to use.

(10) Flexible hoses which show signs of physical damage shall be replaced.

(11) Flexible hose assemblies shall be pressure tested to 1.5 times their MAWP.

(12) GSE flexible hoses shall be identified and marked.

(13) Each flexible hose assembly shall have a metal tag(s) attached which bears the following information:

(a) Date of proof test (month and year).

(b) Dedicated fluid service; e.g., fuels, oxidizers, hydraulics.

(c) MAWP.

(d) Identifier (manufacturer/part number).

(14) After each pressure test recertification, the old tag(s) shall be removed and new ones attached.

20.6.3.5 GSE Hydraulic Systems

(1) GSE hydraulic systems shall comply with MIL-STD-1522A and the requirements herein.

(2) Hoses shall be in accordance with MIL-H-25579, "Hose Assembly, Tetrafluoroethylene, High Temperature, Medium Pressure," Class 1, or "Society of Automotive Engineers (SAE) Standards,"

(3) Hoses shall be suitably protected against chafing where necessary to prevent damage to the hose or adjoining structure, tubing, wiring, and other equipment.

NOTE: Systems over 3,000 psi will be handled on a case-by-case basis.

(4) Only system compatible lubricants shall be used on threaded fluid line connections.

(5) Pressurized reservoirs shall have the pressure controlled by a pressure regulator.

(6) Pressurized reservoirs shall have an air-space relief valve to protect from excessive pressure.

(7) Reservoirs shall be provided with a fluid level indicator.

(8) The suction head of all pumps shall be maintained between the limits recommended by the pump manufacturer.

(9) Pump pulsations shall not adversely affect system tubing, components, and supports and shall not cause damage or improper operation of the equipment on flight systems.

(10) The system shall not cause damage to critical systems due to reduced flow, such as that caused by single pump operation of a multipump system, or increased flow, such as that caused by accumulator operations.

20.6.3.6 Pressure System Operations

a. The following flight and ground support system pressurization operations shall be accomplished remotely (e.g., locate control station behind a blast shield) unless otherwise approved by the LSSO:

(1) The first time a flight system is pressurized above 25 percent of the design burst at the launch site.

NOTE: This pressure is designated the "initial pressurization level."

(2) Any flight system pressurization above the initial pressurization level

NOTE: This latter pressurization becomes the new initial pressurization level.

(3) Any pressurization above MOP/MAWP.

(4) Any pressurization of a system that has suspect integrity.

b. It shall be permissible to conduct flight and ground support system pressurization operations without the use of remote operation if the payload organization provides documentation certifying the following:

(1) The assembled system has been pressure tested at a pressure which is at least 1.5 times the system MOP unless otherwise approved by the LSSO.

NOTE: Flight systems may be pressure tested at the component level if welds will be x-rayed after assembly.

(2) The assembled system has been functionally leak tested at a pressure equal to or greater than MOP.

(3) The system log book shall track system handling/movement in addition to pressurizations, maintenance, etc.

(4) System configuration has not been modified or repaired subsequent to the above testing.

NOTE: Unwelded relief or sensing devices may be replaced after system pressure testing but not after system leak testing, in accordance with item 20.6.3.6.m, below.

(5) A procedure has been written which:

(a) Requires inspection of the system upon arrival at the launch site for damage sustained during transportation and handling.

(b) Requires a check of the pressure system log book to verify that activity after the pressure test and leak test did not affect the integrity of the system.

(6) Procedure name and number, step numbers and test which require the inspection, and any additional inspection criteria shall be provided to the LSSO.

c. Personnel shall be allowed in the immediate proximity of pressure systems only when pressure does not exceed the system MOP.

d. System integrity shall not be broken on pressurized systems without first depressurizing to 10 psig or less.

e. Depressurization shall be accomplished only using components designed for the purpose.

NOTE: Backing off of line fittings to depressurize when pressures exceed 10 psig is permitted if the trapped volume does not exceed 1.5 cubic inches.

f. Tightening of line fittings under pressure shall be prohibited.

g. Systems shall not be pressurized or depressurized at rates which present unsafe situations, such as heat rise to auto-ignition.

h. These rates shall be identified in the applicable operating procedure.

i. Pressure system bolts and fittings shall not be torqued while the component is under pressure.

j. Relief valves shall be inspected, reset, tested, and labeled annually.

k. Pressure gauges shall be inspected and calibrated annually and a due date label applied where used in safety critical systems.

l. All nonhydraulic pressure systems shall be leak tested with an inert medium at MOP at the launch site prior to using propellants or hazardous gases.

m. Any time a component is modified, repaired, or replaced, it shall be pressure tested to 1.5 times MOP at the component level. If the component is welded into the system, the welds shall also be pressure tested at 1.5 times MOP. The reassembled system shall again be leak tested at MOP using an inert medium.

20.6.3.7 Vacuum Systems and Requirements

Negative pressure protection shall be provided for systems not designed to withstand pressure below one atmosphere.

EXAMPLE: This can be accomplished by the use of check valves or ambient automatic pressure valves.

NOTE: Vacuum systems should be designed to T.O. 00-25-223, "Integrated Pressure Systems and Components (Portable and Installed)."

20.6.3.8 Design, Test, and Ground Processing of Payloads/Elements/Cargo Containing Graphite/Epoxy (Gr/EP) COPVs

Payload organizations shall comply with the safety requirements for the design, test, and ground processing of payloads/elements/cargo containing graphite/epoxy (Gr/Ep) COPVs are established within Chapter 13.18 of this KNPR.

20.6.4 Radiation

a. Sources of ionizing and non-ionizing radiation shall be adequately controlled during all phases of ground, launch, and post-launch operations to assure the protection of personnel, facilities, and equipment, and the compliance with applicable federal, state, and NASA/DOD regulations and requirements.

NOTE: Such sources include radioactive materials, radiation-producing equipment (e.g., x-ray devices, particle accelerators, radio frequency/microwave emitters, etc.), lasers, and optical emitters (e.g., ultraviolet, infrared, and high intensity visible light sources).

b. All payload organizations shall be responsible for compliance with the applicable launch site requirements as stated in their approved Radiation Use Authorization.

20.6.5 Ordnance

20.6.5.1 Electroexplosive Device (EED) Categories

a. EEDs are categorized at ER based on the effects of inadvertent initiation. EED classifications are as follows:

(1) Category A: Category A electroexplosive devices are those which, by the expenditure of their own energy, or because they initiate a chain of events, may cause injury or death to people or damage to property.

(2) Category B: Category B electroexplosive devices are those which will not, in themselves, or by initiating a chain of events, cause injury to people or damage to property.

b. A device shall be assigned Category A prior to installation whenever test data to the contrary is not available.

NOTE: A device assigned Category A prior to installation may be downgraded to Category B after installation if the effects of the device and the subsequent chain of events are controlled to

the satisfaction of the LSSO. Conversely, a device assigned Category B prior to installation may require upgrading to Category A after installation.

c. The payload organization shall categorize all EEDs for both the pre- and post-installation situations and be able to provide the LSSO with supporting data for each categorization.

20.6.5.2 General Ordnance Requirements

All ordnance systems shall comply with the requirements of NSTS 1700.7B and the following:

a. All ordnance and solid propellant motors shall be handled and stored in accordance with the requirements of their hazard classification and storage compatibility grouping.

b. Items which have not previously been classified shall be tested in accordance with TB700-2/NAVSEAINST 8020.8B/T.O. 11A-1-47/DLAR 8220.1, Department of Defense Ammunition and Explosives Hazards Classifications Procedures, and classified accordingly.

c. NSS 1740.12, “Safety Standard for Explosives, Propellants, and Pyrotechnics,” and AFMAN 91-201,"Explosive Safety Standards," shall be used for guidance for storage, handling, and transportation of ordnance and propellants.

NOTE: See paragraph 20.6.5.7 for ordnance storage and handling data requirements.

d. All Category A ordnance circuits shall be capable of being physically disconnected between the ordnance device and the power source as close to the ordnance item as possible.

e. Category A ordnance and associated circuitry shall be accessible in the Orbiter to facilitate electrical checkout and connection as late as possible prior to launch.

f. All ordnance device installations at the launch site shall be in an ordnance sited or licensed facility.

g. For Category A EEDs, electrical connections shall be made in the Orbiter unless otherwise approved by the LSSO.

h. Prior to electrical connection of Category A EEDs, a DC power-on and power-off no-voltage check shall be made.

i. The power-off no-voltage check shall be performed immediately before the connection.

NOTE: Receipt of installed or early installation and connection of Category B EEDs may be accomplished with the LSSO approval, provided the connection of these devices does not restrict interface verification tasks.

20.6.5.3 Safe and Arm (S&A) Devices

a. Transition from the SAFE to the ARM position shall require 90 degrees of rotation of the mechanical barrier.

b. The S&A device shall not be capable of propagating the ordnance train with the barrier rotated less than 50 degrees from the SAFE position.

c. The visual and remote SAFE position shall not be indicated unless the device is less than 10 degrees from the normal SAFE position.

d. Firing circuits of S&A devices shall be electrically connected after payload installation in the Orbiter.

NOTE: S&A devices without a direct interface with the Orbiter may be electrically connected after final ordnance electrical system checks and power is removed from the system.

e. The S&A safing pin shall remain installed until final closeout of the payload bay.

f. S&A Rotation Tests

(1) Rotation of S&A devices during ground test and processing shall be done with the Explosive Transfer Assembly (ETA) disconnected from the S&A or at the point of ETA terminus.

(2) All rotation tests of S&As shall be completed before firing circuits are electrically connected.

(3) If the firing circuits are required to be connected during a rotation test, a safety assessment shall be provided to show that inadvertent ignition of the detonators will not cause a hazardous condition.

(4) All rotations shall require LSSO approval.

20.6.5.4 Ordnance Operations

a. Ordnance shall be processed only in those areas approved by the LSSO.

b. Solid/liquid propellants designated for one payload shall not share an operating location with items designated for another payload except for payload integration activities.

c. Test equipment used to check component and circuit operation shall be of a type that limits energy input and be approved by the LSSO.

NOTE: See paragraph 20.6.5.6 for additional test equipment requirements.

d. Electrical continuity and resistance checks of ordnance circuitry shall be performed using only in-calibration test equipment approved by the LSSO.

e. All ordnance deliveries to the launch site shall be coordinated with the LSSO.

f. All ordnance deliveries from storage to the payload organization shall be coordinated with the LSSR.

g. Electromagnetic Interference (EMI) testing shall not be conducted with live EEDs installed without approval of the LSSO.

h. Materials susceptible to the generation, collection, and holding of static electrical charges shall be selected from the LSSO-approved list.

i. Disposal of surplus or defective ordnance items shall be coordinated by the LSSO.

j. Disposition of surplus or defective ordnance items shall be determined jointly by the LSSO and the payload organization.

k. Based upon the RF and EED susceptibility, installation, removal, and electrical connection/disconnection may require RF silence. Local RF silence and no-switching periods shall be required.

l. The periods of RF silence shall be requested by the payload organization and shall be identified by an LSSO-approved TOP.

m. Grounding/bonding is required to ensure that electro-static charges cannot build up to levels which can cause ignition of ordnance items.

n. EED faraday caps shall be required during storage, handling, and after mechanical installation.

o. EED faraday caps shall not be removed until electrical connections are to be made.

p. All personnel within the hazard control area during ordnance operations shall wear nonstatic-producing, flame-retardant coveralls.

q. Persons performing ordnance work shall wear approved grounding devices.

20.6.5.5 Ordnance Marking

a. Live ordnance and associated flight items (e.g., arm plugs) shall be the natural body color of the device.

b. Nonflight items shall be color-coded.

c. The color-coding scheme shall be submitted to the LSSO as part of the ground safety data package.

20.6.5.6 Ordnance Test Equipment

a. Requests for approval for use of ordnance electrical test equipment used for testing explosive ordnance items or circuits connected to these items prior to or after installation shall be submitted to the LSSO.

b. The payload organization shall provide the model number, engineering drawings and specifications, and the system safety analysis of the test equipment.

c. Approval by the LSSO shall be by manufacturer model number and requires a valid calibration seal for use at the launch site.

20.6.5.6.1 EED Bridgewire Resistance Measurement Meters

a. The meter shall be designed such that maximum available applied current does not exceed 10 percent of the no-fire current of the EED or 50 mA, whichever is less.

b. It shall be designed so that in a worst case (multiple) failure condition, the available applied current cannot exceed the no-fire current of the EED.

NOTE: The optimum resistor location is adjacent to the output leads and inaccessible. Other locations are also acceptable, if it can be shown that by-passing the resistor is not credible.

c. Current-limiting resistors in the test leads, to meet the above requirements, are unacceptable.

d. Meter leads shall be shielded.

e. Connector shell-to-shell contact shall precede pin-to-pin contact.

f. Calibration shall be at least annually.

g. Calibration procedures shall verify the safe configuration

EXAMPLE: The proper voltage battery with the encapsulated current-limiting resistor installed.

20.6.5.6.2 No-Voltage Meters

a. No-voltage meters shall be designed to detect one-tenth of the no-fire level of the EED or 50 mV, whichever is less, at a pulse width of 1 millisecond.

b. The use of computerized no-voltage meters is acceptable if proper current-limiting can be demonstrated.

20.6.5.7 Ordnance Storage and Handling Data Requirements

a. The following data is required for all ordnance items:

(1) Payload Organization

(2) Item Identification/Name

(3) Item Manufacturer

(4) DOD Hazard Classification (Q.D. Class/Division)

(5) DOD/UN Storage Compatibility Group

(6) DOT Classification

(7) DOT Markings

(8) Explosive Weight (Per Item)

(9) Gross Weight (Including Container)

(10) Gross Weight (Less Container)

(11) Storage Container Dimensions (L x W x H)

(12) Hook Height Required

(13) Quantity Per Container

(14) Quantity to be Stored

(15) Environmental Controls (Temp/RH Requirements)

(16) Point of Contact (POC) - Name/Phone

b. This data shall be submitted in the Payload Organization's safety data package.

20.6.6 Mechanical, Electromechanical Devices

a. Mechanical or electromechanical devices used for such purposes as structure deployment or actuating release mechanisms shall be evaluated to establish whether in the event of inadvertent activation damage to equipment or injury to personnel could occur.

b. If it is determined inadvertent activation is either critical or catastrophic, then the device shall be failure tolerant in accordance with paragraph 20.4.1.

c. These devices shall be identified in the operational hazards analysis with the requirement for caution and warning notations incorporated in the TOPs (see paragraph 20.3.3.3).

20.6.7 Propellants

20.6.7.1 Propellant System Requirements

a. Materials selected for use in propellant systems shall be compatible with propellants used.

NOTE 1: This should include compatibility under operating pressure, shock, vibration, and temperature loadings and include analysis of items such as stress corrosion.

NOTE 2: Refer to Johns Hopkins University, Chemical Propulsion Information Agency (CPIA) Publication Number 394, Chemical Rocket/Propellant Hazards, Volume III, for specific propellant properties.

b. Propellants shall be separated so malfunction of either the oxidizer or fuel subsystems cannot cause mixing.

c. Incompatible system connections shall be keyed or sized so it is physically impossible to interconnect them.

d. For systems requiring nonmetallic materials, materials selected shall not result in hazardous reactions.

e. For systems requiring insulation or acoustic damping, nonabsorbent, nonflammable materials shall be used in compartments or spaces where fluids and/or vapors could invade the area.

20.6.7.2 Propellant Systems GSE Requirements

a. A positive means of shutting off propellant flow from tanks shall be provided.

b. The means for shutting off propellant flow shall be readily accessible.

c. The actuator for remotely controlled valves shall be capable of opening and closing the valve under design flow and pressure.

d. Throttle capability shall be considered in the selection of remotely controlled valves.

NOTE: Ball and gate valves should not be used.

e. Remotely controlled valves shall provide for remote monitoring of open and closed positions.

f. Normally open or closed valves shall have a spring on the actuator capable of operating the valve to the fail-safe position without an external actuating force under system operating conditions.

g. Manually operated valves shall be capable of being opened or closed under full system pressure.

h. Balanced manual valves that utilize external balancing ports or vents open to the atmosphere shall not be used.

i. The payload organization shall describe their plans for controlling a propellant leak throughout the ground processing timeline up to, and including, installation into the Orbiter payload bay.

j. Provisions shall be made so propellants cannot be trapped in any part of the system without provisions for draining.

k. Hypergol equipment (e.g., valves, quick disconnects) shall be designed to be compatible with and operated by personnel wearing PHE gloves.

l. Hazardous fluid vent system requirements are as follows:

(1) Pressure relief vents for hazardous fluids shall be designed and located so vapors will not enter any inhabited areas.

(2) Venting of toxic fluids shall be through a scrubber or neutralizing agent or by similar methods which would prevent unauthorized release.

(3) Each line venting into a multiple use vent system shall be protected against back pressurization by means of a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

(4) Incompatible fluids shall not be discharged into the same vent or drain system.

(5) Fuel or toxic fluid vent systems shall be equipped with a means of purging the system with an inert gas to prevent explosive mixtures and/or to maintain system cleanliness.

(6) Vents shall be placed in a location normally inaccessible to personnel and at a height or location where venting will not normally be deposited into habitable spaces.

(7) Vents shall be conspicuously identified using appropriate warning signs, labels, and markings approved by the LSSO.

(8) Vent systems shall be sized to provide minimum back pressures consistent with required venting flow rates.

