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3) KSC-STD-Z-0006B (October 25, 1995), Design of Hypergolic Propellants Ground Support Equipment, Standard For.	*YesN*	*o*	*SBU Reviewer's Signature*	*Date*
Contains SBU?	☐	☒	C Wayne Ranow	7/2/2007

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NASA
Export Control Program

METRIC/INCH-POUND

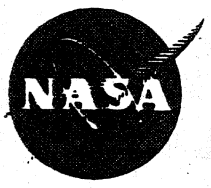
KSC-STD-Z-0006B
October 25, 1995
Supersedes
KSC-STD-Z-0006A
September 15, 1989

DESIGN OF HYPERGOLIC PROPELLANTS GROUND SUPPORT EQUIPMENT, STANDARD FOR

ENGINEERING DEVELOPMENT DIRECTORATE

National Aeronautics and
Space Administration

John F. Kennedy Space Center



KSC-STD-Z-0006B
October 25, 1995
Supersedes
KSC-STD-Z-0006A
September 15, 1989

DESIGN OF HYPERGOLIC PROPELLANTS GROUND SUPPORT EQUIPMENT, STANDARD FOR

Approved:

Walter T. Murphy
Director of Engineering Development

JOHN F. KENNEDY SPACE CENTER, NASA

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ABBREVIATIONS AND ACRONYMS

A-50	Aerozine-50
AFR	Air Force Regulation
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CCAS	Cape Canaveral Air Station
CFR	Code of Federal Regulation
CGA	Compressed Gas Association
cm^3	cubic centimeter
CRES	designation for corrosion-resistant material
DE	Engineering Development Directorate
DOD	Department of Defense
DOT	Department of Transportation
EPA	Environmental Protection Agency
ESMCR	Eastern Space and Missile Center Regulation
ETR	Eastern Test Range
FDEP	Florida Department of Environmental Protection
FED	Federal
FL	Florida
FSN	Federal stock number
gal/min	gallon per minute
GHe	gaseous helium
GN_2	gaseous nitrogen
GP	general publication
GSE	ground support equipment
HVDS	hypergolic vapor detection system
JSC	Lyndon B. Johnson Space Center
KHB	KSC handbook
KMI	KSC management instruction
kPa	kilopascal
KSC	John F. Kennedy Space Center
L	liter
lb/in^2	pound per square inch
L/s	liter per second
m	meter
MA	Massachusetts
MAWP	maximum allowable working pressure
MIL	military
mL/h	milliliter per hour

ABBREVIATION AND ACRONYMS (cont)

mL/s	milliliter per second
mm	millimeter
MMH	monomethylhydrazine
MPa	megapascal
MSFC	George C. Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NDE	nondestructive evaluation
NDT	nondestructive test
NFPA	National Fire Protection Association
NHB	NASA handbook
NPT	National Pipe Thread
NSN	national stock number
NY	New York
N_2H_4	hydrazine
N_2O_4	nitrogen tetroxide
OMRSD	Operating and Maintenance Requirements Document
OSHA	Occupational Safety and Health Act
PA	Pennsylvania
PHE	Propellant Handlers Ensemble
P/N	part number
PTFE	polytetrafluoroethylene
SAE	Society of Automotive Engineers
SPEC	specification
SST	stainless steel
STD	standard
STP	standard temperature and pressure
TFE	designation for type of Teflon
TFP	designation for type of Teflon
UDMH	unsymmetrical dimethylhydrazine
UNC	designation for unified coarse thread (for nuts, bolts, screws, etc.)
VA	Virginia

DESIGN OF HYPERGOLIC PROPELLANTS GROUND SUPPORT EQUIPMENT, STANDARD FOR

1. SCOPE

This standard establishes the minimum design requirements for hypergolic propellant ground support equipment (GSE) required for use at the John F. Kennedy Space Center (KSC). This standard shall be used in conjunction with KSC-DE-512-SM. Hypergolic propellants shall include the following fuels and oxidizers.

Fuels	Oxidizers
Aerozine-50 (A-50)	Nitrogen tetroxide (N_2O_4)
Hydrazine (N_2H_4)	
Monomethylhydrazine (MMH)	
Unsymmetrical dimethylhydrazine (UDMH)	

For the purposes of this standard, GSE shall be classified as fixed, mobile, or portable.

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. When this document is used for procurement, including solicitations, or is added to an existing contract, the specific revision levels, amendments, and approval dates of said documents shall be specified in an attachment to the Solicitation/Statement of Work/Contract.

2.1 Governmental.

2.1.1 NASA Directives.

National Aeronautics and Space Administration (NASA)

NHB 1700.1, (V1)	NASA Safety Policy and Requirements Document

NHB 1700.6	Guide for Inservice Inspection of Ground-Based Pressure Vessels and Systems
NHB 5300.4, (1B)	Quality Program Provisions for Aeronautical and Space System Contractors
NHB 7320.1	Facilities Engineering Handbook

John F. Kennedy Space Center (KSC), NASA

KMI 1710.1	Safety, Reliability, Maintainability, and Quality Assurance Programs
KMI 1710.15	Certification Program for Pressure Vessels and Pressurized Systems
KMI 5310.9	KSC Ground Systems Safety and Reliability Analyses
KMI 8800.6	KSC Environmental Control
KHB 1200.1	Facilities, Systems, and Equipment Management Handbook
KHB 1700.7	Space Transportation System Payload Ground Safety Handbook
KHB 1710.2	Kennedy Space Center Safety Practices Handbook
KHB 1710.15	KSC Pressure Vessel/System Certification Handbook
KHB 5310.9	Kennedy Space Center Ground Systems Safety and Reliability Analyses
KHB 8800.7	Hazardous Waste Management