(9) Back pressures shall not interfere with proper operation of relief devices.

m. Serviceable hypergolic components, such as quick disconnects, filters, hoses, valves, etc., shall be permanently marked by electroetch, metal impression stamp, or other permanent method to indicate the specific hypergolic fluid to which the component will be exposed.

n. Items used in any fuel or oxidizer system shall not be interchanged after exposure to the respective media.

o. Lubricants for hypergolic systems shall be restricted to Krytox 240AC or equivalent.

p. Use of a lubricant other than Krytox 240AC shall be approved by the LSSO.

q. Hypergolic propellant pumps shall be specifically designed for the particular hypergolic fluid.

r. All components, including flow meters, used in hypergolic propellant systems shall be designed and qualified for hypergolic applications.

s. Flanged connections shall utilize the following types of flanges: slip-on, weldneck, lapped joint, or blind.

t. Bonding straps shall be used across flanged connections.

u. Materials used in contact with fuels, oxidizers, or combustible gases shall be selected, tested, and certified in accordance with the requirements of NASA-STD-6001, Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion.

v. All controls and adjustments shall be identified by component number, system function, and direction of operation.

w. The direction of fluid flow shall be clearly indicated with permanent markings on the exterior of each component.

x. All calibration adjustments, locked or unlocked, shall be designed so the setting, position, or adjustment cannot be altered when the equipment is subjected to the service condition.

y. Sight glasses used for liquid level indicators shall be protected from physical damage.

z. The payload organization shall maintain records of the design, maintenance, checkout, and usage of GSE systems used at the launch sites.

aa. Records shall be available to the LSSO.

bb. Check valves (one-way flow) shall be provided whenever a hazardous/contaminated substance can backflow into another system.

cc. Liquid shall not be able to be trapped between valves if changes in ambient temperature can result in pressure rises above 110 percent of MOP.

dd. If the potential for pressure rises above 110 percent of MOP exists, automatic relieving is required.

20.6.7.3 Propellant Systems Operations

a. New, modified, and/or repaired propellant storage or transfer systems shall be validated by functional test prior to being certified for operational use.

b. The following shall be required as part of the certification procedure:

(1) A leak test at MOP with an inert gas shall be performed.

(2) Pressure control units shall be verified by use of certified, calibrated gauges.

(3) Emergency shutdown systems and procedures shall be demonstrated using a referee fluid.

(4) Proper operation of quick disconnects shall be demonstrated.

c. Simultaneous operations with hypergolic propellants shall be prohibited.

d. The payload and the propellant loading system shall be commonly grounded and bonded during propellant transfer operations.

e. Prior to opening a toxic propellant system, it shall be drained and flushed or purged to concentration levels approved by the LSSO.

f. Prior to replacement or storage of components or system repair, hypergolic or toxic system components shall be flushed and purged of all residual elements and appropriately capped or bagged and labeled prior to movement.

g. Disposal of propellants shall be coordinated with the LSSO.

h. Venting of toxic vapors to atmosphere shall only be done with LSSO approval.

i. Procedures shall contain emergency instructions developed by the payload organization to handle leaks and spills.

j. Procedures shall be consistent with CPIA #394, Volume III.

k. Propellant transfers shall be performed only in areas and at times approved by the LSSO.

l. Personnel shall be limited to those needed in direct support of propellant transfer operations.

m. PPE which provides full respiratory protection and body coverage shall be worn during any dynamic payload and/or GSE toxic propellant transfer operations, or whenever the toxic propellants are not in a sealed system.

n. At all other times that toxic propellants are present, emergency escape breathing devices shall be available for all personnel.

o. Full respiratory protection and body coverage is mandatory for the following:

(1) Any connection/disconnection of a propellant transfer system if it contains toxic propellants.

(2) Any connection/disconnection of a propellant transfer system that had contained toxic propellants and concentration levels have not been verified to be below safe concentration levels.

(3) All toxic propellant sampling operations.

(4) Any servicing/deservicing/internal circulation (dynamic flow) of toxic propellants until system integrity has been verified (i.e., no leakage is present).

(5) Any application of pressure to the toxic propellant transfer system until a stabilization period of 15 minutes minimum has been achieved and system integrity has been verified.

p. All PPE shall be compatible with the toxic propellants involved.

q. All PPE use shall be approved by the LSSO and the appropriate Bioenvironmental Engineering/Spaceport Services Office.

r. Toxic vapor monitoring shall be required during break-in to any propellant system which has been contaminated by propellants and during the handling of contaminated parts.

s. Toxic vapor monitoring shall be required at the conclusion of any hazardous operation listed in paragraph 20.6.7.3.o prior to opening of the control area to unprotected personnel.

20.6.8 Cryogenics

All cryogenic systems shall comply with the requirements of paragraph 20.6.7, Propellants, and the following requirements.

20.6.8.1 Cryogenic Systems Requirements

a. Source flow shall have throttling capability.

b. Pressure containing components within hydrogen systems shall be selected for minimum hydrogen blistering or hydrogen embrittlement susceptibility.

c. GSE cryogenic valves with extended stems shall be installed with the actuator approximately vertical above the valve.

d. Joints in piping systems shall be of either butt-welded, flanged, bayonet, or hub type.

e. Cryogenic systems shall provide for thermal expansion and contraction without imposing excessive loads on the system.

NOTE: Bellows, reactive thrust bellows, or other suitable load relieving flexible joints may be used.

f. GSE vacuum-jacketed systems shall be capable of having the vacuum verified.

g. Cryogenic systems shall be designed so anywhere a cryogen can be trapped between any valves in the system, automatic relief is incorporated to preclude excess pressure caused by conversion from liquid to gaseous state causing a rupture.

h. Cryogenic systems shall be insulated with an oxygen compatible material or be vacuum-jacketed to preclude liquefaction of air.

20.6.8.2 Cryogenic Systems Operations

a. Cryogenic systems shall be pressure tested with an inert medium at cryogenic temperature followed by a proof test at ambient temperatures (no less than 60 degrees Fahrenheit).

b. Pressure testing shall be 1.5 times MOP except where lesser factors (no less than 1.1 times MOP) are warranted to avoid adverse effects (e.g., plastic deformation or strain hardening) on the system.

c. Cryogenic systems, including vacuum-jacketed pipe, shall be cold-shock tested with an appropriate cryogenic inert medium (at MOP or greater) prior to introducing any hazardous commodity into the system.

d. For liquid hydrogen systems, a mass spectrometer leak test with liquid helium shall be performed.

NOTE: Cold-shock leak testing can be accomplished at proof pressure to satisfy the cryogenic proof requirements in paragraph 20.6.8.2.a above.

e. Simultaneous loading of fuels and oxidizers shall not occur without prior approval from the LSSO.

f. All personnel involved in cryogenic propellant transfer operations, repairs, or adjustments to the system shall wear LSSO and Biomedical and Bioenvironmental Engineering-approved PPE.

g. Flammable cryogenic systems shall be capable of being connected to an external vent system.

20.6.9 GSE Materials

a. A list of materials shall be maintained for each piece of GSE which interfaces with hazardous fluids.

EXAMPLE: Hazardous fluids include, but are not limited to, gaseous oxygen, liquid oxygen, gaseous hydrogen, liquid hydrogen, hydrazine, nitrogen tetroxide, monomethyl-hydrazine, Freon-21, ammonia, and potassium hydroxide.

b. The list shall be of sufficient detail to permit an evaluation of the compatibility of the GSE design with the environment in which it is to be used.

c. Mercury in liquid or vapor form shall not be used in GSE if a substitute of equivalent performance exists or an appropriate alternate design or method can be used.

d. Mercury shall not be used in any applications where contamination of flight hardware or exposure to personnel could result.

e. Cleaning solvents and adhesive materials shall be contained in NFPA-approved safety containers.

f. The use of and quantity of cleaning solvents and adhesive materials allowed in the payload processing work area shall require the approval of the LSSO.

g. All users of these materials shall comply with local fire, safety, and health regulations.

h. Except where approved by the LSSO, the use of glass containers is prohibited in all payload processing work areas.

i. Use of flammable materials and static-producing materials shall be kept to a minimum in all payload processing areas.

j. If any plastic film/foam/adhesive is to be used, the material shall be selected from the NASA KSC Plastic Films and Adhesive Tapes list.

k. The material, quantity, and location of use shall be included in the payload organization safety data package and approved by the LSSO prior to use.

l. If a plastic film is not on the approved list, a sample (minimum one square yard) shall be submitted to the LSSO for test/evaluation and approval.

m. GSE containing components made of shatterable materials, which is to be used inside the Orbiter or in areas where it could fall into the Orbiter, shall be designed to provide positive containment to prevent fragments from entering the Orbiter.

n. GSE designed for use directly in the Orbiter crew cabin or payload bay shall meet the same materials flammability requirements as the payload/experiment itself.

NOTE: For these requirements, see NSTS 1700.7B, paragraph 209, subparagraphs 2 and 3.

o. GSE used in flight vehicle habitable areas or in the payload bay shall not be painted or coated with materials subject to chipping, flaking, or scaling.

NOTE 1: Materials should be selected which are not nutrients for biological agents such as mold, mildew, fungus, etc.

NOTE 2: Experiments in habitable areas should not provide a source of contamination.

NOTE 3: Materials which are nutrients should be hermetically sealed or treated to render the exposed surfaces resistant to biological attack.

20.6.10 Industrial Hygiene

a. Hazardous materials and physical agents shall be controlled during all phases of launch/landing site operations to protect personnel by preventing exposures in excess of applicable limits and to comply with applicable federal and state regulations and requirements.

b. Descriptive information concerning proposed uses of hazardous materials and physical agents shall be provided by the payload organization to the LSSO for review and evaluation by Health Officials.

c. General Industrial Hygiene requirements include, but are not limited to, the following:

(1) Equipment which contains, possesses, or emits hazardous materials and/or physical agents shall be designed, constructed, installed, and operated in a manner to ensure the potential for exposure is kept as low as feasible.

(2) The payload organization shall provide a list of all hazardous materials and physical agents containing names, quantities, locations, and proposed uses [reference paragraph 20.3.1.c(9)] to the LSSO as part of the Ground Safety Data Package.

(3) The payload organization shall submit to the LSSO one copy of the MSDS for each of materials upon or before arrival at the ER.

(4) MSDS's shall be submitted if at any time additional materials, not previously identified, are introduced onto the ER.

(5) Hazardous materials and physical agents shall be used only by properly trained personnel and in accordance with procedures reviewed by the Health Officials and approved by the LSSO.

(6) Engineering or administrative controls shall be the primary means for preventing personnel exposures.

(7) When such controls are not feasible or adequate to control exposure, PPE shall be required.

(8) PPE shall be approved by the Health Officials.

(9) Planned releases of hazardous materials shall not be permitted without review and approval by the LSSO and the Health Officials.

(10) Supportive data shall be provided by the payload organization to identify maximum expected quantities and concentrations of planned releases.

NOTE: All activities involving hazardous materials or physical agents are subject to monitoring by the Health Officials.

20.6.11 Oxygen

The use of gaseous or cryogenic oxygen involves unique design requirements with respect to materials compatibility. Prior to commencement of design, the payload organization shall contact the LSSO to identify specific safety/compatibility requirements to be incorporated in design.

NOTE: Specific KSC documents providing results of compatibility testing are 79K09560 for liquid oxygen testing and 79K09561 for gaseous oxygen testing.

20.7 ENVIRONMENTAL

20.7.1 Meteorological Requirements

20.7.1.1 Propellants

Meteorological conditions established herein shall be observed by all agencies in scheduling and conducting transfer, handling, and use of toxic propellants.

a. Propellant operations shall not commence when the potential for passage of an electrical storm is within five miles.

b. Propellant operations during storm passage shall be interrupted or expeditiously concluded at the discretion of the LSSR or supervisor in charge of the operation.

c. The supervisor responsible for the transfer/handling operations shall be responsible for obtaining the prevailing meteorological conditions, determining that the conditions meet those specified herein, and obtaining LSSR approval to proceed.

d. In order to protect personnel not involved in toxic propellant operations and the public domain, downwind concentrations of toxic propellant materials shall be controlled by limiting operations to certain meteorological conditions.

e. Concentrations of toxic propellants shall be kept at or below Health Officials approved safe levels at the launch site boundaries in the public domain and in the launch site industrial areas.

f. Personnel shall be evacuated or provided with emergency escape breathing devices and communications equipment in areas potentially at risk from toxic propellant operations as determined by the LSSO.

g. Evacuation of personnel shall be used in those situations where the potential for injury/illness is present.

h. Local propellant operations shall require protection in the immediate downwind sector.

20.7.1.2 Ordnance

a. Ordnance items shall not be transported, handled, installed/removed, or electrically connected/disconnected when the passage of an electrical storm is within 5 nautical miles.

b. Ordnance operations shall be interrupted or safed during storm passage.

20.7.2 Hazardous Atmospheres

NOTE 1: Flammable/Explosive Atmospheres: A percentage of the Lower Explosive Level (LEL) will be established to define a hazardous atmosphere for flammable/explosive gases or vapors by the LSSO on a case-by-case basis. Factors such as commodity involved, quantity, confinement area, the presence of oxygen-enriched atmospheres (greater than 25 percent), credible time for a hazardous condition to develop, and response time to complete emergency actions shall be considered in establishing the percentage of the LEL. This percentage is usually 25 percent of the commodity LEL.

NOTE 2: Oxygen Deficient Atmospheres: A hazardous oxygen-deficient atmosphere may develop in enclosed spaces where operations or processes consume oxygen or release asphyxiating gases or vapors into the atmosphere. Entry into any atmosphere containing less than 19.5 percent oxygen is considered hazardous.

NOTE 3: Toxic/Corrosive Atmospheres: Hazardous toxic/corrosive atmospheres may be present where processes or operations generate airborne materials. Hazardous airborne materials include dusts, fibers, mists, fogs, smokes, fumes, gases, and vapors.

20.7.2.1 Confined Space Entry

Confined space entries shall be performed in accordance with KNPR 1840.19.

20.7.2.2 Hazardous Atmosphere Areas for Electrical Equipment

a. The hazardous atmospheric areas for flammable liquids, such as propellants, shall be as follows:

(1) Service carts, drums, storage vessels, or payload tanks - 50 feet radially from the container or as specified by the LSSO.

(2) Vents - 50 feet radially from the vent opening.

(3) Transfer lines - 25 feet radially from the line.

b. All installation configurations shall be evaluated for approval by the LSSO.

c. The hazardous atmospheric area for solid propellants is within 10 feet of any exposed propellant. Solid propellants shall be considered exposed when:

(1) The motor nozzle is not attached and the nozzle end does not have a cover that precludes propellant offgassing or,

(2) The nozzle is attached but does not have a nozzle plug installed sufficient to preclude propellant off-gassing or,

(3) Unassembled motor segments that do not have front and rear covers that prevent off-gassing.

20.7.2.3 Electrical Equipment in Hazardous Atmosphere Areas

a. When within areas prescribed in paragraph 20.7.2.3, electrical equipment that is operated during system pressurization or flow of flammable propellants shall be either explosion proofed in accordance with the NEC (NFPA 70) or hazard proofed.

NOTE: Hazard proofing may be obtained by potting, hermetically sealing, or by positive pressurization with an inert gas or clean air as described in NFPA 496.

b. The electrical equipment shall be monitored at all times when powered.

c. Electrical equipment to be operated in enclosed rooms or areas where propellants are present but in a static state (i.e., no flow or change of pressurization) shall be controlled by a switch at a single monitoring station capable of deactivating all "nonexplosion/nonhazard proof" equipment within the area.

d. This station shall be manned at all times when the equipment is in use.

e. The master switch shall be explosion/hazard proof if it is located within the hazard area.

f. Equipment which cannot be connected to the master switch shall be identified to the LSSO during the phase safety review process.

NOTE: Hazard groups for hazardous atmospheres are listed in the NEC (NFPA 70). For the purpose of this chapter, kerosene (RP & JP fuels), and solid propellants are to be considered Class I, Group D. Hydrazine is Class I, Group C.

20.7.3 Humidity

a. Any operations involving solid or liquid propellants or Category A EEDs shall not be conducted at humidity levels below 30 percent.

b. Exceptions shall be approved by the LSSO on a case-by-case basis.

20.7.4 Toxic Materials

The LSSO and Health Officials shall establish criteria for operational controls involving all toxic materials.

20.8 HANDLING AND TRANSPORTS

NOTE: Many standards and guides list design requirements written to achieve a safe operation, such as Code of Federal Regulations (CFR), 29 CFR, Occupational Safety and Health Administration, Department of Labor, Part 1910, and the Standard for Lifting Devices and

Equipment, NASA-STD-8719.9. The special nature of launch site safety mandates rigorous considerations in both design and process parameters.

The following definitions are to be used in this section:

a. Lifting devices - slings, linkage, mechanisms, etc., that extend between a lifting hook on a hoist and the object being lifted. Only those items below the lifting hook are intended to be designed to the criteria contained in this document. The requirements for the design of hoist, winches, and cranes are not included. Other systems, if required, shall comply with NASA-STD-8719.9.

b. Ground handling/transportation devices - trucks, dollies, transporters on which an object is placed for subsequent transportation or rotation.

c. Work stand - work platforms, ladders, etc., that are fixed structures, are designed specifically to support personnel, and do not experience the dynamic loading associated with lifting and transportation.

d. Support stand - GSE structure designed to support flight or ground equipment.

e. Rated load - the maximum static weight that the basic equipment can safely support or lift.

f. Working (actual) load - the expected or measured weight of a piece of equipment that is to be supported, lifted, or transported.

20.8.1 Hoisting and Handling

a. All payload organization lifting equipment and its usage shall meet the requirements of 29 CFR, Part 1910; the American National Standards Institute (ANSI), ANSI B30 Series, "American National Standard Safety Standards for Cranes, Derricks, Hoists, Hooks, Jacks and Slings", NASA-STD-8719.9, and the requirements herein.

b. All lifting and hoisting equipment shall show evidence of the equipment having been tested in compliance with the above reference documents and the requirements of the paragraphs in this section.

c. Testing shall be accomplished within one year prior to use.

d. Records of all testing and inspections shall be maintained and be made available to the LSSO upon request.

e. Rated loads shall be posted on all lifting and hoisting equipment and fixtures.

f. Magnetic particle, dye penetrant, radiography, or other suitable crack-detecting tests shall be performed on all load-bearing hooks, shackles, and eyebolts after the initial proof test of the assembled sling but prior to use and annually thereafter.

g. The nondestructive inspection (NDI) method selected shall require approval by the LSSO during the phase safety review process.

h. A defect-detecting method such as radiography or ultrasonics which evaluates the material through 100 percent of its depth shall be performed on all welds constituting a single point of failure (i.e., critical weld) after the initial proof test of the assembled sling.

i. Critical welds shall be eliminated where feasible.

NOTE: If the payload organization certifies that their lifting hardware is for a specific function, is properly controlled in terms of usage/misusage and the environment, and has undergone a thorough NDI prior to application of a protective coating, the LSSO may not require an annual NDI.

j. Thimbles, shackles, links, eyebolts, swaged fittings, wire ropes, and similar devices shall be subjected to and comply with the testing, preoperational and periodic inspection, and maintenance requirements set forth in the applicable ANSI B30 Series or the NASA-STD-8719.9.

NOTE: Eyebolts which are permanently fixed to the load are considered exempt from proofloading and NDI requirements.

k. Eyebolts shall comply with the design requirements of Figure 20-1.

SLING COMPONENT	SAFETY* FACTOR (ULTIMATE:RATED)	PROOF TEST (PROOF:RATED)	PERIODIC LOAD TEST (TEST:RATED)
		NASA KSC	
Wire Rope	5	2	1.25
Alloy Steel Chain	5	2	1.25
Metal Mesh	5	1.5	1.25
Natural or Synthetic Web	5	1	1
Natural or Synthetic Rope			
Manila	5**	1	1
Polypropylene	6**	1	1
Polyester	9**	1	1
Nylon	9**	1	1
Structural Members (e.g., spreader beams)	5***	2	1.25
Shackles, Tumbuckles, Eyebolts, etc.	5	2	1.25

* As relates to this table, safety factor is defined as the ratio of a load that predicts a failure to a rated load.

** Use of rope slings will be limited to 50% of the rated capacity (manufacturer's rating).

*** A 3:1 safety factor against the worst case failure mode that will result in local yielding is acceptable.

FIGURE 20-1: SLING REQUIREMENTS

l. Eyebolts that can be removed and replaced shall have a positive means of determination of full thread engagement (e.g., shoulder, color marking, etc.).

m. Attach points to payloads for the purpose of ground handling shall be classified as either utilizing the flight structural interfaces to the Orbiter or having special attach fittings for the purpose of ground handling.

n. When utilizing the flight attach fittings for ground handling, structural analysis shall not be required if this determination has been made for flight dynamics.

o. When special fittings for ground handling are used, an analysis shall be conducted to ensure the load paths have adequate safety factors for ground handling.

p. The attach points for the Spacecraft (S/C) and fittings (GSE) shall be adequately described in the safety data package, including single failure points, verification methods (e.g., prooftesting, NDI), and the methods used to assure proper connection during ground handling.

q. Proofloading and associated NDI shall be reaccomplished for modified or repaired lifting equipment.

20.8.2 Requirements for Slings

a. Slings shall be designed and tested as an assembled unit (unless otherwise approved by the LSSO) which includes spreader beams and drop legs (ropes, chains, shackles, eyebolts, pins, turnbuckles, etc.) in accordance with NASA-STD 8719.9.

b. Proof or periodic load test shall be accomplished within one year prior to use.

c. All sling assemblies shall be visually inspected each day prior to use.

d. A periodic inspection shall be performed by the using organization on a regular basis with frequency of inspection based on frequency of sling use, severity of service conditions, nature of lifts being performed, and experience gained on the service life of slings used in similar circumstances.

e. Any deterioration which could result in appreciable loss of original strength shall be carefully noted, and an engineering evaluation shall be performed to determine whether further use of the sling would constitute a safety hazard.

f. Periodic inspections shall be conducted annually, as a minimum.

g. Structural sling inspection shall be performed at least annually.

20.8.2.1 Wire Rope Slings

Wire rope slings shall be immediately removed from service if any of the following conditions are present:

a. Ten randomly distributed broken wires in one rope lay or five broken wires in one strand in one rope lay.

b. Wear or scraping of one-third the original diameter of outside individual wires.

c. Kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure.

d. Evidence of significant heat damage.

e. End attachments that are cracked, deformed, or worn.

f. Hooks that have been opened more than 15 percent of the normal throat opening measured at the narrowest point or twisted more than 10º from the plane of the unbent hook.

g. Significant corrosion of the rope or end attachment.

20.8.2.2 Replacing Due to Deficiencies Identified During Inspection

a. Discrepancies found during the following inspections shall be cause for replacement or repair:

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

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

(3) Inspect load-bearing bolts and verify that there is no visual evidence of bending, cracking, gross wear, or improper configuration.

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

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

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

(7) Remove and inspect load-bearing slip pins for visual deformation, evidence of bending, abnormal defects such as galling, scoring, brinelling, and diameters not within drawing tolerances. NDI shall be used when required by design requirements or when cracks are suspected.

(8) Inspect pin bores visually for cracks, deformation, local yielding, scoring, galling, and brinelling. NDI shall be performed as required.

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

(a) Visual inspection of all welds.

(b) Magnetic particle, x-ray, or other suitable crack-detecting methods as appropriate for critical welds as identified on the drawings.

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

20.8.2.3 Identification Requirements

a. For identification and onsite assurance purposes, equipment shall have a periodic recertification tag containing equipment identification, next required test date, and quality control stamp.

b. Hoists/winches and slings shall have proofload tags containing rated load, proofload, and proofload date.

c. Slings which have components that are normally disassembled shall be either marked, coded, or tethered to assure proper assembly of verified hardware.

NOTE: Components not marked, coded, or tethered will invalidate the proofload/certification of the whole assembly.

d. Removable lifting lugs used on flight hardware or GSE shall be identified to ensure the lugs can be reinstalled in the proper location if necessary.

e. Synthetic or natural rope slings shall be derated by 50 percent after the proofload; this then becomes the rated load.

EXAMPLE: Manufacturer's rating x 1.0 (prooftest factor) x 0.50 (derating factor) = posted rated load.

20.8.3 Hydrasets

a. Hydrasets shall be initially load tested to 200 percent and annually thereafter to 125 percent of their rated load.

b. Hydrasets shall be tested to 125 percent whenever seals are replaced.

NOTE: Manufacturer's certification of test is acceptable for either new or reworked hydrasets.

c. The piston rod shall be fully extended for load test.

d. An operational test of the pump shall be done every six months.

20.8.4 Chainfalls

Chainfalls shall be initially and annually load-tested to 125 percent of rated load.

20.8.5 Load Cell

Load cells shall be annually load-tested and calibrated to 100 percent of their rated load.

20.8.6 Stands

a. Ground handling devices and support stands shall have a safety factor of 3:1 against yield.

b. Personnel work stands shall have a safety factor of 4:1 against ultimate.

c. A one-time prooftest and NDI of support stands shall be required based upon hazard potential.

d. The prooftest level shall be at least 1.25 times the rated load.

e. An LSSO-approved NDI shall be performed after the prooftest.

f. A prooftest and NDI shall be required after misuse or modification.

20.8.7 Transporters

a. Prior to use, checks shall be made to ensure:

(1) Proper tire inflation.

(2) An operable braking system.

(3) Tow bar and safety chains are properly fastened.

(4) Payload securing devices are properly tightened.

(5) Availability of wheel chocks.

(6) Availability of fire extinguisher(s).

b. Maximum speed shall be prominently and permanently displayed on both the front and rear of the transporter.

c. Transporters shall be parked only in approved areas.

d. Movement of transporters carrying liquid fuel, solid motors, or installed ordnance shall comply with AFMAN 91-201 and not commence when electrical storms are within 5 miles.

e. Transporters shall have a safety factor of 3:1 against yield

NOTE: Commercially available equipment (e.g., flatbed trailers) are acceptable.

20.9 MISHAP INVESTIGATION AND REPORT

NOTE: Requirements are established within this KNPR, Chapter 10.

5.3 TOOLS

a. All tools and equipment shall be tethered when in processing facilities above and around flight hardware or when in working environments where there is the potential for personnel injury, equipment damage, or where the tools may become Foreign Object Debris (FOD) in an inaccessible area.

b. Tools used in flight hardware processing facilities shall be traceable to their storage location.

CHAPTER 9: TECHNICAL OPERATING PROCEDURES (TOPs) (SUPPLEMENTS NPR 8715.3, NASA GENERAL SAFETY PROGRAM REQUIREMENTS)

9.1 GENERAL

9.1.1 Laboratory operations shall comply with 29 Code of Federal Regulations (CFR) 1910.1450 in lieu of the requirements of this chapter.

9.1.2 TOPs shall identify and direct work to be performed; provides detailed instructions necessary to accomplish the intended task; and are to be followed step-by-step unless otherwise permitted by section 9.9 of this chapter. The use of TOPs ensures an organized and systematic approach for performing work and to identify and control hazards.

9.1.3 TOPs shall be required when any of the following apply:

a. Equipment operations, planned or unplanned, are hazardous as defined in section 9.8 herein.

b. An operation constitutes a potential launch, test, vehicle, or payload processing constraint.

c. An operation is detailed or complicated and there is reasonable doubt that it can be performed correctly without written procedures.

9.1.4 TOPs shall be reviewed for KSC and offsite areas to ensure that hazardous operations are properly classified and the appropriate safety precautions have been specified.

9.1.5 TOPs shall be classified as hazardous or non-hazardous. Each operation shall be evaluated for the task and location. Hazardous operations are defined in section 9.8 herein.

9.1.6 A Category II TOP may be used for one-time-only hazardous operations when work is of limited scope, and for repetitive non-hazardous operations when work is of limited scope. Category II procedures shall not be used to change or replace Category I procedures.

9.1.7 TOPs shall be prepared in clear, precise language that can be readily understood by personnel involved in the operation.

9.1.8 Unique symbols shall be used on all bar charts, integration, and element schedules to differentiate between operations having a major control area, a local control area, and no control area. A legend shall be provided on each page.

9.2 ALL TOPS

All TOPs shall contain:

9.2.1 Identification of the hazard level on the cover for paper TOPs or immediately upon opening of an electronic TOP that defines the TOP as “hazardous” or “nonhazardous.”

9.2.2 A brief description of the purpose or objective of the task, operation, or procedure.

9.2.3 Identification of the operating location and/or departing/arriving areas.

9.2.4 Identification of specific hazards that personnel will be exposed to during the operation.

9.2.5 Operations Maintenance Requirements and Specifications Document (OMRSD), Hazard Analyses, and/or Payload Hazard Reports that specify procedural controls for specific hazardous conditions. These procedural controls shall be uniquely identified within the TOP.

9.2.6 Safety precautions (WARNING/CAUTION notes) for any activities, hazardous or non-hazardous, where specific guidelines must be observed or actions taken to prevent or limit hazards.

a. WARNING/CAUTION notes shall be inserted prior to the step (for electronic TOPs this can be a hyperlink inserted prior to the step) and shall be reviewed immediately preceding the step that directs the activity.

NOTE: If using Maximo, all WARNING/CAUTION notes can be contained in the WAD safety plan rather than prior to the step, as long as the hyperlink to the WARNING/CAUTION note is provided immediately prior to the step as required in 9.2.6 a.

b. If using hyperlinks for WARNINGS/CAUTION note, a procedural step within the TOP shall verify that all WARNING/CAUTION notes are reviewed prior to starting a hazardous task (as defined in paragraph 9.8).

c. For multiple steps for related work within a TOP, the above requirements (9.2.6 a. and b.) shall only be implemented for the first step that requires the safety precautions.

9.2.7 Identification of tools, equipment, clothing and/or any other personal protective equipment (PPE) required for the safe performance of the operation or as required by emergency procedures associated with the operation shall be contained/specified within the WARNING note.

9.2.8 Identification of organizational elements and facilities required to support the operation.

9.2.9 A list of applicable safety documents and references that are specifically called out within the TOP required to support the operation. The list shall contain the document identifying number, latest issue (LI), and title.

9.2.10 Safety rules and requirements that are required for the safe conduct of the operation.

9.2.11 Identification of the personnel certifications required for the safe performance of the operation.

9.2.12 Emergency instructions when operations directed in the TOP activate a system or equipment capable of causing personnel injury or equipment damage if not expeditiously shutdown or safed, should a malfunction occur. When a TOP is in progress, the emergency instruction in the TOP shall take precedence over the Emergency Procedures Document (EPD). Reference KNPR 8715.2 for facility EPD requirements. Emergency instructions shall:

a. Contain specific actions necessary to cope with emergency conditions.

b. Address hazards unique to the operation and shall provide for rapid safing to protect personnel and equipment.

c. Contain all the steps required to accomplish the shutdown or safing, or shall be readily available as part of the work package.

d. Be available to the test team at all times and be included as a separate operation that is uniquely identifiable (e.g., Unique title for electronic TOPs, distinctive border, or cut corners for printed TOPs).

9.2.13 The following data when involving the pressurization of vessels within GSE or facilities:

a. Maximum Allowable Working Pressure (MAWP).

b. Relief valve set pressure (if installed).

c. Burst disc pressure/temperature rating (if installed).

d. For initial (first-time) pressurization, a WARNING stating the MAWP immediately before the step that calls for pressurization. For subsequent pressurizations this may be in the form of a statement.

NOTE: A sketch or diagram which shows the configuration of the system to be pressurized and which includes maximum allowable working pressures, relief valve set pressures, and burst disc pressure/temperature ratings may be used to meet the requirements listed in (a), (b), and (c) above.

9.3 HAZARDOUS TOPS

Hazardous TOPs, as defined in section 9.8 herein, shall contain, in addition to the above:

9.3.1 Identification of all conditions that cause the TOP to be classified as hazardous.

9.3.2 A procedural step verifying the performance of a pretest briefing for integrated TOPs that require a major control area.

9.3.3 The following items shall immediately precede the step(s) that direct the hazardous task/sequence:

a. A procedural step requiring the performance of a pre-task briefing.

b. A procedural step with task leader verification that personnel participating in the hazardous operation are certified and ready to proceed.

c. A procedural step to identify/specify each control area for hazardous operations. The instructions shall include placement of signs, barriers (i.e. ropes, chains, tape), warning lights, and directions for all non-essential personnel to clear the specified control area, allowing sufficient time for them to do so before the start of the hazardous step(s).

d. A list identifying all the essential personnel required to perform the hazardous operation. The list shall identify the individuals by call sign/ functional title, number of personnel, and the organization or contractor employing the individual.

e. A procedural step providing for public address announcements, or other positive means, to be made to alert personnel of the dangers and information associated with the hazardous operation.

f. A procedural step verifying that a pre-route survey has been accomplished before transporting Ground Support Equipment (GSE) and flight hardware where length, height, or width may cause interference problems/hazards.

g. A procedural step verifying that a pre-operational inspection for operations having a major control area and/or an operational safety inspection for all hazardous operations has been performed. Any discrepancies that constrain or have the potential to impact the operation shall be documented and dispositioned or resolved, prior to the commencement of any hazardous step(s).

h. A procedural step requiring Safety concurrence prior to starting the hazardous step(s), and prior to opening the area for controlled work at the conclusion of the hazardous step(s).

i. A WARNING note, or a Note, specifying the start of a hazardous operation immediately preceding the first hazardous step, and a Note specifying completion of the hazardous operation immediately following the last hazardous step.

j. A step verifying the safed and armed circuits are safed and the Pyro Initiator Controller (PIC) capacitors are discharged prior to the disconnection of live explosives.

9.4 SUBTASK SAFETY CONTROLS

Integrated/controlling TOPs shall manage the specific safety controls contained in subtask TOPs/documents.

9.5 JOB CARDS

Safety requirements for Job Cards shall be identical to safety requirements for Category I TOPs.

9.6 OPERATIONS PLANNING SHEETS

The responsible safety and health professional(s) and, if required, the appropriate NASA KSC S&MA Division representative shall approve Operations Planning Sheets that include hazardous operations (as defined in section 9.3 of this chapter) prior to implementation of the TOP.

9.7 PLACARD PROCEDURES

9.7.1 The use of placards shall be limited to non-hazardous repetitive simple tasks.

9.7.2 Placards shall be used only for GSE and facility items. They shall not be used for equipment when interfacing with flight hardware, unless authorized by a TOP.

9.7.3 Placards shall define any prerequisites, contacts, or pre-operations that must be performed or made prior to implementation.

9.7.4 Placards shall be attached to equipment or positioned near equipment to provide assembly or operating instructions.

9.7.5 Installation of placards shall be authorized using a TOP initiated by the organization using the placard and an exact copy of the placard shall be attached to the authorizing TOP.

9.8 HAZARDOUS CLASSIFICATION OF TOPS

A TOP is classified as hazardous to ensure that an operation which has potential to result in loss of life, serious injury to personnel or damage to systems, equipment or facilities is performed in a step-by-step fashion and contains all appropriate hazard controls. TOPs shall be classified by the originating organization as hazardous if the activity controls or involves, but not limited to, operations that:

9.8.1 Require personnel to be present in an enclosed or dangerous area (tanks, manholes, etc.) in which the environment deviates from a normal atmosphere.

9.8.2 Involve the handling, receipt, storage, transportation, installation, removal, checkout, or closeout of explosives including solid propellants. For any operation or checkout of an explosive system, following explosive item installation/connection and prior to power on/off simulated or direct explosive system checks or tests, the condition or status of the explosives (connected, safed, or disconnected) must be stated and verification required within the TOP.

9.8.3 Involve liquid propellant loading, unloading or flow, venting, sampling, connecting or disconnecting, moving or storing of loaded storage units, or opening of contaminated systems.

9.8.4 Involve cryogenic loading, unloading or flow, venting, sampling, connecting or disconnecting, moving or storing of loaded storage units, or repairing of a system containing cryogenics.

9.8.5 Involves the handling or transfer of hazardous fluids, hazardous gases, combustible/corrosive liquids, or other materials hazards when the given quantity of the gas or liquids's vapor, when mixed or unmixed with air, is hazardous to personnel or equipment due to flammability, toxicity, or extremes of temperature.