2.1.2 Specifications.

John F. Kennedy Space Center (KSC), NASA

KSC-C-123	Surface Cleanliness of Fluid Systems, Specification for
KSC-E-165	Electrical Ground Support Equipment Fabrication, Specification for
KSC-E-166	Electrical Ground Support Equipment Installation and Assembly, Specification for
KSC-F-124	Fittings, Flared Tube, Specification for
KSC-SPEC-Z-0007	Tubing, Corrosion Resistant Steel, Types 304 and 316, Seamless, Annealed, Specification for
KSC-SPEC-Z-0008	Fabrication and Installation of Flared Tube Assemblies and Installation of Fittings and Fitting Assemblies, Specification for
KSC-SPEC-Z-0009	Lubrication, Thread, Corrosion-Resistant Steel and Aluminum Alloy Tube Fittings, Specification for
KSC-SPEC-Z-0013	Penetrant, Magnetic Particle and Ultrasonic Inspection, Requirements for, Specification for
KSC-SPEC-Z-0020	Welding of Aerospace Ground Support Equipment and Related Facilities, Specification for

Lyndon B. Johnson Space Center (JSC), NASA

JSC 08123	Certification of Flexhoses and Bellows for Flow Induced Vibration

JSC-NSTS-7700	Space Shuttle Flight and Ground System Specification
Federal	
QQ-A-200/8	Aluminum Alloy 6061 Bar, Rod, Shapes, Tube and Wire, Extruded
QQ-A-250/11	Aluminum Alloy 6061, Plate and Sheet
QQ-S-763	Steel Bars, Wire, Shapes, and Forgings, Corrosion Resisting
Military	
MIL-P-26536	Propellant, Hydrazine
MIL-P-26539	Propellants, Nitrogen Tetroxide
MIL-P-27402	Propellant, Hydrazine-Unsymmetrical dimethylhydrazine (50 Percent N_2H_4 - 50 Percent UDMH)
MIL-P-27404	Propellant, Monomethylhydrazine
MIL-W-83420	Wire Rope, Flexible, for Aircraft Control

2.1.3 Standards.

John F. Kennedy Space Center (KSC), NASA

KSC-STD-164	Environmental Test Methods for Ground Support Equipment, Standard for
KSC-STD-C-0001	Protective Coating of Carbon Steel, Stainless Steel, and Aluminum on Launch Structures, Facilities, and Ground Support Equipment, Standard for

KSC-STD-E-0002	Hazardproofing of Electrically Energized Equipment, Standard for
KSC-STD-E-0012	Bonding and Grounding, Standard for
KSC-STD-E-0013	Lightning Protection for Facilities, Standard for
KSC-STD-E-0015	Marking of Ground Support Equipment, Standard for
KSC-STD-F-0004	Fire Protection Design for Facilities, Standard for
KSC-STD-G-0003	Qualification of Launch Support and Facility Components, Standard for
KSC-STD-SF-0004	Ground Piping Systems Color Coding and Identification, Safety Standard for
KSC-STD-Z-0005	Design of Pneumatic Ground Support Equipment, Standard for

George C. Marshall Space Flight Center (MSFC), NASA

MSFC-STD-486	Threaded Fasteners, Torque Limits for, Standard
MSFC-20 M 02540	Assessment of Flexible Lines for Flow Induced Vibrations

Federal

29 CFR 1910	Occupational Safety and Health Standards
40 CFR 264	Standard for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities Systems, Subpart J, Tank

40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
40 CFR 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)
49 CFR 100 to 199	Hazardous Materials Regulations Board, Shipping Container Specifications, Transportation, Subpart C, Parts 100 through 199

Military

DOD 6055.9-STD	Ammunition and Explosives Safety Standards
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-889	Dissimilar Metals
MIL-STD-1472	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MS-33649	Bosses, Fluid Connection - Internal - Straight Thread

2.1.4 Drawings.

John F. Kennedy Space Center (KSC), NASA

79K03040	Transducer, Temperature, Platinum Resistance, Specification for
79K03449	Precision Temperature Bulb With Integral Electronics, Specification for
79K03450	Discrete Liquid Level Sensor With Integral Electronics, Specification for

79K08420	Hypergolic Vapor Detection Unit S70-1221, Specification for
79K11948	Material Selection List for Type J Service
79K14768	Hypergol System Operating Criteria, MMH/N_2O_4, Hypergol Vapor Detection System (HVDS) for Space Shuttle
80K51846	Flex Hose Handling and Installations Requirements, Specification for
81K00643	Propellant Mobile Ground Support Equipment, Marking of, Specification for

George C. Marshall Space Flight Center (MSFC), NASA

75M04185	Identification Tag, Tubing and Hose Lines

2.1.5 U.S. Air Force Regulations.

AFR 127-100	Explosive Safety Standards
ERR 127.1	Range Safety

2.1.6 Publications.

John F. Kennedy Space Center (KSC), NASA

DE-MI 8060.1	Selection of Materials and Processes in Accordance With the KSC Materials and Pressures Control Program
GP-425	Engineering Standards
GP-435	Engineering Drafting Practices Manual
GP-1098	KSC Ground Operations Safety Plan

KSC-DE-512-SM	Facility, System, and Equipment General Design Requirements
TM-584	Corrosion Control and Treatment Manual

John F. Kennedy Space Center (KSC), NASA and Cape Canaveral Air Station (CCAS)

4-0-385	Chemical Cleaning and Testing Manual, KSC and CCAS

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specified procurement functions should be obtained from the procuring activity or as directed by the Contracting Officer.)

2.2 Non-Governmental.

2.2.1 Industry Publications

American Society for Testing and Materials (ASTM)

ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A182	Standard Specification for Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A240	Standard Specification for Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service

ASTM A312	Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes
ASTM A320	Standard Specification for Alloy Steel Bolting Materials for Low Temperature Service
ASTM A403	Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings

(Application for copies should be directed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

American Society of Mechanical Engineers (ASME)

ANSI/ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
ANSI/ASME B16.5	Pipe Flanges and Flanged Fittings
ANSI/ASME B16.9	Factory-Made Wrought Steel Buttwelding Fittings
ANSI/ASME B16.21	Nonmetallic Flat Gaskets for Pipe Flanges
ANSI/ASME B18.2.1	Square and Hex Bolts and Screws Inch Series
ANSI/ASME B18.2.2	Square and Hex Nuts (Inch Series)
ANSI/ASME B31.3	Chemical Plant and Petroleum Refinery Piping
ANSI/ASME B36.19	Stainless Steel Pipe
ANSI/ASME B40.1	Gauges - Pressure Indicating Dial Type - Elastic Element

ASME Boiler and Pressure Vessel Code

Section V	Nondestructive Examination
Section VIII	Pressure Vessels, Divisions 1 and 2 (Unfired)
Section IX	Qualification Standard for Welding and Brazing Procedures; Welders, Brazers, and Welding and Brazing Operators

(Application for copies should be directed to the American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.)