9.8.6 Involve moving GSE or flight hardware where length, height, width, or weight may cause interference or hazards.

9.8.7 Involve crane-hoisting operations. The procedure for crane-hoisting shall be classified hazardous unless the cognizant program/project or NASA KSC S&MA Division determines that

the size or weight of the equipment to be hoisted is such that it would not be considered a hazardous operation.

9.8.8 Involve forklift operations for loading, unloading, and transporting of hazardous materials.

9.8.9 Involve the use of ionizing or non-ionizing radiation sources that have hazard controls specified in the approved Radiation Use Authorization for that source as issued by the KSC Radiation Protection Program.

9.8.10 Involve an electrical hazard that may cause injury or death.

9.8.11 Call up hazardous step(s) of subtask TOPs. The controlling TOP shall be classified as hazardous.

9.8.12 Involve the pressurization of systems or components and include at least one of the following cases:

a. Flight system pressure vessels controlled by fracture mechanics with:

(1) Any pressurization that exceeds any previously recorded pressurization in the pressure vessel operational time/ cycle log.

(2) Any pressurization above the MAWP.

(3) Any pressurization above 25 percent of the MAWP when the vessel contains hazardous fluids.

b. Flight system pressure vessels not controlled by fracture mechanics with:

(1) Any pressurization above 25 percent of MAWP that exceeds any previously recorded pressurization in the pressure vessel operational time/ cycle record log.

(2) Any pressurization above MAWP.

(3) Any pressurization above 25 percent of MAWP when the vessel contains hazardous fluids.

9.8.13 Involve the pressurization of ground-based pressure vessels/systems and include at least one of the following cases:

a. Any pressurization above the MAWP/Design Pressure.

b. First time pressurization to rated pressure of any new vessel/system or the modified portion of an existing vessel/system. This excludes pressurization after removal or replacement of a component with a like item that has been pressure tested prior to installation. This also excludes pressurization of flex hoses up to rated operating pressure, provided hose restraints required by section 13.12.10 of this KNPR are in place.

c. In-place calibration at more than 80 percent of full scale for pressure gauges with scale range over 200 pounds per square inch gauge (psig) unless the gauge has a solid front case with pressure relief back.

d. Involve procedures that manually control pressurization of systems where MAWP/Design Pressure can be reached. The TOP shall contain a CAUTION/WARNING note stating the maximum allowable pressure.

9.9 TOP CHANGES AND REVISIONS

9.9.1 Interim changes (reference definition in Appendix A) to existing Category I and II TOPs shall be in accordance with the following:

a. Insufficient time exists to make a formal change to a previously released TOP.

b. An approved deviation authorizing an interim change is obtained prior to implementation.

c. Each change shall specify whether it adds or modifies hazardous step(s).

d. Safety approval is required for interim changes that add or modify hazardous step(s), including out-of-order processing.

e. All approved deviations or other documentation authorizing permanent changes to a TOP during its use shall be incorporated, or addressed, as part of the next printed change or revision.

9.9.2 An approved deviation is required for changes to any section of a TOP. All deviation requests shall be processed using an approved deviation process, and shall be approved prior to implementation. For emergency or time-critical situations, operations may continue with the deviation processed after the fact, provided concurrences are recorded on the net and/or documented within the TOP. Deviations shall not be required for non-technical or clerical errors.

The following apply to changes that allow for steps/sequences to be performed out-of-order:

a. Out-of-order processing for hazardous steps

(1) Out-of-order changes to hazardous steps require an approved deviation. For emergency or time-critical (real-time) situations, operations may continue with the deviation processed after the fact, provided concurrences are recorded on the net and/or documented within the TOP. Actual order shall be documented within the TOP.

(2) Pre-planned out-of-order changes to hazardous steps documented within the TOP may be performed without a deviation. Actual order shall be documented within the TOP.

b. Out-of-order processing for non-hazardous steps

(1) Out-of-order changes to non-hazardous steps require an approved deviation.

(2) For emergency or time-critical (real-time) situations, out-of-order changes to non-hazardous steps may be performed without a deviation after necessary concurrence is obtained and documented within the TOP.

(3) Pre-planned out-of-order changes to non-hazardous steps documented within the TOP may be performed without a deviation.

c. Pre- and post operations tasks may be performed in any order without a deviation provided it is preplanned and documented.

9.9.3 All TOPs/changes/deviations involving the flight termination system shall be forwarded to the KSC Range Safety Manager for coordination with the appropriate signatories per NPR 8715.5, Range Safety Program.

9.9.4 All TOPs/changes/deviations involving hazardous operations for NASA Launch Services Program (LSP) at Vandenberg Air Force Base (VAFB) or at the Cape Canaveral Air Force Station (CCAFS), shall be forwarded to the S&MA Launch Services Division.

9.9.5 All TOPs/changes/deviations involving hazardous operations for NASA payloads (KSC or CCAFS) shall be forwarded to the S&MA ISS/Payload Processing Division.

9.10 PROCESSING OF TOPS

All organizations operating in areas under KSC jurisdiction shall ensure all TOPs they originate are developed, classified (hazardous or non-hazardous), and processed as follows:

9.10.1 CATEGORY I TOPS

a. Prior to use, final version of any new, changed, or revised Category I hazardous TOP shall be reviewed and approved (by signature) by the appropriate S&MA professional(s) for compliance with the requirements herein.

b. New Category I hazardous TOPs shall be released at least seven days prior to scheduled use.

c. Changed or revised Category I hazardous TOPs shall be released at least five days prior to scheduled use and three days prior to scheduled use for page changes.

9.10.2 CATEGORY II TOPS

a. Prior to use, Category II hazardous TOPs shall be reviewed and approved (by signature) by the appropriate safety and health professional(s) for compliance with the requirements herein.

b. Category II hazardous TOPs shall be released at least two days before the procedure is performed, except in the case of real-time TOPs.

9.10.3 Nonhazardous TOPs are not required to be approved by safety if the responsible safety organization has an audit/sampling plan to ensure the safety requirements are met. The sampling plan shall be developed and documented by each program/project and audited by the appropriate NASA KSC S&MA Division.

9.10.4 Prior to use, all repetitive TOPs shall be reviewed and updated, if needed, for compliance with current requirements if it has been 3 years since its last publication.

CHAPTER 10: MISHAPS AND CLOSE CALLS (SUPPLEMENTS NPR 8715.3, NASA GENERAL SAFETY PROGRAM REQUIREMENTS)

10.1 GENERAL REQUIREMENTS

Shuttle-Specific Requirements for this section are contained in Chapter 18.

All mishaps and close calls shall be reported to the responsible supervisor and the organizational (NASA or contractor) safety office and shall be investigated to determine the root cause(s), to develop and implement corrective actions in order to prevent recurrence, and to document and share lessons learned. In addition, all mishaps and close calls shall be electronically entered into the NASA Incident Reporting Information System (IRIS) database. The requirements stated herein implement NPR 8621.1, NASA Procedural Requirements for Mishap and Close Call Report, Investigating, and Recordkeeping. The KSC mishap and close call processes are documented in program-specific Launch Contingency Plans; and KSC-PLN-2807, KSC Mishap Preparedness and Contingency Plan.

10.2 DEFINITION OF MISHAPS AND CLOSE CALLS

10.2.1 MISHAPS

A mishap is an undesired and unexpected event that results in injury requiring more than first aid, occupational illness to personnel, and/or damage to property of at least $1000. Mishaps also include injuries or occupational illnesses resulting from repetitive stresses or exposures over a prolonged period of time. Mishaps resulting in damage to aircraft, space hardware, or ground support equipment that meet these criteria are included, as are test failures in which the damage was unexpected or unplanned. For purposes of investigation and reporting, mishaps are categorized as follows:

a. Type A Mishap

A mishap resulting in one or more of the following:

(1) An occupational injury or illness resulting in a fatality, a permanent total disability, or the hospitalization for inpatient care of 3 or more people within 30 workdays of the mishap;

(2) A total direct cost of mission failure and property damage of $1 million or more;

(3) A crewed aircraft hull loss;

(4) An occurrence of an unexpected aircraft departure from controlled flight (except high performance jet/test aircraft such as F-15, F-16, F/A-18, T-38, and T-34, when engaged in flight test activities).

b. Type B Mishap

A mishap that caused an occupational injury or illness that resulted in a permanent partial disability, the hospitalization for inpatient care of 1-2 people within 30 workdays of the mishap, or a total direct cost of mission failure and property damage of at least $250,000 but less than $1,000,000.

c. Type C Mishap

A mishap resulting in a nonfatal occupational injury or illness that caused any days away from work, restricted duty, or transfer to another job beyond the day or shift on which it occurred, or a total direct cost of mission failure and property damage of at least $25,000 but less than $250,000.

d. Type D Mishap

A mishap that caused any nonfatal OSHA recordable occupational injury and/or illness that does not meet the definition of a Type C mishap, or a total direct cost of mission failure and property damage of at least $1,000 but less than $25,000. Permanent occupational hearing loss in excess of 25 decibels in either ear is classified as an OSHA reportable event.

10.2.2 CLOSE CALLS

An occurrence or a condition of employee concern in which there is no injury or only minor injury requiring first aid and no significant equipment/property damage/mission failure (less than $1000), but which possesses a potential to cause a mishap or negative mission impact.

10.3 CLASSIFYING MISHAPS AND CLOSE CALLS

10.3.1 INITIAL ASSESSMENT

For purposes of initial assessment of mishaps and close calls, it is recognized that severity of the event may not be known. Therefore, a worst-case estimate of injury/illness and/or damage or its potential shall be made and updated as needed.

10.3.2 MISHAPS

Mishaps are classified as Type A, B, C, or D in accordance with the definitions in section 10.2.1. All mishaps shall be entered into the NASA IRIS database and information updated every 30 days until the investigation and the corrective actions are complete and closed by the responsible organization.

NOTE: For assistance with the NASA IRIS database or its use, contact the Institutional S&MA Division.

10.3.3 CLOSE CALLS

The definition of a close call is contained in section 10.2.2. For close calls, an assessment of the worst case potential mishap severity and probability of occurrence shall be performed. The mere existence of a hazard does not constitute a close call. In order to meet the definition of a close call, there must be an undesired and unexpected event that has potential for causing a mishap or negative mission impact, even though neither occurred. For example, a sidewalk that is buckled and uneven is classified as a hazard by its mere existence. If someone were to trip or fall, and escape injury or only require first aid, the event is classified as a close call if the event had significant potential to have been any type of mishap. All close calls shall be entered into the NASA IRIS database.

NOTE: For assistance with the NASA IRIS database or its use, contact the Institutional S&MA Division.

10.3.4 EXPOSURE TO HAZARDOUS SUBSTANCE

Personnel exposure, or suspected exposure, to a hazardous substance exceeding allowable limits (quantity level or exposure time) shall be reported immediately to the Occupational Health Facility (OHF) or, if not located at KSC, to a licensed medical physician. All exposures shall go through the OHF or licensed medical physician (if not located at KSC) for medical evaluation and treatment. Confirmed exposures exceeding allowable limits shall be reported and documented as a mishap or close call.

10.3.5 MUSCULOSKELETAL DISORDERS (MSD)

Lost time cases due to a MSD or repeated trauma injury or illness shall be classified as a mishap. For these cases, the date of diagnosis by a licensed physician or the first official lost time day, whichever occurs first, is the reported date that shall be entered into the NASA IRIS database.

10.3.6 OCCUPATIONAL ILLNESS

For cases of occupational illness due to long term exposure to hazards, such as abestosis, silicosis or hearing loss, the date of diagnosis by a licensed physician or the first official lost time day, whichever occurs first, is the date that shall be entered into the NASA IRIS database.

10.3.7 INJURIES INCURRED AS A RESULT OF A RECREATIONAL ACTIVITY

Recreational activitiy injuries shall be classified as NASA mishaps if the employee is on duty and is required to participate for job certification, training or by labor agreement. Each program/project or directorate organization sponsoring such recreational activity shall determine which activities employees can perform. Recreational activities shall be designed to minimize the potential for personal injury. Injuries resulting from off-duty use of KSC exercise facilities are not classified as NASA mishaps. On-duty, nonsponsored recreational activities are prohibited.

10.3.8 NATURAL PHENOMENON AND WEATHER-RELATED EVENTS

Damage resulting from natural phenomena or acts of nature (e.g., flooding, hurricanes, tornados, lightning strikes, wild fires), without human intervention, shall not be classified as a NASA mishap by the organization owning/controlling the damaged or lost property. An assessment of all damages incurred shall be performed and cost of repairs and/or replacement shall be tracked and entered into the NASA IRIS database. Natural phenomenon damage resulting from or made worse by failure of personnel to follow established procedures or standard practices, such as damage caused by animals as a result of personnel failing to properly secure and protect facilities and equipment, is not considered damage from natural phenomena, but is still classified as a NASA mishap or close call.

10.3.9 HIGH VISIBILITY MISHAPS AND CLOSE CALLS

Mishaps or close calls that may draw media attention, cause embarassment to NASA, or other events deemed important by NASA management are considered “high visibility” mishaps or close calls and may warrant a full NASA mishap investigation board.

10.3.10 MISHAPS AND CLOSE CALLS INVOLVING PROPERTY DAMAGE

The responsible manager, with review and concurrence by the NASA S&MA, shall calculate the direct cost of a mishap or close call by adding all the actual costs (or the estimate of the cost) (the greater value of actual or fair market value) of damaged property, destroyed property, or mission failure, actual cost of repair or replacement, labor (actual value of replacement or repair hours for internal and external/contracted labor), cost of the lost commodity (e.g., the cost of the fluid that was lost from a ruptured pressure vessel), as well as resultant costs such as environmental decontamination, property cleanup, and restoration. In cases where replacement parts are available from salvaged or excess equipment at little or no cost to NASA, the direct cost of the mishap or close call shall include the actual costs of replacement parts (if they were purchased new) plus labor calculated as if the salvage/excess parts were unavailable. In cases where insurance compensation, contractor compensation, or other compensation is available or provided, the direct cost of the mishap or close call shall include the direct cost (or estimate of the cost) as if this compensation were not available or provided.

10.4 REPORTING MISHAPS AND CLOSE CALLS

10.4.1 GENERAL REQUIREMENTS (CIVIL SERVICE AND CONTRACTOR)

a. Initial Reporting

Initial reporting requirements for mishaps and close calls are based on the preliminary, worst-case assessment of actual or potential severity and visibility.

b. NASA IRIS Database

All mishaps and close calls shall be entered into the NASA IRIS database within 24 hours of the event. Within 24 hours, NASA S&MA shall ensure that all NASA mishaps and close calls are recorded in IRIS and include the following information: Center submitting report; author of report; author's phone number and mail code; date report submitted; time report submitted; incident date; incident time; incident general location; exact location (if known); responsible organization; organization's point of contact; point of contact's phone number and mail code; mission affected; program impact (if known); number and type of injuries or fatalities (if known); type of damage to equipment, flight hardware, flight software, or facilities; estimate of direct cost of damage; and a brief description of the mishap or close call. IRIS cases shall be continuously updated as new information becomes available and, at a minimum, updated at least every 30 days until it is closed. For mishaps or close calls involving injury, the occupational health representative or other medical person shall provide the appropriate medical information regarding the person(s) injured and the nature of the injury(s) to the appropriate NASA KSC S&MA Division for inclusion in IRIS.

10.4.2 TYPE A, TYPE B, OR OTHER HIGHLY VISIBLE MISHAPS AND CLOSE CALLS (CIVIL SERVICE AND CONTRACTOR)

a. In order to facilitate the timely investigation and other notification requirements of NPR 8621.1, the responsible Civil Service or Contractor program/project or directorate organization shall immediately (within one hour) provide initial notification by telephone or in person to NASA S&MA, the Contracting Officer, and Contracting Officer Technical Representative (COTR). Initial notification shall include the time, the location, a description of the event, the organization(s) involved in the event, and a preliminary worst case estimate of the injuries/illness and/or the direct cost estimate of the damage resulting from the event.

NOTE: The NASA Safety and Mission Assurance Directorate will provide additional Center-wide and NASA Headquarters notifications.

b. Mishap notification must be acknowledged verbally, by e-mailed, or by fax. Information to be reported includes the Center name, location of incident, time of incident, number of fatalities (if known), number of hospitalized employees (if known), type of injury (if known), type of damage (if known), contact person, contact person's phone number, and a brief description of the mishap. In addition, within 24 hours, the S&MA Directorate shall follow up the initial phone notification to NASA Headquarters by sending an electronic notification that includes the following information: Center submitting report; author of report; author's phone number and mail code; date report submitted; time report submitted; incident date; incident time; incident general location; exact location (if known); responsible organization; organization's point of contact; point of contact's phone number and mail code; mission affected; program impact (if known); number and type of injuries or fatalities (if known); type of damage to equipment, flight hardware, flight software, or facilities; estimate of direct cost of damage; and a brief description of the mishap or close call.

c. Within 8 hours of a work-related mishap involving death of a Federal employee, or the hospitalization for inpatient care of 3 or more employees (provided at least 1 is a Federal employee) within 30 workdays after the mishap, the S&MA Directorate shall notify OSHA and provide the following information: the establishment name, location of incident, time of incident, number of fatalities (if known), number of hospitalized employees (if known), contact person, contact person's phone number, and a brief description of the mishap. After notifying OSHA, the S&MA Directorate shall inform NASA Headquarters that an oral report has been provided to OSHA. Contractors are responsible for reporting directly to OSHA when the mishap involves contractor personnel only.

d. For Type A, B or highly visible mishaps and close calls, a formal Mishap Investigation Board (MIB) (Contractor and/or Civil Service) shall be formed per section 10.5.1.

10.4.3 TYPE C OR D MISHAPS AND CLOSE CALLS

a. Contractor

Shuttle-Specific Requirements for section 10.4.3.a are contained in Chapter 18.

(1) The responsible contractor organization shall, within four hours of the event (or by 7:30 AM the next workday for mishaps occurring during shifts other than first shift), submit an initial report (e-mail or fax) to S&MA.

(2) In addition, all mishaps and close calls shall be electronically entered into the NASA Incident Reporting Information System (IRIS) database while complying with section 10.4.1.b.

(3) The initial report shall contain a description, the time, the location, and the organizations involved in the event, a preliminary worst case estimate of the injuries and/or cost estimate of the damage resulting from the event.

b. Civil Service

(1) Civil Service Mishaps Involving Injury or Illness (and which may also include property damage)

For mishaps involving more serious injury or illness involving direct emergency transport to off-site medical facilities, the emergency responders shall provide the OHF initial medical information documented on a KSC Form 6-2. For nonlife threatening injury or illness, the employee shall notify their supervisor and report to the OHF. The OHF shall record the medical evaluation on a KSC Form 6-2, and forward a copy to the Institutional S&MA Division and to the employee's supervisor (yellow copy). Upon receipt, the employee's supervisor shall fill out Section III of the KSC Form 6-2 and forward it to the Institutional S&MA Division within 72 hours of the mishap. The Institutional S&MA Division shall enter the information into the NASA IRIS database, and update as appropriate.

(2) Civil Service Mishaps or Close Calls Involving Property Damage Only

For mishaps or close calls involving damaged property only, the responsible Civil Service organization shall provide initial notification to S&MA and forwarded to the appropriate S&MA division and the Institutional S&MA Division, Institutional Safety Branch within 4 hours of the mishap or close call (or by 7:30 AM the next workday for mishaps occurring during shifts other than first shift). The appropriate NASA KSC S&MA Division shall ensure that the responsible civil service organization enters the data into the NASA IRIS database, and update as appropriate.

10.4.4 REPORTING DAYS AWAY FROM WORK (CIVIL SERVICE AND CONTRACTOR)

a. Civil Service and Contractors

Days away from work shall be entered into the NASA IRIS database by the responsible contractor organization (for contractor days away from work) or the Institutional S&MA Division (for Civil Service days away from work). Days away from work shall be counted for the calendar days away from work for 180 days duration. Reporting of days away from work beyond 180 total days away due to a single injury or illness is not required. A day away from work is defined as a full work day, and results from a nonfatal traumatic injury, or a nonfatal nontraumatic illness, that causes one or more days away from work beyond the day or shift on which it occurred. Only days away from work directed or approved by a licensed physician shall be recorded as days away. In calculating total days away from work, the total number of calender days off prescribed by the physician shall be counted, even if the employee would not normally work on some of those days (e.g., weekends, holidays or scheduled days off). For injuries or illnesses that become long-term or permanent disability cases, the mishap report status shall be updated in the NASA IRIS database by the responsible contractor organization or the Institutional S&MA Division to reflect the new mishap classification.

b. For Civil Service Only

When an injury or illness becomes a “time away from work” case, the Institutional S&MA Division Chief or Lead Engineer shall provide notification per NPR 8621.1.

10.4.5 OTHER NASA CENTERS PERFORMING WORK AT KSC

For work performed at KSC that is exclusively under the control of another or other NASA Center(s) (i.e., without the participation of KSC employees or contractors), initial and follow-up mishap/close call reporting will include notification of the host KSC program/project and S&MA Directorate. This requirement is in addition to their own NASA Center mishap/close call reporting and follow-on investigation, corrective action, and lessons learned requirements.

10.5 INVESTIGATION

10.5.1 MISHAP INVESTIGATION BOARDS (MIBS)

a. NASA MIBs

NASA Mishap Investigation Boards shall be formed for all Type A or B mishaps. Mishap Boards may also be formed for other mishaps or close calls as deemed necessary by the Center Director or program/project or organizational Director. Mishap Board investigations shall be accomplished in accordance with the requirements of NPR 8621.1.

b. Contractor MIBs

For NASA mishaps resulting from NASA contractor operations, the NASA Board Appointing Official, with the concurrence of the S&MA Director, may delay the formation of a separate NASA Mishap Investigation Board (or activity) pending the review and acceptance of the contractor report. In this case, a letter signed by the NASA Board Appointing Official shall be sent to the contractor notifying them of NASA’s intent to delay formation of a separate NASA Mishap Investigation Board. NASA also retains the option of providing a Government representative on Contractor-managed MIBs.

10.5.2 NON-BOARD MISHAP AND CLOSE CALL INVESTIGATIONS

All mishaps and close calls shall be investigated to identify the root cause(s) and other contributing cause(s). Within 30 working days of the mishap or close call, the results of the investigation shall be documented in the NASA IRIS database.

a. Civil Service Non-board Mishap and Close Call Investigations

For mishaps or close calls with damage to property exclusively under the control of NASA Civil Service personnel, the appropriate NASA KSC S&MA Division shall ensure that the NASA program/project conducts the investigation and enters the data into IRIS. When injury or illness to civil service personnel is involved, the Institutional S&MA Division, in conjunction with the NASA program/project or NASA KSC S&MA Division, shall conduct the investigation. Civil Service injury and illness investigation results shall be documented in Section III of KSC Form 6-2 and submitted to the Institutional S&MA Division for entry into the NASA IRIS database. The program/project or NASA KSC S&MA Division shall maintain involvement and oversight in the investigation and analysis, and provide consultation on an as needed basis.

b. Contractor Non-board Mishap and Close Call Investigations

Contractor organizations are responsible for investigating their own nonboard mishaps and entering the results of the investigation directly into the NASA IRIS database. Both the appropriate program/project and the appropriate NASA KSC S&MA Division shall maintain insight into the investigation of contractor mishaps, track progress as documented in the NASA IRIS database and perform independent assessments of the investigation results and the effectiveness of the identified corrective action.

10.6 MISHAP REPORTS

10.6.1 MISHAP INVESTIGATION BOARD (MIB) REPORTS

a. The mishap investigation report shall contain a description of the structured analytical techniques used to identify causal factors, detailed documentation of mishap data, discussion of root cause(s), and significant observations, findings and recommendations. The report shall also include a proposed Corrective Action Plan (CAP) to be used as a framework for further development and implementation. Witness statements shall be kept separate from the main portion of the report so that they can be easily separated and withheld from release and distribution of the report. NPR 8621.1 contains detailed information on report requirements and format. Within 75 workdays of the mishap or close call, the MIB shall submit the completed and signed mishap report to the appointing official. Once the report is approved, the MIB Chair shall ensure that the NASA IRIS database is updated with the report and proposed corrective action plan and distribute the final report in accordance with NPR 8621.1. The Institutional S&MA Division is the official repository for all MIB reports and associated documentation. Witness statements and medical records shall be sealed and retained by the S&MA Directorate in a locked file, and are not part of the distributed MIB report.

b. Contractor reports shall undergo a formal review by NASA, and, once accepted, a formal letter of acceptance from the NASA Board Appointing Official will be provided to the Contractor.

10.6.2 NON-BOARD MISHAP INVESTIGATION BOARD REPORTS

A mishap report documenting investigation results including identification of root cause(s), significant observations, findings, and recommendations shall be entered into the NASA IRIS database within 30 days of the event.

10.7 CORRECTIVE ACTIONS

a. Corrective action(s) shall be determined and implemented in order to prevent recurrence of similar events.

b. Immediately after the mishap report has been authorized for public release, the appointing official shall direct the responsible organization to develop a CAP for those recommendations approved by the endorsing officials.

c. Within 15 workdays from being tasked, the responsible organization shall develop and submit the CAP to the appointing official.

d. The CAP shall contain a matrix or other means of matching corrective actions to all findings and recommendations.

e. The CAP shall provide corrective action(s) for the root cause(s) identified, the proximate and intermediate causes, contributing factors, and for all other failed controls or barriers to the mishap or close call.

f. The CAP shall provide a description of the corrective action(s), and identify (to the lowest level possible) the organization(s) responsible for implementation and the organization(s) responsible for ensuring completion the action item(s).

g. The responsible organization shall monitor corrective action activities for mishaps and close calls and determine if they are carried out according to plan.

10.8 LESSONS LEARNED

a. All mishaps and close calls shall be evaluated for any lessons learned.

b. When the evaluation results in lessons learned, then the lessons learned shall be submitted to the NASA Lessons Learned Information System (LLIS) in order to share this information and prevent recurrence.

NOTE: The LLIS is available to all NASA and NASA contractor personnel at http://llis.nasa.gov/.

10.9 METRICS AND TREND ANALYSIS

10.9.1 SAFETY STATISTICS RECORD (SSR)

a. A Safety Statistics Record, KSC Form 6-22V2 NS, shall be completed monthly by all KSC contractor, program/project, and directorate organizations and submitted to the Institutional S&MA Division for use in developing Center-wide safety metrics.

b. If adjustments, corrections or additions to a previous fiscal year's statistical data occur, an updated year-end SSR for the affected fiscal year shall be submitted.

10.9.2 TREND ANALYSIS

All KSC program/project or directorate organizations shall perform regular analysis of safety-related mishap and metric data in order to identify trends requiring corrective or preventive actions.

10.10 MISHAPS INVOLVING PAYLOAD CUSTOMERS, RESIDENT OFFICE PERSONNEL AND OFFICIAL VISITORS

For mishaps exclusively affecting non-KSC Civil Service or Contractor personnel or property (i.e., personnel who are conducting official business on KSC but who are not NASA KSC Civil Servants or Contractors), KSC will provide initial response, medical services, and control of the mishap scene. In this case, the investigation and reporting process will be determined by the appropriate Memorandum of Understanding (MOU) or Customer Agreement, or the organization's Center or corporate safety office. These mishaps will not be counted as NASA

KSC mishaps unless otherwise stated by a formal agreement. The appropriate NASA KSC program/project and S&MA Directorate shall be provided insight into the investigation and be provided courtesy copies of the final mishap report.

13.18 SAFETY REQUIREMENTS FOR DESIGN, TEST, AND GROUND PROCESSING OF FLIGHT COMPOSITE OVERWRAPPED PRESSURE VESSELS (COPVS) AT THE KENNEDY SPACE CENTER (KSC), CAPE CANAVERAL AIR FORCE STATION (CCAFS), AND THE VANDENBERG AIR FORCE BASE (VAFB)

Shuttle-Specific Requirements for this section are contained in Chapter 18.

NOTE: The interim requirements letter between NASA KSC and the Air Force dated November 23, 1993, remains in effect for COPVs processed at KSC, CCAFS, VAFB, and Dryden under the requirements of AFSPCMAN 91-710.

13.18.1 GRAPHITE/EPOXY (Gr/Ep)COMPOSITE OVERWRAPPED PRESSURE VESSELS (COPVs)

a. The design, qualification, and acceptance testing of Gr/Ep COPVs shall comply with the requirements of ANSI/American Institute of Aeronautics and Astronautics (AIAA) S-081A-2006, "Space Systems-Composite Overwrapped Pressure Vessels (COPVs)."

b. Gr/Ep COPVs shall employ proven processes and procedures for manufacture and inspection. The fabrication process shall provide for initial, in-process, and final inspections of the liner and overwrap to support the safe operation and mission success of the vessels as required by ANSI/AIAA S-081A-2006.

c. Prior to the first pressurization of Gr/Ep COPVs at the KSC, CCAFS, VAFB or Dryden, an inspection of the vessel for visible damage shall be performed by a trained inspector. The trained inspector's skills shall be comparable to a Level II visual inspector, per the American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A (see ANSI/AIAA S-081A-2006, Paragraph 5.5.3). If this inspection is not possible at the launch site (i.e. the Gr/Ep COPV is not accessible), then it shall be conducted the last time the Gr/Ep COPV is accessible for inspection.

d. After completing the visual inspection, and determining that there is no evidence of critical damage to the Gr/Ep COPV, the vessel shall be pressure tested to 1.1 times the ground maximum operating pressure. The pressure shall be held a minimum of ten (10) minutes. This pressurization shall be conducted remotely or a blast shield shall be used to protect personnel.

e. If Gr/Ep COPVs are to be pressurized at the KSC, CCAFS, VAFB, or Dryden to pressures greater than one third of the Gr/Ep COPVs design burst pressure, the pressurizations shall be performed remotely or a blast shield shall be used to protect personnel. If the vessel is to remain pressurized, personnel access shall not be permitted to the area for at least ten (10) minutes after pressurization is completed.

f. Personnel limits for each operation on or near the Gr/Ep COPV/Spacecraft shall be established to minimize personnel exposure to the pressurized tank when at pressures greater than one third design burst pressure.

g. The transport of pressurized Gr/Ep COPVs at pressures greater than one third design burst pressure shall be along routes that minimize exposure to personnel and facilities with escort during designated "off-shift" time periods.

h. The Mechanical Damage Control Plan (MDCP) for the Gr/Ep COPVs shall be provided by the design agency and made available for review by the applicable NASA Safety organization.

i. Users shall develop Emergency Response Plans (ERPs) that include contingency safing and backout plans for Gr/Ep COPVs containing hazardous fluids or in proximity to hazardous commodities. The ERPs shall consider leaks, impacts, and exposure to incompatible chemical agents. If implemented, a real-time assessment shall be accomplished and contingency operations taken as required. The ERP shall be approved prior to the start of ground operations by the applicable NASA Safety organization.

13.18.2 KEVLAR COMPOSITE OVERWRAPPED PRESSURE VESSELS (COPVs)

a. All new Kevlar COPVs shall comply with the design, qualification, and acceptance testing requirements of ANSI/AIAA S-081A-2006.

b. Kevlar COPVs shall employ proven processes and procedures for manufacture and inspection. The fabrication process shall provide for initial, in-process, and final inspections of the liner and overwrap to support the safe operation and mission success of the vessels as required by ANSI/AIAA S-081A-2006. .

c. Prior to the first pressurization of Kevlar COPVs at the KSC, CCAFS, VAFB or Dryden, an inspection of the vessel for visible damage shall be performed by a trained inspector. The trained inspector's skills shall be comparable to a Level II visual inspector per the American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A (see ANSI/AIAA S-081A-2006, Paragraph 5.5.3). If this inspection is not possible at the launch site (i.e. the Kevlar COPV is not accessible), then it shall be conducted the last time the Kevlar COPV is accessible for inspection.

d. After completing the visual inspection, and determining that there is no evidence of critical damage to the Kevlar COPV, the vessel shall be pressure tested to 1.1 times the ground maximum operating pressure. The pressure shall be held a minimum of ten (10) minutes. This pressurization shall be conducted remotely or a blast shield shall be used to protect personnel.

e. If the Kevlar COPVs are to be pressurized at the KSC, CCAFS, VAFB, or Dryden to pressures greater than one-third the Kevlar COPV design burst pressure, the pressurization shall be conducted remotely or a blast shield shall be used to protect personnel. If the vessel is to remain pressurized, personnel access shall not be permitted to the area for at least ten (10) minutes after pressurization is completed.

f. Personnel limits for each operation on or near the Kevlar COPV/Spacecraft shall be established to minimize personnel exposure to the pressurized tank when at pressures greater than one third design burst pressure.

g. The transport of pressurized Kevlar COPVs at pressures greater than one third design burst pressure shall be along routes that minimize exposure to personnel and facilities with escort during designated "off-shift" time periods.

h. The Mechanical Damage Control Plan (MDCP) for the Kevlar COPVs shall be provided by the design agency for review by the applicable NASA Safety organization.

i. Users shall develop Emergency Response Plans (ERPs) that include contingency safing and backout plans for Kevlar COPVs containing hazardous fluids or in proximity to hazardous commodities. The ERPs shall consider leaks, impacts, and exposure to incompatible chemical agents. If implemented, a real-time assessment shall be accomplished and contingency operations taken as required. The ERP shall be approved prior to the start of ground operations by the applicable NASA Safety organization.

APPENDIX A - DEFINITIONS

Acceptance: *(Safety Variances)* Taking the responsibility for the potential outcome of a documented increase in risk.

Affected Employee(s): *(Lockout/Tagout)* Those employees who operate or use the equipment being serviced or maintained, or others in the area where equipment is locked and/or tagged out.

Alteration: (PVS) Change that affects the pressure containing capability of a pressure vessel. Nonphysical changes such as an increase in the maximum allowable working or design pressure (internal or external) or design temperature of a pressure vessel is considered an alteration. A reduction in minimum temperature such that additional mechanical tests are required is also considered an alteration. See ANSI/NB-23, Chapter 1, Glossary of Terms.

Applicable Codes, Standards, Guides: Any national consensus code, standard or guide, or any NASA KSC accepted design code, standard or guide for the design verification of pressure vessels, systems, or their components.

Approval: *(Safety Variances)* Decision by the SMA TA that the request for relief is for relief from NASA policy and may be implemented after the appropriate person accepts the risk.

Authorized Employees: *(Lockout/Tagout)* Those employees who service or maintain equipment and perform lockout/tagout procedures.

Authorized Personnel: The maximum number of personnel permitted within a control area at any one time. Presence of all personnel is not mandatory. Mandatory personnel participation is normally controlled by call to stations and/or steps/sequences within the body of the procedure.

Blast Danger Area (BDA): A hazardous clear area. Clearance prior to establishment of a major explosive hazard, such as vehicle fuel/oxidizer load and pressurization. The area subject to fragment and direct overpressure resulting from the explosion of the booster/payload.

Breathing Escape Unit (BEU): Used only for escape from a hazardous environment.

Buddy System: An arrangement used when risk of injury is high, where personnel work in pairs with one person in the pair stationed nearby (the system does not demand shoulder-to-shoulder contact, but rather visual contact and a proximity that allows each buddy to help the other in an emergency), to serve as an observer to render assistance if needed.

Category I SCAPE: PHE with backpack. Operating time from air on to air off is 120 minutes.

Category IV SCAPE: Same as Category I with hose-line breathing in lieu of the backpack.

Category VI SCAPE: ‘Chemturion’ CPS - “blue suit” with hose-line breathing.