Compressed Gas Association, Inc. (CGA)

Pamphlet S-1.2	Pressure Relief Device Standards, Part 2, Cargo and Portable Tanks for Compressed Gases
Pamphlet S-1.3	Pressure Relief Device Standards, Part 3, Compressed Gas Storage Containers

(Application for copies should be directed to the Compressed Gas Association, Inc., 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202-4102.)

National Fire Protection Association (NFPA)

NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection (National Fire Codes, Volume 1)
NFPA 30	Flammable and Combustible Liquids Code (National Fire Codes, Volume 1)
NFPA 70	National Electrical Code

NFPA 496	Standard for Purged and Pressurized Enclosures for Electrical Equipment (National Fire Codes, Volume 7)

(Application for copies should be directed to the National Fire Protection Association, One Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.)

Society of Automotive Engineers, Inc. (SAE).

ARP 901	Bubble-Point Test Method
AIR 1082	Fluid System Component Specification Preparation Criteria

(Application for copies should be directed to the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.)

2.2.2 State of Florida Regulations.

Florida Department of Environmental Protection (FDEP), Florida Administrative Code.

3. REQUIREMENTS

3.1 General. - The following requirements are applicable to all phases of design of hypergolic propellant GSE.

3.1.1 Environmental Conditions. - All GSE shall be designed as defined in KSC-DE-512-SM to withstand, without damage or degradation of performance, continuous exposure to the natural and induced conditions that occur at KSC.

3.1.1.1 Corrosion Protection. - All GSE shall be protected against corrosion in accordance with KSC-STD-C-0001. The use of dissimilar metals shall also comply with KSC-STD-E-0012 and MIL-STD-889. Corrosion protection practices specified in KSC TM-584 shall also be followed.

3.1.1.2 Cathodic Protection. - Underground systems should not be used; however, if underground systems are required they shall be protected against corrosion by cathodic protection. Cathodic protection systems (sacrificial or direct current power) shall be designed such that a periodic check of the current flow can be obtained. The systems shall comply with NHB 7320.1.

3.1.2 Design Life. - All GSE shall be designed for an operational life of 20 years or in accordance with the applicable program requirement. Normal preventive maintenance, repair, calibration, etc., may be accomplished to maintain the specified performance.

3.1.3 Safety. - All GSE shall be designed to preclude failures or hazards that would jeopardize personnel safety or would damage or degrade the flight vehicle. The design shall comply with the applicable program requirements as stated in NHB 1700.1, KMI 1710.1, KHB 1710.2, 29 CFR 1910, and GP-1098. Safety analyses will be performed in accordance with KHB 5310.9 and KMI 5310.9.

Safety requirements for servicing facilities shall include, but shall not be limited to, such items as area warning lights, vapor concentration alarms, foam/deluge, water sprays (i.e., fire suppressant and water flushing), and personnel safety devices (i.e., safety showers and eye washers). Emergency personnel safety shower, eyewash, and washdown hoses shall be located within 6 m (20 feet) of any facility transfer apron. Showers shall be sized to accommodate Propellant Handlers Ensemble (PHE) [previously called Self-Contained Atmospheric Protective Ensemble (SCAPE)] operators. Minimum side-to-side dimensions shall not be less than 915 mm (36 inches).

3.1.3.1 Hypergolic Vapor Detection System (HVDS). - The purpose of the HVDS is to detect hypergol leaks during a hypergol transfer or where hypergols are being stored. This fixed-point monitoring system provides a remote leak-detection capability and increases the safety margin by allowing early detection of leaks. An HVDS shall be specified in accordance with the latest revisions of 79K08420. Note that transfer of propellant quantities of 5 gallons or less does not require a fixed-point HVDS.

3.1.3.2 Safety Factor. - The term safety factor is commonly used to describe the ratio of burst pressure to working pressure or the ultimate tensile stress to maximum allowable stress of the material. However, safety factor is not used in the American National Standards Institute (ANSI) or American Society of Mechanical Engineers (ASME) codes and use of the term is discouraged except for components that cannot be designed in accordance with ANSI/ASME piping or pressure vessel codes (e.g., wire braid reinforced hoses). Appropriate safety factors have been factored into the ANSI/ASME codes by specifying maximum allowable stress values for all approved piping/pressure vessel materials. Unless otherwise specified herein, the design of all system tubing, piping, and other pressurized components shall be based on the maximum allowable stress values specified in ANSI/ASME B31.3 and ASME Boiler and Pressure Vessel Code, section VIII, division 1 or 2 (as applicable), or with Department of Transportation (DOT) standards in 49 CFR for commodity equipment (see 6.2).

3.1.3.3 Test Pressure. - All pressurized parts shall be hydrostatically tested in accordance with the applicable provisions of ANSI/ASME B31.3, 49 CFR, or the ASME Boiler and Pressure Vessel Code, as applicable. Test certification shall be provided with all procured components such as hoses, valves, and regulators, etc. Piping shall be tested as individual fabricated assemblies. Tubing assembly test requirements are specified in KSC-SPEC-Z-0008. Where hydrostatic testing is not practical, refer to the ASME Boiler and Pressure Vessel Code or ANSI/ASME B31.3 for alternative pneumatic tests.

3.1.3.4 Operating Pressure. - To determine the required system operating pressure, as a minimum, consider liquid head, liquid-specific gravity, vapor pressure, transfer pressure, component tolerance, system relief valve setting, gaseous nitrogen (GN_2) (pneumatic) relief valve setting, and temperature effect. As a guideline, the operating pressure may be considerably lower than the maximum allowable working pressure (MAWP) for hypergol systems.

For commodity equipment (see 6.2), the ratio of operating pressure to the design pressure shall be evaluated for the specific type of equipment involved in accordance with 49 CFR and/or applicable DOT regulations.

3.1.3.5 Design Drawings and Specifications. - Where applicable, the responsible design organization shall provide design drawings and specifications responsive to the design requirements specified herein, in sufficient detail to provide a complete physical definition of the equipment or facility. The design drawings shall be prepared in accordance with GP-435, volume I, for fixed facility or equipment. Design specifications shall use the NASA SPECSINTACT format. Specifications may be incorporated into the design drawings for commodity or equipment design. The design organizations shall provide in document form the detailed, substantiating calculations for the design and any special erection requirements. Physical interfaces between the newly designed hardware and existing hardware shall be completely defined in the design drawings and specifications.

3.1.3.6 Connect/Disconnect Points. - Connect/disconnect points are locations at piping connections that are made between commodity equipment and GSE or between GSE and flight hardware during routine propellant servicing operations. For the purpose of this standard, hypergol connect/disconnect points are divided into three categories: (1) GSE, (2) commodity equipment, and (3) flight hardware.

3.1.3.6.1 GSE. - The requirements for the connect/disconnect points of GSE are governed by this standard. Additional marking, specified as follows, is also required for each GSE connect/disconnect point:

a. A color band shall be applied within two pipe diameters of the interface. The band width and method of application shall be in accordance with KSC-STD-SF-0004.

b. A color tag shall be attached to the interface. The tag shall be an aluminum tag per foto foil "A," or equivalent, or 3.2-mm (1/8-inch-) thick laminated phenolic plastic engraving stock [25 mm by 50 mm (1 x 2 inches)] with white engraved letters ("FUEL" or "OXID," 19 mm (3/4 inch) high] and attached with stainless steel wire [300 series, 1.02 mm (0.040-inch) diameter minimum].

The color of the band and the tag shall be yellow for fuels and green for oxidizers (secondary warning color in accordance with KSC-STD-SF-0004).

3.1.3.6.2 Commodity Equipment. - The requirements for the connect/disconnect points of commodity equipment are governed by this standard to the extent specified in 3.3.

3.1.3.6.3 Flight Hardware. - The requirements for the connect/disconnect points of payloads and payload-specific support equipment are governed by KHB 1700.7. The requirements for the connect/disconnect points of the Shuttle are prescribed by the individual component specification drawings.

3.1.3.7 Intermixing. - System design shall provide for the complete isolation of fuel and oxidizer systems to preclude the intermixing of propellants. Vapors of fuels and oxidizers must be vented through separate systems. For connect/disconnect points, all of the following means shall be used to ensure safety:

a. Color coding and marking

b. Procedural controls (standard operational practices and controlling documents)

c. Personnel training and qualification

d. Proximity (separation distance)

Where close proximity presents a hazard due to the possibility of a fuel/oxidizer cross-connection, uniquely sized or mechanically keyed connecting hardware shall be used.

3.1.3.8 Quantity-Distance. - Safety requirements for quantity versus distance limitations for the handling and storage of hypergolic propellants shall comply with AFR-127-100 (fixed facility) or DOD 6055.9-STD (mobile equipment).

3.1.3.9 Fire Protection. - The design of hypergolic propellant facilities shall include provisions for fire protection in compliance with NFPA 30, NFPA 70, NFPA 15, and KSC-STD-F-0004. The vessel, tanker transfer, and operator transfer area deluge systems shall be designed with a minimum of 0.34 L/s per square meter (0.5 gal/min per square foot) of surface area.

3.1.3.10 Lightning Protection. - The design of hypergolic propellant GSE shall include provisions for lightning protection in compliance with KSC-STD-E-0013.

3.1.3.11 Hazardproofing. - Provisions for hazardproofing of electrical enclosures and equipment to be used in hypergolic propellant systems shall be in compliance with KSC-STD-E-0002, KSC-E-165, and NFPA 496. For new designs, the use of pneumatic air or inert gas purging in lieu of standard hazardproofing techniques is discouraged when equipment is available that already meets the required hazardous classification (i.e., class 1, division 1 or 2). Engineering Development Directorate (DE) concurrence is required for such applications.

3.1.3.12 Vapor Disposal. - The design of GSE for hypergolic propellant systems shall provide for the safe disposal of toxic vapors and shall be in full compliance with applicable regulations of the Florida Department of Environmental Protection (FDEP).

3.1.3.13 Liquid Traps. - The design of GSE for the transfer of hypergolic propellants shall preclude unnecessary liquid traps. Adequate draining capability must be provided where it is not feasible for the system design to preclude all liquid traps.

3.1.3.14 Servicing Areas. - All hypergol servicing areas with fixed equipment shall be within a contained area that drains to a collection/removal location. The system design shall consider proper purges, slope, and drain location to remove liquid from the transfer manifold prior to disconnect and, therefore, minimize the potential for spillage. Consideration should also be given to the use of drip pans and/or aspirators at these locations. If the propellant is stored inside a closed building, the building shall be designed to meet the applicable hazard classification.

3.1.4 Electrical. - Power, control, and instrumentation subsystems shall comply with the provisions of NFPA 70, KSC-STD-E-0002, KSC-E-165, and KSC-E-166.

Instrumentation connectors, control connectors, and cable subassemblies shall be in accordance with KSC-DE-512-SM.

3.1.5 Ecological Considerations. - Consideration shall be given to ecological or environmental impacts caused by installation, operation, maintenance, or malfunctions of proposed, new, or altered systems. The analysis shall be performed in accordance with KHB 1200.1 and KMI 8800.6.