Caution: A notation before an operational step which, if not adhered to or observed, could result in damage to equipment.

Certification: (PVS) Documentation qualifying a vessel or system to operate in its particular service. GSE/GS functional validation of each critical function by test, analysis, and/or similarity.

Cleared Area: An area where a hazardous condition exists or a hazardous operation is in progress; personnel are prohibited from entering.

Close Call: An occurrence or a condition of employee concern in which there is no injury or only minor injury requiring first aid and no significant equipment/property damage/mission failure (less than $1000), but which possesses a potential to cause a mishap.

Code PVS: (PVS) Pressure vessels and pressurized systems that are designed, fabricated, installed, Code stamped, and maintained in strict conformance with the requirements of the national consensus code or standard.

Commercial Off the Shelf (COTS): Commercial items that require no unique Government modification or maintenance over the life cycle of the product to meet the needs of the procuring agency. A commercial item is one customarily used for non-Governmental purposes that has been or will be sold, leased, or licensed (or offered for sale, lease, or license) in quantity to the general public. An item that includes modifications customarily available in the commercial marketplace or minor modifications made to meet NASA requirements is still a commercial item.

Compatibility: (COPV) The ability of two materials or substances to come into contact without altering their structure or causing a reaction in terms of permeability, flammability, ignition/combustion, functional/material degradation, contamination, toxicity, pressure/ temperature, shock, oxidation, and corrosion.

Competent Person *(Electrical Extension Devices)* An individual who, by way of training and/or experience, is knowledgeable of applicable standards, is capable of identifying workplace hazards relating to the specific operation, is designated by the employer, and has authority to take appropriate actions by OSHA's definition a competent person.

Concurrence: (Safety Variances) Formal documentation of an agreement/recommendation/opinion, but with no authority to approve or accept risk.

Consequence (Severity): An assessment of the worst case credible potential effect(s) of a risk without any controls in place that is documented in terms of a consequence/severity level using the applicable risk matrix..

Control Area: A designated, limited-access area where a hazardous condition exists or a hazardous operation is in progress; nonessential personnel are prohibited from entering.

Control Point: The area or place where the task leader and any other support groups direct and monitor the operation.

Controlled Switching: No flight vehicle/element or GSE commands issued, no switches or circuit breakers operated on the flight elements or GSE electrically connected to the flight elements, except those commands and switch/ circuit breaker operations directed by the TD (and sub-tasks) requiring controlled switching.

Credible: A condition that can occur and is reasonably likely to occur. A condition is considered reasonably likely to occur (using numeric data if available), if conditions or failure

modes have a probability of occurrence greater than 1 X 10^{-6} in the projected usage/life of the equipment.

Critical Function: A system function which, if lost or improperly performed could result in a Level 4 or 5 consequence/severity effect per the applicable risk matrix.

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.

Critical Position: A critical position is one in which the worker's job performance can directly impact ground safety, flight safety or mission success. This includes but is not limited to:

a. Workers dealing directly with flight hardware, software, or ground support equipment, or

b. Employees having authority to make decisions on flight hardware or software processing, or

c. Workers involved in launch or landing activities, or

d. Personnel who work in ground systems that have a functional or physical interface with flight systems, or

e. Employees working with other systems that are hazardous by nature.

In the types of positions delineated above, there is not more than one level of check and balance regarding the employee's decisions or actions.

Critical Lift: A lift where loss of control could result in loss of life, loss 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, etc., where loss would have serious programmatic impact.

Critical System: A system that has at least one critical function.

De-Rating: (PVS) The lowering of the maximum allowable working pressure or narrowing of the allowable operating temperature range of a pressure vessel or system.

Dead Front: (Electrical Extension Devices) Without live parts exposed to a person on the operating side of the equipment.

Design Burst Pressure: (PVS) The theoretical pressure at which a vessel or other pressurized component would burst, based on calculations using accepted formulas and material properties. Vessels and systems to be placed in service are never subjected to a burst pressure test.

Design Pressure: (PVS) The pressure used in the design of a vessel or system for the purpose of determining minimum permissible thickness or physical characteristics of the different parts. When applicable (for liquids), static head will be added to the design pressure to determine the thickness of any specific part of a vessel. (Reference Appendix 3, Paragraph 3-2, ASME Code, Section VIII, Division 1, and Paragraph 301.2, ASME B31.3).

Design Temperature: (PVS) The metal temperature used in the design of a vessel or system for determining the minimum required thickness of the components, and for selecting the maximum allowable stress for the materials used in the vessel or system.

Deviation:

(General) An authorization for temporary relief in advance from a specific requirement, requested during the formulation/planning/design stages of a program/project operation to address expected situations. OSHA refers to this as an alternate or supplemental standard.

(Safety Variances) A variance that authorizes temporary relief in advance from a specific requirement and is requested during the formulation/planning/design stages of a program/project operation to address expected situations.

(TOPs) Documented and approved permission that authorizes the addition, deletion, or modification of steps or sequences in a Category I or Category II TOP. KSC Form 4-30A can be used for this purpose.

DOT Service: (PVS) Those uses of PVS covered by the regulations contained in 49 CFR 100 – 185, Pipeline and Hazardous Materials Safety Administration.

Electroexplosive Device (EED): EED Categories – EEDs are categorized based on the effects of inadvertent initiation. EED categories are as follows:

a. Category A: EEDs which, by the expenditure of their own energy, or because they initiate a chain of events, may cause injury of death to people or damage to property.

b. Category B: EEDs, which, in themselves, or by initiating a chain of events, will not injure people or damage property.

Eliminated Hazard: A hazard that has been eliminated by completely removing the hazard causal factors.

Emergency Egress: The capability to exit a location and leave a hazardous situation within a specified amount of time.

Emergency Instructions: *(TOPs)* Instructions, contained within a TOP that provide for safing hardware and for implementing emergency actions required to evacuate or safeguard personnel, and prevent or limit the extent of damage should an emergency arise.

Emergency Life Support Apparatus (ELSA): A self-contained, short duration, portable breathing device consisting of a full hood attached to a compressed air cylinder to provide breathable air to personnel during emergency escape from hazardous environments.

Emergency Procedures Document (EPD): A document produced for work areas to provide the processing teams with procedures to be followed if an emergency occurs at any time in that facility.

End Item: A final combination of end products, components, parts, or materials that is ready for its intended use.

Essential Personnel: The number of personnel required within the control area for a particular operation as documented in the procedure.

Exception: A variance that authorizes permanent relief from a specific requirement which may be requested at any time during the life cycle of a program/project.

Excluded PVS: (PVS) A PVS that is not required to meet the certification (or recertification) requirements of NPD 8710.5, NASA Safety Policy for Pressure Vessels and Pressurized Systems, and need not be included in the PVS configuration management system. Excluded PVS are subject to all applicable laws, regulations, safety requirements, NASA requirements, and appropriate NCS and must be maintained in accordance with applicable NCS.

Existing PVS: (PVS) PVS are considered to be "Existing PVS" if installed no later than 6 months from the date of original issue of this document.

Explosive Test Equipment: Electrical circuit test equipment used for testing explosives items, pyrotechnic devices, or circuits connected to those items before or after installation.

Explosives: Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, detonation, or other suitable initiation, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate.

Extension Device: (Electrical Extension Devices) Extension cord, power strip, wall multi-outlet plug that increases the number of outlets, power plug adapter.

Facility: A location where equipment/machinery resides (e.g., buildings, labs, shops, processing areas).

Factor of Safety (FOS or FS):

(General) Ratio of the design condition to the maximum operating conditions specified during design.

(COPVs) Ratio of design burst pressure to maximum ground processing pressure.

(*PVS)* Unless otherwise noted, this refers to the material design factor of safety on structural failure and is equal to the lesser of the material strength divided by the material stress under anticipated loading or the actual buckling load divided by the anticipated buckling load.

First Aid: Medical assistance provided to a person in need. Emergency First Aid is the first response to a life-threatening medical emergency until regular medical personnel can be notified or arrive onsite. Non-Emergency First Aid is the treatment of minor medical needs which may or may not require further medical treatment.

According to 29CFR 1904.7(b)(5)(ii)), the following actions are considered "First Aid":

(a) Using a non-prescription medication at nonprescription strength (for medications available in both prescription and non-prescription form, a recommendation by a physician

or other licensed health care professional to use a non-prescription medication at prescription strength is considered medical treatment for recordkeeping purposes);

(b) Administering tetanus immunizations (other immunizations, such as Hepatitis B vaccine or rabies vaccine, are considered medical treatment);

(c) Cleaning, flushing or soaking wounds on the surface of the skin;

(d) Using wound coverings such as bandages, Band-Aids™, gauze pads, etc.; or using butterfly bandages or Steri-Strips™ (other wound closing devices such as sutures, staples, etc., are considered medical treatment);

(e) Using hot or cold therapy;

(f) Using any non-rigid means of support, such as elastic bandages, wraps, non-rigid back belts, etc. (devices with rigid stays or other systems designed to immobilize parts of the body are considered medical treatment for recordkeeping purposes);

(g) Using temporary immobilization devices while transporting an accident victim (e.g., splints, slings, neck collars, back boards, etc.).

(h) Drilling of a fingernail or toenail to relieve pressure, or draining fluid from a blister;

(i) Using eye patches;

(j) Removing foreign bodies from the eye using only irrigation or a cotton swab;

(k) Removing splinters or foreign material from areas other than the eye by irrigation, tweezers, cotton swabs or other simple means;

(l) Using finger guards;

(m) Using massages (physical therapy or chiropractic treatment are considered medical treatment for recordkeeping purposes); or

(n) Drinking fluids for relief of heat stress.

NOTE: Per 29CFR 1904.7(b)(5)(iii) this is a complete list of all treatments considered first aid.

Flexhose: There are two basic types of flexhoses – those constructed entirely of metal, herein described by the term “metal hose”, and those constructed of elastomeric material or a combination of elastomeric material and metal, herein described by the term “nonmetallic hose”.

a. Metal Hose: A metal hose consisting of a flexible metal pressure carrier tube surrounded by an outer layer of wire braid (some low pressure metal hoses do not utilize an outer layer of wire braid). The flexible metal pressure carrier tube and the wire braid are attached to the hose end fittings by welding, silver-soldering, or brazing (some metal hoses used for cryogenic applications utilize an inner and outer flexible metal tube with a vacuum in the space between the inner and outer flexible tubes).

b. Nonmetallic Hose: A nonmetallic hose consists of a polytetrafluoroethylene or other flexible elastomeric material pressure carrier tube reinforced by fabric or wire braid with metal end fittings attached by mechanical means such as swaging or crimping.

Flight Hardware: Hardware designed and fabricated with the intent to fly.

Flight Hardware Processing Facilities: Buildings and areas, to include their respective perimeter fence, where flight hardware is processed.

Flight Termination System: A type of range safety system designed, tested, and incorporated into vehicles that provides for the independent and deliberate termination of an errant/erratic vehicle's flight.

Fracture Control: Fracture control is a set of policies and procedures involving the application of analysis and design methodology, manufacturing technology, and operating procedures to prevent structural failure due to the initiation of and/or propagation of flaws or crack-like defects during fabrication, testing, and service life.

Fracture Mechanics: An engineering concept used to predict flaw growth and fracture behavior in materials and structures containing cracks or crack-like flaws.

Ground-based PVS: (PVS) All PVS, including PVS based on barges, ships, or other transport vehicles, not specifically excluded in this document. Flight weight PVS used for their intended purpose aboard active air or space craft, even though on the ground, are not included in this definition, but flight weight PVS converted to ground use are included.

Ground-Fault Circuit-Interrupter: (Electrical Extension Devices) A device intended for the protection of personnel that functions to deenergize a circuit or a portion of a circuit within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Ground Support Equipment (GSE): Nonflight systems, equipment, or devices and associated software with a physical or functional interface with flight hardware that are used to support the operations of transporting, storing, receiving, handling, assembly, inspection, tests, checkout, monitoring, controlling, servicing, launch, and recovery of aircraft, spacecraft, launch vehicles and payloads.

Ground System (GS): Ground-based systems used to transport, handle, test, checkout, service, and control aircraft, launch vehicles, spacecraft, or payloads

Hazard: A condition that has the potential to result in or contribute to injury, death, or equipment damage.

Hazard Analysis: Identification and evaluation of existing and potential hazards, and the recommended mitigation for the hazard sources found.

Hazardous Energy: (*Lockout/Tagout)* Any electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, gravity, or other energy that could cause injury to personnel.

Hazardous Fluids: (PVS) Gases or liquids of such a nature that a given quantity of the gas or liquid's vapor, when mixed or unmixed with air, is hazardous to personnel or equipment due to

flammability, toxicity, or extremes of temperature. The following fluids are considered to be hazardous; additional fluids may be designated to be hazardous at the discretion of the KSC PSM.

a. Alcohol
b. Ammonia
c. Gaseous Hydrogen
d. Hydrazine
e. Liquefied Petroleum Gases (Propane, Butane, as defined in NFPA 58)
f. Liquid Air
g. Liquid Hydrogen
h. Liquid Nitrogen
i. Liquid Oxygen
j. Monomethylhydrazine
k. Nitrogen textroxide
l. Trichloroethylene

Hazardous Material: Any solid, liquid, or gaseous material which meets the hazard reporting requirements of 29CFR 1910.1200. This includes commodities that, under foreseeable conditions, are toxic, carcinogenic, cryogenic, explosive, flammable, pyrophoric, water-reactive, corrosive, an oxidizer, a compressed gas, a combustible liquid, or are chemically unstable.

Hazardous Operation (Hazardous Tasks): Any operation or other work activity that has a high potential to result in loss of life, serious injury to personnel or public, or damage to property due to the material or equipment involved or the nature of the operation/activity itself.

Hazardous Steps Affected/Added: All changes and deviations which:

a. Change or modify hazardous steps.

b. Initiate/add hazardous steps to existing hazardous/nonhazardous TOPs.

c. Intensify/extend hazardous steps to existing hazardous TOPs (e.g., extend duration/time of hazardous operation, extend hazardous control area, and add number of personnel in control area).

d. Change the existing safety requirements.

Hazardproof: Prevention of an explosive atmosphere penetrating electrical fixtures where sparking or arcing could occur.

Hydrostatic Test: (PVS) The test of a pressure vessel or system during which the vessel or system is filled with a liquid (usually water) and pressurized to a designated level in a manner prescribed in the applicable code. (Reference Paragraph UG-99, ASME Code, Section VIII, Division 1 or Article T-3, ASME Code, Section VIII, Division 2.)

Hydraulics: (PVS) Hydraulic systems using commercially available hydraulic fluid. Note: Associated pneumatic storage, actuation devices, or components that are used in a hydraulic system are not considered hydraulics. Pressurized hydraulic fluid containing devices are included if the system is included.

Hyper Ops Class A PPE: Personal protective equipment category that is the minimum PPE required for hypergolic operations that have a potential for liquid flow release and heavy vapor concentrations. Refer to Figure 8-2.

Hyper Ops Class B PPE: Personal protective equipment category that is the minimum PPE required for hypergolic operations that have very low or no potential for liquid flow, and a low potential for liquid residuals, and a potential for vapor release. Refer to Figure 8-2.

Hyper Ops Class C PPE: Personal protective equipment category that is the minimum PPE required for hypergolic operations that have no potential for liquid flow (hypergolic fluids), and a low potential for limited vapor release, and an expectation that the Threshold Limit Valve/time Weighted Average (TLV-TWA) will not be attained through the monitoring of the breathing zone, and there is a two-valve isolation (with independent controls) from liquid sources. Refer to Figure 8-2.

Identified: (Electrical Extension Devices) Approved as suitable for the specific purpose, function as applied to equipment use, environment, or application, where described in a particular requirement.

Impact Limit Line: A line defining a limit beyond which a missile/spacecraft or specified portions thereof will not be allowed to impact.

Inactive Vessels/Systems: (PVS) These are vessels/ systems which are not in service because of changes in program requirements and have no current planned usage but have not been determined to be unsafe.

Industrial Operation: A task, usually performed in one location, and consisting of one or more work elements in which the person(s) performing the task has had training (certificate, license, etc.) to meet the technical requirements for processes, procedures, practices and methods that have been adopted as standard (e.g., machinist, electrician, plumber, fork lift operator, chemical handler.)

Inservice Inspection (ISI): (PVS) A periodic inspection of a vessel or system while in service. If required, the vessel or system will be inoperative during the inspection.

Inservice Inspection (ISI) Plan: (PVS) The plan is a list of inspections and tests and the frequency to be performed on the pressure vessels and/or pressurized systems.

Integrated Procedure: A procedure requiring the concurrence/approval of more than one contractor or KSC Primary Directorate Government organization, or other independent separate organizations involving test of interfacing systems, components, or elements.

Interim Change: Change made to an existing and approved TOP when there is insufficient time available to prepare a formal change (e.g., change pages). OMI deviations are one form of an interim change.

Job Cards: A Category I TOP designed for computer release through work control.

Labeled: *(Electrical Extension Devices)* Equipment bearing a label, symbol, or other identifying mark indicating compliance with nationally recognized standards/tests to verify safe use in a

specified manner, as confirmed by a nationally recognized testing laboratory which conducts periodic inspections of the production of the labeled equipment.

Leak Before Burst (LBB): (COPV) A failure mode such that any initial flaw in the Gr/Ep COPV liner will grow through the liner to cause leakage without burst of the overwrap.

Lethal Fluids: (PVS) Poisonous gases or liquids of such a nature that a very small amount of the gas or liquid mixed, or unmixed with air, is dangerous to life when inhaled. See ASME Code, Section VIII, Division 1, Paragraphs UW-2 and UCI-2, Division 2, Paragraph AG 301.1, and ASME B31.1, Appendix M. The following specification-grade fluids are to be considered lethal; additional fluids may be designated to be lethal at the discretion of the KSC PSM.

a. Aerozene 50
b. Hydrazine
c. Monomethyl Hydrazine
d. Nitrogen Tetroxide
e. Unsymmetrical Dimethyl Hydrazine

Lifting Devices and Equipment Manager (LDEM): The individual, designated by the KSC Center Director, who is responsible for the overall management of the KSC Lifting Devices and Equipment Program. The LDEM resides in the Launch Vehicle S&MA Division.