3.1.6 Human Engineering. - The requirements for human engineering shall be in accordance with MIL-STD-1472 and KSC-DE-512-SM. GSE at KSC is normally designed to be operated and maintained by skilled (trained) technicians and engineers. Further consideration in the design shall be given to the limitations imposed on individuals dressed in PHE suits.

3.1.7 Reliability. - All GSE designs shall comply with the applicable program reliability requirements and KMI 1710.1. Equipment and components that have been successfully tested and qualified shall be specified for new design. Components for noncritical applications may use industry-proven parts when the determining factors are reduced to cost only. In some cases, features not available in proven hardware may necessitate advance ordering of components for testing and qualification.

3.1.7.1 Qualification Testing. - The appropriate qualification testing of new, unqualified components to be used in hypergol systems shall be conducted. KSC-STD-164, KSC-STD-G-0003, and AIR 1082 (Fluid System Component Specification Preparation Criteria, an SAE document) should be referenced for the development of the test requirements. The scope of qualification testing shall be based on the intended function of the component and all available field experience with similar components (e.g., from NASA installation, other Government installations, and commercial industry).

3.1.8 Special Capabilities. - For failure modes that could result in a time-critical emergency, provision shall be made for automatic switching to a safe mode of operation. Caution and warning signals shall be provided for these time-critical functions.

3.1.9 Components Selection. - Equipment and components that have been successfully tested and qualified shall be specified for new design. Components for noncritical applications may use industry-proven parts when the determining factors are reduced to cost only. In some cases, features not available in proven hardware may necessitate advance ordering of components for testing and qualification. Design pressure ratings of all components shall be in accordance

with ANSI/ASME B31.3 and the ASME Boiler and Pressure Vessel Code. Special valves, soft goods, and stems may be required for hypergol service.

3.1.9.1 Materials. - All materials used in hypergol systems shall meet the requirements of DE-MI 8060.1. Each material shall be suitable in every respect for its intended use and shall conform to the specified Government requirements. Refer to 79K11948 for the list of approved materials for hypergolic fluids.

All materials that could possibly come in contact with the service propellant or vapors in the event of a spillage or component/system rupture shall be reviewed for compatibility with that service propellant. Consideration should be given to all items within the boundaries of class 1, division 2, groups C and D (in accordance with NFPA 70) vapor exposure areas. Such items as grating, supports, sump system, deluge piping, etc., shall be included in the review process.

3.1.9.2 Component Identification. - Each component (excluding piping assemblies) shall be identified as follows. This information shall be engraved or stamped on the component:

a. The manufacturer's name (on the component)

b. The component part number (vendor P/N) (on the component)

c. The specification part number (KSC P/N) (on the component), if applicable

The following information shall be legibly marked on a stainless-steel tag and attached to the component:

a. The find number may be permanently and legibly marked on a stainless-steel tag, and the tag shall be attached to the component using stainless-steel safety wire. Other information must be affixed to the component, engraved, or stamped.

b. The applicable design pressure rating (on the component)

c. The fluid or medium types, such as hypergolic fuel or hypergolic oxidizer, with which the component is suitable for use (on a separate tag) or color tape.

3.1.9.3 Cleaning. - The cleaning of pipe, tubing, fittings, gaskets, and components shall be in accordance with a KSC-approved cleaning procedure and shall comply with level 300A of KSC-C-123 for oxidizer services and level 300 of KSC-C-123 for

fuel services. Vent and waste systems shall comply with level 1000A of KSC-C-123 for oxidizer services and level 1000 of KSC-C-123 for fuel services. Systems/ piping downstream of the final GSE filter shall be cleaned to level 100A of KSC-C-123 for oxidizer services and level 100 of KSC-C-123 for fuel services.

Pickling and passivation are required for all materials in contact with hypergolic oxidizer N_2O_4 prior to cleanliness level verification. Recommended pickling and passivation as well as cleaning procedures may be found in manual 4-0-385.

All hazardous wastes generated during cleaning and processing shall be managed in accordance with KHB 8800.7.

3.1.10 Special Tools. - GSE shall be designed to minimize the requirement for special tools.

3.1.11 Welding. - All welding shall be in accordance with KSC-SPEC-Z-0013, KSC-SPEC-Z-0016, and KSC-SPEC-Z-0020 or with ANSI/ASME B31.3 and ASME Boiler and Pressure Vessel Code, section VIII, division 1 or 2 (weld requirements for lethal service)and section IX, as applicable.

Appurtenances (ancillary supports, lifting lugs, etc.) may be welded to pipe or vessel walls using an oval or circular reinforcing pad attached with a full-circumferential weld in accordance with ANSI/ASME B31.3 or the ASME Boiler Pressure Vessel Code, as applicable.

3.1.12 Nondestructive Examination. - Nondestructive examination of weldments shall include one or more of the following: radiographic inspection, magnetic particle inspection, dye penetrant inspection, ultrasonic inspection, and visual and gaging of weld sizes using standard gages.

WARNING

All nondestructive testing materials (e.g., liquid penetrants, developers, ultrasonic couplants, etc.), which are to be applied to surfaces that will be exposed to hypergols in service, shall be compatible with that service fluid. Compatibility with hypergols shall be assessed by testing in accordance with NHB 8060.1. Final approval for use of these materials must be obtained from the KSC Materials Science Laboratory/ Center Materials Representative.

3.1.12.1 Radiographic Inspection. - In addition to the radiograph inspection requirements of ANSI/ASME B31.3 and ASME Boiler and Pressure Vessel Code, section VIII, division 1 or 2, 100 percent radiograph inspection is required of all pressure vessels and system piping welds (butt welds, branch connections, nozzle penetrations, etc.) including those welds made by an automatic process. The radiograph inspection flaw/acceptability criteria shall comply with the requirements defined in KSC-SPEC-Z-0013 or ANSI/ASME B31.3 and ASME Boiler and Pressure Vessel Code, section VIII, division 1 or 2, specification.

3.1.12.2 Other Inspections. - The methods of other nondestructive inspections are specified in KSC-SPEC-Z-0020. The specific applications for these types of inspections are to be defined in the applicable engineering drawings and specifications. Other weldments shall be inspected, for example, by a dye penetrant inspection of any external fillet weld attachment to pipe or vessel walls during construction of the vessel.

3.1.13 Color-Coding. - Pipe and tubing systems shall be color-coded in accordance with KSC-STD-SF-0004.

3.1.14 Bonding and Grounding. - Bonding and grounding of GSE shall be in accordance with KSC-STD-E-0012. Only compatible grounding material shall be used within hazardous liquid/vapor areas. Interconnecting dissimilar ground metals that are prone to galvanic corrosion over a relatively short time period shall not be used.

3.1.15 Marking of GSE. - Fixed GSE shall be marked in compliance with KSC-STD-SF-0004 and KSC-STD-E-0015. Mobile equipment shall be marked in accordance with 81K00643 and with the latest DOT specifications. GSE shall be marked with model numbers, and equipment racks shall be marked with rack numbers. Components shall be marked in accordance with 3.1.9.2 except for hoses, which shall be marked in accordance with 3.5.1.3. The piping interfaces of GSE shall be additionally marked with color bands and color tags as specified in 3.1.3.6.1.

3.1.16 Blanket Pressure. - Provide a capability for blanket GN_2 with a gage pressure up to 138 kPa [20 pounds per square inch (lb/in^2)] for all GSE. A gage may be provided at the pressurization point, sized in accordance with 3.5.6.1.2.

3.2 Fixed Equipment.

3.2.1 Pneumatics. - Pneumatic systems shall comply with KSC-STD-Z-0005.

3.2.1.1 Pressurant Check Valves. - Check valves shall be designed into the piping system immediately adjacent to all pressurant/purge (normally GN_2) interface connection points. To preclude hypergol migration, the design constraints of KSC-STD-Z-0005 are applicable.

3.2.2 Servicing System. - Systems for operations such as propellant loading, propellant offloading, equipment decontamination, and any other operations where hypergolic propellants, vapors, or wastes are present shall be classified as hypergol servicing systems.

3.2.2.1 General Layout. - The design of servicing systems shall provide for complete separation/isolation of fuel and oxidizer systems (see 3.1.3.7 and 3.1.3.8).

3.2.2.2 Manifold Piping. - Manifold piping (liquid and vent) of similar hypergol commodities stored at one fuel or oxidizer facility (e.g., A-50 and MMH) shall be kept separate. Vapor interaction or residual liquid accumulation will degrade a product beyond specification limits.

3.2.2.3 Storage Pressure Vessels. - Storage vessels shall be located aboveground and shall incorporate solar heat shields to reduce solar heating. For the separation distance of fuel and oxidizer vessels, see 3.1.3.8. All hypergol storage vessels shall have containment areas for leaks and spills. The usable volume of each containment area shall be sufficient to hold the entire contents of the storage vessel.

3.2.2.4 Waste Tanks. - Waste tank design and operating criteria shall be determined by the type of waste (hazardous/nonhazardous) to be maintained within the specified tank. All underground hazardous waste tanks and ancillary piping shall comply with the requirements set by Environmental Protection Agency (EPA) standards in 40 CFR 264.193 and 40 CFR 280. Waste tanks may be located aboveground or underground. Underground tanks should not be used; however, if underground systems are required, the waste tanks and ancillary piping shall have secondary containment systems with leak detection capability.

3.2.2.5 Vent Stacks. - All hypergolic vent effluent (except for emergency venting) shall be scrubbed prior to venting to the atmosphere. All hypergol vent stacks shall be equipped with rain bonnets to preclude intrusion of water, organic materials, or other foreign incompatible substances into the hypergol vent system. Hazardous waste generated during a scrubbing operation shall be managed in accordance with KHB 8800.7.

3.2.2.6 Bonding and Grounding Station. - All fixed facility transfer apron areas shall be equipped with a bonding and grounding station for use with associated mobile equipment. The bonding and grounding station shall comply with KSC-STD-E-0012.

3.3 Mobile Equipment. - For the purpose of this standard, mobile equipment shall be divided into two types: (1) mobile equipment for highway use and (2) mobile equipment for nonhighway use. Furthermore, for the purpose of this standard, all roadways (between restricted facilities) within the confines of KSC and the Eastern Range (ER) are considered to be highways.

3.3.1 Mobile Equipment for Highway Use. - Mobile equipment for highway use (see 6.2.b) shall be designed to meet the requirements set by DOT standards in 49 CFR, subpart C, parts 100 through 199.

3.3.2 Mobile Equipment for Nonhighway Use. - Hazardous materials may not be transported on KSC roadways unless packaging is in accordance with 49 CFR or of a listed DOT exemption. Mobile equipment for nonhighway use shall be designed to meet the intent of applicable specification requirements. DOT noncompliance equipment shall be designed to be capable of being drained and purged prior to transport out of controlled areas onto KSC and Cape Canaveral Air Station (CCAS) roadways.

3.4 Portable Equipment. - All portable equipment shall be designed to meet the applicable drawing and specification requirements. Portable equipment designed for use as storage or for transportation of hypergol propellants or hypergol waste shall be designed to meet applicable requirements for packaging as set by DOT standards in 49 CFR. The total maximum weight of such a device or container shall meet the requirements of the Occupational Safety and Health Administration (OSHA) as related to the permissible weight limit for an individual to transport. Further consideration in the design shall be given to the limitations imposed on individuals dressed in PHE units in accordance with KSC-DE-512-SM.

3.5 Components. - The selection of components shall be in accordance with the requirements defined in 3.1.9. Specific requirements for components, in addition to the ones defined in the following paragraphs, shall be identified in the applicable engineering drawings and specifications. Components shall have flange- (raised face with concentric serrations) or straight-thread connections (MS 33649). Threaded National Pipe Thread (NPT) connectors are not allowed.