Likelihood (of Occurrence): An assessment of the likelihood or probability of a hazard's most severe effects transpiring. Likelihood (probability) takes into account that the hazard controls are in-place and effective.
Listed: *(Electrical Extension Devices)* Equipment is “listed” if it is of a kind mentioned in a list that is published by a nationally recognized laboratory that makes periodic inspection of the production of such equipment.

Local Control Area: A controlled access area (usually less than a 50-foot radius of the hazardous task) in which control is manageable on location by the operation and maintenance contractor and safety personnel using visual/voice contact to ensure personnel safety.

Lock: Lockout/tagout device that physically prevents the use of equipment or machinery.

Lockout Device: A mechanical block with a lock and key, or combination type, designed to secure an energy-isolation device in the safe position and prevent the energizing of equipment or machinery.

Lockout/Tagout: The process of configuring equipment in a temporary condition in which the release of energy is prevented from endangering personnel performing servicing and/or maintenance. The placement of a lock/tag on the energy isolating device in accordance with the established procedure, indicating that the energy isolating device shall not be operated until removal of the lock/tag in the accordance with the established procedure.

Major Control Area: A controlled access area (usually greater than a 50-foot radius of the hazardous task) in which access management requires additional positive controls to ensure the safety of personnel.

Manloading: The maximum number of personnel permitted to occupy a defined area at a single time.

Maximum Allowable Stress Value: (PVS) The maximum unit stress permissible for any specified material that may be used in the design formulas.

Maximum Allowable Working Pressure (MAWP): (PVS) The maximum gage pressure permissible at the top of a completed vessel in its operating position for a designated temperature. This pressure is based on calculations for every element of the vessel using nominal thickness exclusive of allowances for corrosion and thickness required for loading other than pressure. It is the same as the design pressure for all cases where separate calculations are not made to determine MAWP. The MAWP is the basis for the pressure setting of the pressure relieving devices protecting the vessel.

Maximum Operating Pressure (MOP): (PVS) The highest pressure at which a vessel or system component normally operates. This pressure is based on operating requirements and may not exceed the MAWP or design pressure. MOP is synonymous with MEOP (Maximum Expected Operating Pressure) or maximum working pressure.

Maximum Work Time Deviation: An authorized exceedance of the MWT provisions that is documented and approved prior to the exceedance.

Maximum Work Time Violation: Exceedance of MWT limits without preapproval.

Medical Treatment: (29CFR 1904.7(b)(5)(i)) "Medical treatment" means the management and care of a patient to combat disease or disorder. For the purposes of Part 1904, medical treatment does not include:

(a) Visits to a physician or other licensed health care professional solely for observation or counseling;

(b) The conduct of diagnostic procedures, such as x-rays and blood tests, including the administration of prescription medications used solely for diagnostic purposes (e.g., eye drops to dilate pupils); or

(c) "First aid" as defined – see **First Aid**.

Mishap: An undesired and unexpected event that results in injury requiring more than first aid, occupational illness to personnel, and/or damage to property greater than $1000. Mishaps also include injuries or occupational illnesses resulting from repetitive stresses or exposures over a prolonged period of time. For purposes of investigation and reporting, mishaps are categorized as follows: Type A, Type B, Type C or Type D.

National Consensus Standard: (PVS) Any standard, or modification thereof: (1) adopted or promulgated by a nationally recognized standards-producing organization using procedures that demonstrate to the Secretary of Labor for Occupational Safety and Health that those persons interested in or affected by the standard have reached substantial agreement on its adoption; (2) formulated so that an opportunity existed for diverse views to be considered; and (3) designated by the Secretary or the Assistant Secretary, after consultation with other appropriate Federal agencies. (NOTE: A standard, as defined, requires appropriate conditions or activities to provide a safe and healthful employment environment.)

Non-Code PVS: (PVS) Any pressure vessel that is not stamped with the appropriate symbol and documented as complying with the original construction Code or any pressure piping system that does not meet the requirements of the appropriate fabrication code (e.g. ASME Section VIII, B31.1, B31.3), including PVS that were fabricated from non-Code materials by non-Code processes or organizations.

Non-Safety-Related Discrepancy: (PVS) Any discrepancy that does not increase the potential for injury or death to personnel or damage to hardware. The following are considered non-safety-related discrepancies (others may be added at the discretion of the KSC PSM):

a. Panels/systems not properly identified.

b. Stainless steel piping or tubing not coated for corrosion protection.

c. Missing or illegible identification tags on components (except for relief devices, pressure gages, and flex hoses).

d. Discrepancies between documentation and hardware.

e. Minor corrosion of vessels, piping, components, or supports.

Nondestructive Examination: (PVS) The 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.

Open Grain: Exposed solid propellant.

Operating or Working Temperature: (PVS) The metal temperature that will be maintained in the part of the vessel or system under consideration during normal operation.

Operating Pressure: (PVS) The gage pressure at which a vessel (top of the vessel) or system normally operates. For a vessel, the operating pressure does not exceed MAWP/design pressure, and for a system, it does not exceed the design pressure.

Operations Planning Sheets: A form used for repetitive TOPs, which is released for documentation and control of a single performance of a TOP.

Other Employees: (Lockout/Tagout) Those employees who may have reason to enter or work in the area where lockout/tagout procedures may be implemented.

Owner: (PVS) The management of the organization responsible for the PVS as defined in NPD 8710.5, NASA Safety Policy for Pressure Vessels and Pressurized Systems.

Personal Protective Equipment: Portable equipment that provides a barrier between an individual employee and hazardous materials or agents in the workplace.

Phase 1 Lightning Watch: Conditions in the atmosphere, developing or observed, that is expected to produce, or is producing, lightning which will arrive at specified areas within 30 minutes.

Phase 2 Lightning Warning: Lightning observed or thunder heard within 5 nautical miles, or forecaster determines the threat of lightning is immediate.

Photographic Equipment: Cameras, still and video, and electronic and/or enclosed flash assemblies.

Physical Agent: Any environmental factor, such as noise, temperature extremes, vibrations, etc., which may cause harm or injury to personnel

Piggybacking/Daisy Chaining: (Electrical Extension Devices) Plugging one or more electrical extension devices into another.

Placard Procedure: A simple procedure written or printed on a plaque attached to a facility or GSE end item that provides instructions for activating/deactivating that item.

Pneumatic Test: (PVS) A test of a pressure vessel or system in which a gas is introduced and pressurized to a designated level in a manner prescribed in the applicable code. (Reference Paragraph UG-100, ASME Code, Section VIII, Division 1, or Article T-4, ASME Code, Section VIII, Division 2, and Paragraph 345.5, ASME B31.1.)

Power Strip: (Electrical Extension Devices) (Also known as a plug board, power board, power bar, distribution board, gang plug, plug bar, multibox, extension lead, or relocatable power tap) is a strip of sockets that attaches to the end of a flexible cable and allows multiple devices to be plugged in.

Pressure Cycle: (PVS) The initiation and establishment of new pressure levels followed by a return to the conditions that prevailed at the beginning of the cycle. Two types of pressure cycles are considered:

a. Full pressure (startup or shutdown) cycle: any pressure cycle which has atmospheric pressure as one of its extremes and normal operating conditions (not exceeding vessel MAWP/design pressure) as its other extreme.

b. Partial pressure (normal operating) cycle: any pressure cycle within the full pressure cycle, which is required for the vessel or system to perform its intended purpose.

Pressure Relief Device (PRD): (PVS) A pressure relief device designed to actuate on inlet static pressure and to reclose after normal conditions have been restored. This includes relief valves, safety valves, and safety relief valves (NOTE: this definition is that of ASME PTC 25-2001).

Pressure Relief Device Set Pressure: (PVS) The pressure at which a pressure relief device is set to operate. Set to operate means the set pressure of a relief valve or spring-loaded nonreclosing device, the bursting pressure of a rupture disk device or the breaking pressure of a breaking pin device. (Reference Paragraphs UG-125 and UG-134, ASME Code, Section VIII, Division 1, and Part AR, ASME Code, Section VIII, Division 2.)

Pressure System: (PVS) An assembly of components under pressure, including vessels, piping, valves, relief devices, pumps, expansion joints, gages, etc. This includes systems containing hazardous or lethal fluids at any pressure above 0 MPa (gage) (0 lb/in^2 (gage)) and

systems containing nonhazardous or nonlethal fluids above 0.1 MPa (gage) (15 lb/in^2 (gage)), unless otherwise specifically excluded.

Pressure Systems Manager (PSM): (PVS) The individual designated by the KSC Center Director who is responsible for the overall management of the KSC Pressure Vessel/Systems (PVS) Certification Program. The KSC PSM resides in the Institutional S&MA Division.

Pressure Test: See **Hydrostatic Test** and **Pneumatic Test**.

Pressure Vessel: (PVS) Any vessel used for the storage or handling of gas or liquid under positive pressure. Included in this definition are components of systems (e.g., heat exchanger shells and drying towers, and other shell structures) for which the rules of the ASME Code, Section VIII, would apply. Vessels containing hazardous or lethal fluids at any pressure above 0 MPa (gage) (0 lb/in^2 (gage)), and vessels containing nonhazardous or nonlethal fluids above 0.1 MPa (gage) (15 lb/in^2 (gage)) are included unless otherwise specifically excluded.

Pretask Briefing: A briefing held immediately prior to the start of (a) hazardous sequence(s), which details the hazard(s) and objective(s) associated with that particular sequence.

Pretest Briefing: A briefing held prior to the start of a hazardous operation with a major control area, which details the hazard(s) and objective(s) of the operation and confirms that all operational and support elements are ready.

Processing Mishap/Close Call: A mishap or close call, which occurs during the act of ground processing of flight hardware.

Program/Project or Directorate Organization: The Government/contractor organization having direct responsibility for performing a task associated with: assembly/ disassembly; checkout, maintenance; servicing; repair; and operation of ground support equipment or flight hardware/systems.

Proof Tests to Establish Maximum Allowable Working Pressure: (PV) Pressure test which establishes the maximum allowable working pressure of a vessel, system, or component thereof, may be used: (1) When the strength cannot be computed with a satisfactory assurance of accuracy; (2) When the thickness cannot be determined by means of the design rules of the applicable code or standard; or (3) When the critical flaw size to cause failure at the certified pressure cannot be identified by other nondestructive test methods. This test is to be performed in a manner equivalent to one of the methods specified in Paragraph UG-101 of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, latest edition. Proof tests may be performed only upon approval of the KSC PSM.

PVS Representative: (PVS) The individual(s) assigned and who has been identified to the PSM as the representative for an organization in all matters relating to PVS.

Qualified: *(Electrical Extension Devices)* One who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated his ability to solve or resolve problems relating to the subject matter, the work, or the project.

Radio Frequency (RF) Control Area: The area within a facility where only KSC-approved transmitters/emitters are allowed to operate during an operational task which requires RF silence.

Radio Frequency (RF) Silence: A period of time where RF transmitters/emitters, either fixed-in-place or transient, are prohibited from emitting RF energy in a specified area.

Rated Load: The static weight the basic equipment can safely support or lift.

Real-Time Decision/Action: A real-time decision or action is one that affects personnel safety or NASA operational mission accomplishment by causing:

a. The potential to deviate from a normal or standard practice.

b. A minimum amount of time or no time to functionally verify the adequacy of the real-time decision or action and its effect to be performed.

Recall System: (PVS) A system which tracks selected components subject to periodic calibration, inspection, or test. Components included in recall systems are relief valves, pressure gages, and flex hoses.

Receptacle: (Electrical Extension Devices) A receptacle is a contact device installed at the outlet for the connection of an attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is two or more contact devices on the same yoke.

Recertification: (PVS) The procedure (appropriate tests, inspections, examinations, analyses, and documentation), which qualifies a previously certified vessel or system to continue or be returned to operation at a designated pressure. Also applies to GSE.

Recertification Interval: (PVS) The time between recertifications when a certified status is maintained through documented periodic examinations and inspections to determine acceptable vessel or system condition. This time period must be determined when the ISI plan is developed, and the length of this period will depend on the results of the initial and subsequent inspections, tests, and engineering analyses.

Reissue: A revised edition of an existing approved TOP that contains updated material, or has a different effectivity, to which the OMI or change applies.

Relocatable Power Tap: (Electrical Extension Devices) See **Power Strip**

Repair: (PVS) The work necessary to restore a pressure vessel or system to a safe and satisfactory operating condition, provided there is no deviation from the original design.

Rerated Vessel or System: (PVS) (1) A vessel or system judged to be unsafe, unsuitable, or unnecessary for continued operation at its original design pressure and/or temperature limits. (2) A vessel or system recertified to operate at a lesser or greater pressure and/or temperature limit relative to its original designs.

Residual Risk: The level of risk that remains after applicable safety-related requirements have been satisfied. In a risk-informed context, such requirements may include measures and provisions intended to reduce risk from above to below an acceptable level.

Revision: *(TOPs)* A modification of information contained in an approved existing TOP.

Risk: The combination of the likelihood (qualitative or quantitative) that an activity will experience an undesirable event and the consequence/severity of the undesired event were it to occur.

Risk (Safety) Assessment: Process of qualitative risk categorization or quantitative risk (safety) estimation, followed by the evaluation of risk significance.

Risk Assessment Code: A numerical expression of comparative risk determined by an evaluation of both the potential severity of a condition and the likelihood of its occurrence causing an expected consequence.

Safety Concurrence: The consent required from the safety organization, having operational jurisdiction, prior to start of procedures containing hazardous operations, prior to hazardous steps or sequences, prior to the alteration of hazardous steps/sequences, and prior to opening the control area for controlled work at the conclusion of hazardous activities.

Safety Coverage: The presence of a Safety professional, or designee, during operations as determined by an assessment as follows:

a. Full-time Coverage: The safety professional will be onsite to provide a go-to-proceed with the operation, monitor operations and controls to ensure compliance with safe performance and provide technical safety assistance as needed during the entire operation.

b. Part-time Coverage: The safety professional is present onsite to provide a go-to-proceed with the operation, periodically and at the end to reopen the area.

c. Optional Coverage: The safety professional is not required for onsite coverage.

Safety Critical: Anything (system, subsystem, equipment, component, operation, event, process, function, software, etc.) that could cause or lead to severe injury, major damage, or mission failure if performed or built improperly, or allowed to remain uncorrected (i.e., could result in a consequence severity Level 4 or 5 effect in the applicable risk matrix).

Safety Factor: Ratio of the design limit to the maximum operating conditions.

Safety Professional: Person meeting the Office of Personnel Management standards for such occupations defined in 29CFR 1960.2(s) (Definitions) for Government operations or equally qualified military, agency or nongovernment for contractor operations. NASA KSC Safety is responsible for determination of equally qualified personnel. Safety Specialists, Representatives, and Inspectors have sufficient experience within their discipline to recognize Safety and/or health hazards in the workplace.

Safety-Related Hardware Discrepancy: (PVS) Any hardware discrepancy that could increase the potential for injury or death to personnel or damage to hardware. The following are considered safety-related discrepancies:

a. Primary relief device set above the certified MAWP or design pressure.

b. Relief device with insufficient flow capacity.

c. Relief device past due for calibration.

d. Relief device with missing or illegible identification tag.

e. Pressure gage out of calibration or past due.

f. Obvious physical damage (e.g., crushed or kinked flexhose, dented or nicked piping/tubing/vessels, or heavy corrosion of vessels/piping).

g. Not labeling the vessel's MAWP/service fluid.

Safety-Relief Device Set Pressure: (PVS) The pressure at which a pressure relief device is set to operate. Set to operate means the set pressure of a relief valve or spring-loaded nonreclosing device, the bursting pressure of a rupture disk device or the breaking pressure of a breaking pin device. (Reference Paragraphs UG-125 and UG-134, ASME Code, Section VIII, Division 1, and Part AR, ASME Code, Section VIII, Division 2.)

Safety or Safety Representative: The term Safety is used without context to contractor or NASA personnel. The phrase "NASA S&MA" is used to mean a Government Safety representative only.

Scoop-proof: An electrical connector's shell design that prevents inadvertent cocking of the mating plug connector into the mating receptacle. Such cocking can occur in other connector designs, causing physical damage to the pins or inadvertent pin to pin contact which could result in electrical shorting. In a blind mating application, mating shells cannot "scoop" the pins and cause a shorting or bending of contacts.

Shall: A mandatory S&MA requirement. Noncompliance with a "shall" statement requires approval of a variance.

Should: An S&MA rule/requirement that is recommendation (guidance). The advisability of a "should" statement depends on the specific facts in a given situation. Implementation of a "should" statement is at the discretion of the responsible KSC program/project or directorate organization.

Software: Computer programs, procedures, rules, and associated documentation and data pertaining to the development and operation of a computer system. Software includes programs and operational data contained in hardware (e.g., firmware, programmable logic, and programmable gate arrays). This also includes COTS, GOTS, MOTS, reuse, legacy, and heritage software products and components.

Splash (KSC Vapor Suit): Two-piece garment consisting of a hooded pullover blouse and trousers with boots and lightweight, long gauntlet gloves.

Sub-task TOP: A procedure used to perform work when called up by another TOP (usually an integrated TOP).

Sub-task-only TOP: A procedure preplanned to be performed only as a subtask to a controlling procedure and may contain limited Safety controls.

System Certification Pressure: (PVS) The maximum pressure that has been applied to a system; however, no system element can have its MAWP exceeded when the certification pressure has been applied.

System Safety: Application of engineering and management principles, criteria, and techniques to optimize safety and reduce risks within the constraints of operational effectiveness, time, and cost throughout all phases of the system life cycle.

Tag: Lockout/tagout device that alerts workers regarding equipment/machinery status.