3.5.1 Hoses.

3.5.1.1 Construction Features. - Hoses shall consist of a seamless polytetrafluoroethylene (PTFE) or compounded PTFE inner tube reinforced with a 300-series stainless steel (SST) wire braid or spiral wrap, or shall consist of a flexible 300-series SST convoluted hose reinforced with 300-series SST braid.

3.5.1.2 End Connections. - Hoses shall be provided with 300-series SST end fittings of the coupling-nut, 37-degree flared type, with fittings to mate with the appropriately sized ANSI pipe flanges with raised face and concentric serrations in accordance with ANSI/ASME B16.5 or with KC159 hubs.

3.5.1.3 Marking/Identification. - Each hose shall be provided with an identification tag that is permanently and legibly marked with the following information:

a. Date (month and year) of hydrostatic test and test pressure

b. Hose size

c. Design pressure rating

d. KSC part number or assembly part number, if applicable

e. Vendor part number or contractor's tracking number

f. Hypergolic fuel or hypergolic oxidizer medium

The information shall be provided on the hose by means of an attached metal band (in accordance with 75M04185) that has been die stamped or electrochemically etched in accordance with KSC-STD-E-0015. Alternately, the hose information may be stamped or embossed on a "dog tag" (Federal Stock Number 8465-00-242-4804) that is attached by a nylon-coated steel cable [1.02-mm (0.040-inch) minimum diameter] (Federal Stock Number 4010-00-K03-8998) in accordance with MIL-W-83420.

3.5.1.4 Servicing Limitations. - Hose assemblies shall require hydrostatic testing at the time of fabrication. Carbon-filled, Teflon-lined flexible hoses blister in hypergol usage. The life cycle of hose assemblies is considered to be 2 years; therefore, the hose assemblies should be replaced every 2 years. All flexhoses in positive pressure applications shall be visually inspected over the entire length (externally) prior to use and at least annually for evidence of damaged fittings, kinks, broken wire braid, or other signs of degradation. If the hose cannot be inspected in place over the entire length, it shall be removed and inspected. The

hose shall be replaced if any degradation is found. The date (month and year) of the latest inspection, the inspection procedure number, and the inspection organization shall be documented on the hose by means of a permanent tag such as a "dog tag" marked and attached as described in 3.5.1.3.

3.5.1.4.1 Inspection Criteria. - The cognizant design organization shall establish any special inspection criteria for hoses. This special criteria and the inspection criteria and interval defined by 3.5.1.4 shall be defined in the system Operating and Maintenance Requirements Document (OMRSD) or other operating and maintenance documents. Severity of the operating environment, type of service fluid, and operating pressure shall be considered in establishing shorter inspection intervals. Coordination with the safety, reliability, and quality assurance organization is recommended.

3.5.1.5 Applications Design.

3.5.1.5.1 Restraints. - Flexhose installations designed for 1.03 megapascals (MPa) (150 lb/in^2 gage) or greater shall incorporate hose restraints in accordance with 80K51846 and KHB 1710.2, volume 2, SFOP 41, Safety Operating Procedure for Pressure System Safety. Eyebolts or other anchor points shall be provided for the attachment of required hose restraints and shall be capable of withstanding any loads that could occur should the hose break during service.

3.5.1.5.2 Flow-Induced Vibration. - Designs utilizing convoluted, unlined bellows or flexible metal hoses shall include analysis in accordance with JSC 08123 or MSFC-20 M 02540, as applicable, to preclude premature failure due to flow-induced vibration.

3.5.1.5.3 Permeability. - Hoses utilizing a PTFE or filled PTFE inner liner tube shall not be used in applications where permeation of gases through the liner tube is not acceptable.

3.5.2 Valves. - Valves shall comply with the following requirements.

3.5.2.1 Shutoff Valves. - Shutoff valves shall be globe (straight or angle) type or ball type. Metal-to-metal seats for shutoff valves in hypergolic service are not permitted without the approval of DE.

"Firetight" valves utilizing carbon graphite stem seals may be required by applicable DOT codes in certain locations. However, they are not recommended by the KSC Materials Control Board for long-term use (above 1 year) without refurbishment in hypergol service.

3.5.2.2 Metering Valves. - Metering valves shall be globe (straight or angle) type.

3.5.2.3 Flow Control Valves. - Flow control valves shall be pilot-operated, pneumatic-powered, or electrically controlled type fail-safe valves.

3.5.2.4 Relief Devices. - For detailed definitions of various safety devices, see 6.2.n through 6.2.r. Relief valves shall be the adjustable, spring-loaded type with soft seat. Pilot-operated safety valves are prohibited on hypergolic systems without the written approval of DE (see 6.2.r). Safety relief valves are generally used in hypergol systems (see 6.2.q).

3.5.2.4.1 Relief Valve Sizing. - Relief valves shall be designed and sized in accordance with ASME Boiler and Pressure Vessel Code, section VIII, division 1. Relief flow requirements shall be determined from Compressed Gas Association (CGA) Pamphlet S-1.3 for ground support equipment and from Pamphlet S-1.2 for mobile equipment or as stated in accordance with the applicable DOT codes. The design should consider flow reductions due to lesser heat inputs because of the deluge system. (Refer to NFPA 15 and 30 for CGA correlation to the reduction factor.)

3.5.2.4.2 Pressure Relief Piping. - Pressure relief piping shall be designed in accordance with the ANSI/ASME B31.3 code and sized in accordance with the ASME Boiler and Pressure Vessel Code, section VIII, division 1, appendix M. Consideration shall be given to relief valve weight and thrust for support design.

3.5.2.4.3 Isolation Block Valve. - Pressure relief systems on fixed ground support pressure vessels shall be equipped with an isolation block valve between the relief valve inlet manifold and the vessel outlet nozzle for inspection and repair purposes. This valve shall be chain-locked open and shall only be closed by an authorized person who shall remain stationed there the entire time the valve is closed. This person shall also monitor and verify nominal vessel pressure conditions during the period the valve is closed and shall chain-lock the valve open prior to leaving the vessel station. A three-way valve with a dual relief valve is required where continuous operation of the system is needed during relief valve calibration. For mobile equipment, refer to the applicable DOT regulations.