Tagout Device: A prominent warning means such as a tag and a means of attachment, which can be securely fastened to an energy isolating device and the equipment being controlled.

Task Leader: A person who has been trained and certified/stand boarded by his organization for a particular task.

Technical Operating Procedure (TOP): A written communication that identifies and directs work to be performed and provides the detailed instructions necessary to accomplish a task.

a. Category I TOP: Provides detailed procedures for the operation, maintenance, and verification of ground support systems and equipment. Instructions for assembly and disassembly, checkout, servicing, verification, handling, and transportation of the space vehicle and components including payload systems, subsystems, and experiments during prelaunch, launch, and postlaunch operations are also provided.

b. Category II TOP: Provides engineering instructions, authorizes work, establishes work control methods, in order to accommodate special tests or authorize temporary installations, removals, or replacements. Category II procedures cannot be used to change or replace Category I procedures.

Temporary Equipment (PVS) (PVS) Non-government owned equipment that is not required to meet the certification (or recertification) requirements of NPD 8710.5, NASA Safety Policy for Pressure Vessels and Pressurized Systems or NASA-STD-8719.17, NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PVS). Temporary equipment is subject to all applicable laws, regulations, NASA safety requirements, OSHA requirements, and appropriate NCS. This typically includes contractor supplied rental equipment leased from an offsite location.

Temporary Power Taps: (Electrical Extension Devices) Connector switch assembly, surge suppressor power strip outlet. See Power Strip definition

Temporary Voltage Surge Suppressor Strip: (Electrical Extension Devices) A protective device for limiting transient voltages by diverting or limiting surge current; it also prevents continued flow of follow current while remaining capable of repeating these functions.

Test Article PVS: (PVS) A PVS object(s) being tested for the sole purpose of obtaining data (other than integrity data) on the object(s).

Test Specific PVS: (PVS) PVS used to perform testing of a specific test article. PVS used on a permanent or repeated basis, or built up of components used repeatedly for testing different hardware or configurations are not part of this category.

Threshold Limit Value-Time Weighted Average (TLV-TWA): The time weighted average concentration for a normal 8 hour workday and a 40 hour workweek, to which workers may be repeatedly exposed, day after day, without adverse effect.

Trained Inspector: (COPV) A person trained specifically in the detection of visual damage of COPVs and familiarized with the NDE methods and results that could be used to aid in the interpretation of visual damage. JSC White Sands Test Facility typically conducts this training.

Type A Mishap: A mishap causing death, permanent total disability, hospitalization (within a 30 day period from the mishap) of three or more persons for other than observation, and/or damage to equipment or property and/or mission failure resulting in loss equal to greater than $1 million. Mishaps resulting in damage to aircraft, space hardware, or GSE that meet these criteria are included, as are test failures in which the damage was unexpected or unplanned.

Type B Mishap: A mishap resulting in permanent partial disability to one or more persons, in-patient hospitalization of 2 or less personnel, damage to equipment or property and/or mission failure resulting in loss equal to or greater than $250,000, but less than $1 million. Mishaps resulting in damage to aircraft, space hardware, or GSE that meet these criteria are included, as are test failures in which the damage was unexpected or unplanned.

Type C Mishap: A mishap resulting in damage to equipment or property, or mission failure resulting in loss equal to or greater than $25,000, but less than $250,000, and/or causing occupational injury or illness that results in a case involving day(s) away from work or restricted duty. Mishaps resulting in damage to aircraft, space hardware, or GSE that meet these criteria are included, as are test failures in which the damage was unexpected or unplanned.

Type D Mishap: A mishap consisting of personal injury requiring medical treatment greater than first aid but without any lost time or restricted duty and/or property damage or mission failure resulting in loss equal to or greater than $1000, but less than $25,000. Permanent occupational.

Uninterruptible Power Supply: (Electrical Extension Devices) Designed for use with electronic computer/data supply processing equipment, and supplies uninterrupted power to said equipment during commercial power failures.

Unprotected Heights: Personnel exposure to within 6-feet of an unprotected-leading edge from which there is a drop of more than 4-feet.

Unsafe Vessels or Systems: (PVS) These are vessels or systems, which have been determined to be unsafe for service.

Vacuum System: (PVS) An assembly of components under vacuum (internal pressure less than that of the surrounding atmosphere) including vessels, piping, valves, relief devices, pumps, expansion joints, and gages.

Vacuum Vessel: (PVS) A vessel in which the internal pressure has been reduced to a level less than that of the surrounding atmosphere.

Variance: (Safety Variance) Documented and approved permission to perform some act or operation contrary to established requirements. The three types of safety variances are exceptions, deviations, and waivers. A variance may involve the approval of alternative means that provide an equivalent or lower level of risk or formal acceptance of increased risk due to the fact that the requirement is not satisfied.

Visible Damage: (COPV) Anomalies that are visible to the naked eye under not less than 15-foot candles at a distance no greater than 24 inches and no less than a 30 degree angle. Lighting up to 50-foot candles may be used for the detection or study of small anomalies.

Waiver: A variance that authorizes temporary relief from a specific requirement after the fact. Requested during the implementation of a project or operation to address situations that were unforeseen during design or advanced planning.

Warning: A notation which if not adhered to or observed could result in loss of life, personal injury, or exposure.

Watertight: (Electrical Extension Devices) So constructed that moisture will not enter the enclosure.

Weatherproof: (Electrical Extension Devices) So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, rain tight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness are not a factor.

Wet Location: (Electrical Extension Devices) Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle-washing areas and locations unprotected and exposed to weather.

Workday: Any day a person reports to work, regardless of the amount of time spent on the job. The workday begins when a person reports to work and ends when he or she leaves.

Workweek: Any seven day period beginning on Sunday and ending on Saturday, or other seven day period, as specified and documented by an organization for accounting purposes.

APPENDIX B - ACRONYMS AND ABBREVIATIONS

AC	Alternating Current
ACGIH	American Conference of Governmental Industrial Hygienists
AFGE	American Federation of Government Employees
AFMAN	Air Force Manual
AFMC	Air Force Material Command
AFSCF	Air Force Satellite Control Facility
AIAA	American Institute of Aeronautics and Astronautics
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
AP	Ammonium Perchlorate
API	American Petroleum Institute
APS	Aft Propulsion System
APU	Auxiliary Power Unit
ARCS	Aft Reaction Control System
ARF	Assembly and Refurbishment Facility
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
AWWA	American Water Works Association
B/L	baseline
BDA	Blast Danger Area
BEU	Breathing Escape Unit
BSM	Booster Separation Motor
C	Centigrade
c/o	Check-Out
C&W	Caution and Warning
CAP	Corrective Action Plan
CAPPS	Checkout Assembly & Payload Processing Services Contract
CCAFS	Cape Canaveral Air Force Station
CCB	Change Control Board
CCF	Converter Compressor Facility
CD	Center Director
CDE	Center Declared Emergency
CDDT	Countdown Demonstration Test
CDF	Confined Detonating Fuse
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CIL	Critical Items List
COPV	Composite Overwrapped Pressure Vessel
COTR	Contracting Officer Technical Representative
COTS	Commercial Off The Shelf
CPIA	Chemical Propulsion Information Agency (Johns Hopkins University)
CPS	Chemical Protection Suit
CT	Crawler Transporter
CTC	Chief Test Conductor
dB	Decibels
DBP	Design Burst Pressure

DC	Direct Current
DCR	Document Change Recommendation
DMES	Dimethylethoxsilane
DO	Duty Officer
DOD	Department of Defense
DOP	Detailed Operational Procedure
DOT	Department of Transportation
DRA	Document Release Authorization
ECS	Environmental Control System
ECU	Environment Control Unit
EDC	Engineering Documentation Center
EDO	Extended Duration Orbiter
EE&SE	Emergency Eyewash and Shower Equipment
EED	Electroexplosive Device
EEE	Electronic, Electrical, Electromechanical
ELSA	Emergency Life Support Apparatus
ELV	Expendable Launch Vehicle
EM	Electro-Mechanical
EMI	Electromagnetic Interference
EMS	Emergency Medical Services
EMU	Extravehicular Mobility Unit
EOM	End of Mission
EPD	Emergency Procedures Document
ERP	Emergency Response Plan
ESP	Engine Service Platform
ET	External Tank
ETA	Explosive Transfer Assembly
ETE	Explosives Test Equipment
ETI	Explosives Technologies International, Inc.
ETVAS	External Tank Vent Arm System
EWR	Eastern Western Range
FDS	Fluid Distribution System
FIV	Fuel Isolation Valve
FJAF	Field Joint Assembly Fixture
FM	Factory Mutual
FM	Frequency Modulation
FMEA	Failure Modes and Effects Analysis
FOD	Foreign Object Debris
FOS	Factor of Safety
FRCS	Forward Reactant Control System
FRF	Flight Readiness Firing
FRSI	Felt Reusable Surface Insulation
FSI	Factor of Safety
FSM	Fuel Supply Module
FSS	Fixed Service Structure
FTA	Fault Tree Analysis
GFCI	Ground Fault Circuit Interrupter
GHe	Gaseous Helium

GH_2	Gaseous Hydrogen
GO_2	Gaseous Oxygen
GOAL	Ground Operations Aerospace Language
GOX	Gaseous Oxygen
Gr/Ep	Graphite Epoxy
GSE	Ground Support Equipment
GSRP	Ground Safety Review Panel
GUCP	Ground Umbilical Carrier Plate
H_2	Hydrogen
HB	High Bay
HDP	Hold Down Post
HGDS	Hazardous Gas Detection System
HMF	Hypergol Maintenance Facility
HP	High Pressure
HPU	Hydraulic Power Unit
HPWF	High Pressure Wash Facility
HVAC	Heating, Ventilation, and Air Conditioning
HVDS	Hypergol Vapor Detection System
HVES	Hypergolic Vent Exhaust System
IA	Independent Assessment
ID	Identification
IDLH	Immediately Dangerous to Life or Health
IGSCC	Intergranular Stress Corrosion Cracking
IRIS	Incident Reporting and Investigation System
ISC	Institutional Services Contract/Contractor
ISEA	International Safety Equipment Association
ISI	Inservice Inspection
ISO	International Organization of Standardization
ISS	International Space Station
ISSP	International Space Station Program
IT	Intertank
IUS	Inertial Upper Stage
JSC	Johnson Space Center (NASA, Houston, Texas)
KCA	Kennedy Customer Agreement
KDP	Kennedy Documented Procedure
KEDS	KSC Electronic Documentation System
KHB	Kennedy Handbook
KNPD	Kennedy NASA Policy Directive
KNPG	Kennedy NASA Procedures and Guidelines
KNPR	Kennedy NASA Procedural Requirements
KPD	KSC Program Directive
KSC	Kennedy Space Center (NASA, KSC, Florida)
kV	Kilovolt
kW	Kilowatt
lb/in	Pound per square inch
LC	Launch Complex

LD	Launch Director
LDA	Launch Danger Area
LDEM	Lifting Devices and Equipment Manager
LEL	Lower Explosive Limit
LH	Left Hand
LH_2	Liquid Hydrogen
LLIS	Lessons Learned Information System
LO_2	Liquid Oxygen
LOTO	Lockout/Tagout
LOMS	Left OMS
LOX	Liquid Oxygen
LP	Liquefied Propane
LSC	Linear Shape Charge
LSP	Launch Support Program
LSSO	Launch Site Safety Office
LSSP	Launch Site Safety Plan
LSSR	Launch Site Safety Representative
LVP	Launch Vehicle Processing
M&P	Materials and Processes
MAWP	Maximum Allowable Working Pressure
MDCP	Mechanical Damage Control Plan
MDD	Mate/Demate Device
MDMT	Minimum Design Material Temperature
MDOP	Maximum Design Operating Pressure
MEC	Master Events Controller
MEOP	Maximum Expected Operating Pressure
MESC	Medical and Environmental Support Contractor
MIB	Mishap Investigation Board
MIL	Military
MLG	Main Landing Gear
MLP	Mobile Launch Platform
MMH	Monomethylhydrazine
MOP	Maximum Operating Pressure
MOU	Memorandum of Understanding
MPa	MegaPascal
MR	Material Review
MRB	Material Review Board
MSD	Musculoskeletal Disorder
MSDS	Material Safety Data Sheet
MTB	Materials Testing Branch
mV	Millivolt
MVAK	Module Vertical Access Kit
MWT	Maximum Work Time
N_2H_4	Hydrazine
N_2O_4	Nitrogen Tetroxide
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NBIC	National Board Inspection Code
NCC	NASA Convoy Commander

NCS	National Consensus Codes and Standards
NDE	Nondestructive Evaluation
NDI	Nondestructive Inspection
NEC	National Electrical Code
NEPO	NASA Emergency Preparedness Officer
NFC	National Fire Code
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NPD	NASA Policy Directive
NPG	NASA Procedures and Guidelines
NPS	Nominal Pipe Size
NS	Nonstock
NSI	NASA Standard Initiator
NSS	NASA Safety Standard
NSTS	National Space Transportation System
NTD	NASA Test Director
O_2	Oxygen
O&C	Operations and Checkout
O&M	Operations and Maintenance
O&SHA	Operating and Support Hazard Analysis
OAA	Orbiter Access Arm
ODS	Orbiter Docking System
ODMS	Oxygen Deficiency Monitoring System
OHF	Occupational Health Facility
OIC	Orbiter Integration Clerk
OIS	Operational Intercommunications System
OMBUU	Orbiter Midbody Umbilical Unit
OMD	Operations and Maintenance Documentation
OME	Orbiter Main Engine
OMI	Operations and Maintenance Instructions
OMRSD	Operational Maintenance Requirements and Specifications Document
OMS	Orbiter Maneuvering Subsystem
OPF	Orbiter Processing Facility
OPR	Office of Primary Responsibility
OSF	Ordnance Storage Facility
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
OSMA	NASA Headquarters Office of Safety and Mission Assurance
OTC	Orbiter Test Conductor
OTV	Operational Television
PA	Public Affairs
PAWS	Paging and Area Warning System
PCR	Payload Changeout Room
PDE	Program Declared Emergency
PEL	Permissible Exposure Level
PFA	Plastic Films, Foams, and Adhesives
PGOC	Payloads Ground Operations Contract
PHA	Preliminary Hazard Analysis
PHE	Propellant Handlers Ensemble

PIC	Pyro Initiator Controller
PLB	Payload Bay
PM	Preventive Maintenance
PMN	Program Model Number
PNL	Panel
POC	Point-of-Contact
PPE	Personal Protective Equipment
ppm	Parts per million
PRA	Probabilistic Risk Assessment
PRD	Pressure Relief Device
PRSD	Power Reactant Supply and Distribution
psid	Pounds Per Square Inch Differential
psig	Pounds Per Square Inch Gage
PSM	Pressure Systems Manager
PTCR	Pad Terminal Connection Room
PV	Pressure Vessel
PVS	Pressure Vessel/Systems
PVT	Pressure Volume Temperature
QD	Quick Disconnect
R&D	Research and Development
R&M	Reliability and Maintainability
RAC	Risk Assessment Code
RBDA	Reliability Block Diagram Analysis
RCM	Reliability Centered Maintenance
RCS	Reaction Control System
RF	Radio Frequency
RH	Relative Humidity
rms	Root-Mean-Square
ROMS	Right OMS
RPSF	Rotation, Processing, and Surge Facility
RPT	Relocatable Power Tap
RRB	Risk Review Board
RSS	Rotating Service Structure
RTG	Radioisotope Thermoelectric Generator
RTLS	Return to Launch Site
S&A	Safe and Arm
S&MA	Safety and Mission Assurance
S/C	Spacecraft
S/N	Serial Number
SAE	Society of Automotive Engineers
SAR	Supplied Air Respirator
SCA	Shuttle Carrier Aircraft
SCAPE	Self Contained Atmospheric Protective Ensemble
SCBA	Self Contained Breathing Apparatus
SCC	Safety Control Center
SCFM	Standard Cubic Feet per Minute
SCO	Space Craft Operator
SPOC	Space Program Operations Contractor

SFP	Single Failure Point
SHA	System Hazard Analysis
SLF	Shuttle Landing Facility
SLOAA	Suspended Load Operation Analysis/Approval
SPF	Spray Paint Facility
SQ&MA	Safety, Quality, and Mission Assurance
SRB	Solid Rocket Booster
SRL	Self Retracting Lifeline/Lanyard
SRE	Safety and Reliability Engineering
SRM	Solid Rocket Motor
SRM&QA	Safety, Reliability, Maintainability, and Quality Assurance
SRSS	Shuttle Range Safety System
SS	Station Set
SSA	Software Safety Analysis
SSHA	Subsystem Hazard Analysis
SSME	Space Shuttle Main Engine
SSP	Space Shuttle Program
SSR	Safety Statistics Record
SSV	Space Shuttle Vehicle
STD	Standard
STE	Special Test Equipment
STS	Space Transportation System
SW	Switch
SW	Space Wing
TAL	Transatlantic Abort Landing
TC	Test Conductor
TCDT	Terminal Count-Down Test
TD	Test Director
TDC	Technical Documentation Center
TLV-TWA	Threshold Limit Value-Time Weighted Average
TOP	Technical Operating Procedure
TP	Test Procedure
TSM	Tail Service Mast
TTL	Task Team Leader
TVC	Toxic Vapor Check
TVSS	Transient Voltage Surge Suppression
UDS	Universal Documentation System
UFGS	Unified Facilities Guide Specifications
UHF	Ultra High Frequency
UL	Underwriters Laboratories
UPS	Uninterruptable Power Supply
USAF	United States Air Force
UT	Ultrasonic Thickness
UTPA	Universal Throat Plug Assembly
UT-THK	Ultrasonic Testing-Thickness
VAB	Vehicle Assembly Building
VAFB	Vandenberg Air Force Base
VE	Visual Examination

VHF	Very High Frequency
VPF	Vertical Processing Facility
WAD	Work Authorization Document
WLAN	Wireless Local Area Network