3.5.2.5 Check Valves. - Check valves shall be the spring-loaded type with a soft seat.

3.5.2.6 Electrically Operated Solenoid Valves. - Electrically operated solenoid valves may be used as determined on a case-by-case basis, although pneumatically operated valves are preferable. Both primary and secondary valve seals must satisfy materials requirements.

3.5.2.7 Materials. - Valves shall utilize the following materials where contact with fluid media is possible. DE concurrence is required for any deviations.

3.5.2.7.1 Metals. - Metal valve parts shall be type 304 or 316 SST or type 304L or 316L SST (if welded).

3.5.2.7.2 Nonmetals. - All nonmetals (softgoods) shall conform to 79K11948, type J fluid service. Use of any nonstandard material requires approval from the NASA Materials Science Laboratory.

3.5.2.7.3 Lubricants. - Lubricants shall be restricted to either Braycote 601; Krytox 240AC; Tribolube 16, types II and III; or Tribolube 10, type III, or equal. All other potential lubricants must be approved by KSC DE prior to use. Note that Krytox 240AC is not acceptable downstream of the final GSE filter.

3.5.2.8 End Connections. - All end connections shall be flanged type unless otherwise approved. Flanged connections shall be raised face with concentric serrations in accordance with ANSI/ASME B16.5. All system components shall be removable for maintenance and calibration. If threaded connection is required, straight thread in accordance with MS-33649 shall be used. NPT connections are not allowed.

3.5.2.9 Allowable Leakage. - Valves shall be tested for both internal and external leakage at their design pressure. The normal leakage rate shall not exceed that detected by a volumetric bubble leak test conducted with a minimum 10-percent helium mixture. Certain critical system components may require additional elaborate testing with a mass spectrometer to verify the external leak rates do not exceed 1 x 10^{-6} mL/s [at standard temperature and pressure (STP)] of helium gas in accordance with ASME Boiler and Pressure Vessel Code, section V, article 10, Leak Testing. The internal leak rates shall not exceed 10 milliliters per hour (mL/h) [cm^3 (standard) per hour] while using GN_2 test media or 25 mL/h while using gaseous helium (GHe) test media.

NOTE

Subject requirement exceeds ANSI/ASME B31.3, as ANSI/ASME B31.3 only requires a 10^{-3} mL/s (at STP) leak rate for lethal service commodities.

3.5.3 Filters. - Filters shall be installed immediately upstream of all interfaces where control of particulate matter is critical and at other appropriate points as required to control particulate migration. Selection of filters shall be based on a careful analysis of overall system performance requirements to ensure maximum

protection of critical components with the least performance penalty (pressure drop) is provided. Tee-type filters are preferred over inline types, since the tee-type filters can be maintained without disconnecting fluid system fittings. All filters shall be designed with replaceable elements. Filter elements shall maintain the filtering quality and not be damaged in any way when subjected to worst-case system conditions (i.e., maximum design flow rate and element clogged to its maximum design capability). Where possible, filter elements shall be designed to withstand a differential pressure equal to or greater than the maximum operating pressure to which they will be subjected in the system without degradation of the filter element bubble point.

Filter elements shall be of a type 304 or 316 SST or type 304L or 316L SST (if welded) with a minimum filtration rating of 2-μm (2 microns) nominal and 10-μm (10 microns) absolute or 10-μm (10 microns) nominal and 25-μm (25 microns) absolute as specified by particular requirements. Except for final filter and interface filters, the degree of contamination tolerance (degradation) shall be established in accordance with JSC-NSTS-7700, volume X, and shall be well documented in OMRSD requirements. Filter elements shall be cleaned, tagged, and certified periodically for hypergol services. Determination of the largest pore or hole size of filter elements shall be in accordance with ARP 901.

Connections for a differential pressure measuring device across the filter itself or within its associated piping shall be provided. Filter housing shall be equipped with a bottom drain. Note that use of the NPT drain connection is not allowed.

3.5.3.1 Materials. - The filter body and element shall be type 304 or 316 SST or type 304L or 316L SST (if welded) and all other major components shall be type 304 or 316 SST or type 304L or 316L SST (if welded). All seals, gaskets, and O-rings shall be in accordance with 79K11948.

3.5.3.2 End Connections. - Filter end connections shall be of flange design, unless otherwise approved by DE. Flange connections shall be in accordance with ANSI/ASME B16.5, with raised face and concentric serrations. If a threaded connection is required, straight threads in accordance with MS-33649 will be used. Use of NPT connectors is not allowed.

3.5.3.3 Allowable Leakage. - When filters are tested for external leakage at the design pressure, the leakage shall not exceed 1×10^{-6} mL/s (at STP) of helium gas, in accordance with ASME Boiler and Pressure Vessel Code, section V, article 10, Leak Testing. Note that bubble leak checking can measure leakage rates down to 1×10^{-4} mL/s (at STP) of helium gas. A mass spectrometer is therefore required to verify leak rates below this level.

3.5.4 Pumps. - Pumps shall be the centrifugal type and shall be specifically designed for pumping hypergolic propellants. When designing a pump system, consideration shall be given to the increased vacuum potential on the source tank or to the installation of a fail-safe vessel blanket pressure supply. Also, for hypergol centrifugal pumps, special consideration shall be given to the seals, drive mechanism, piping inlet/outlet configuration (recommended straight lengths and reductions), and priming configuration with a bypass.

Pump materials shall be entirely stainless steel (type 304 or 316, or type 304L or 316L if welded) and shall be hazardproofed in accordance with 3.1.3.11. All components (seals, gaskets, packings, and O-rings) shall conform to 79K11948. Use of any other material requires approval of the NASA Materials Science Laboratory.

3.5.5 Pressure Vessels.- All pressure vessels shall be designed, constructed, tested, certified, registered, and code stamped in accordance with the ASME Boiler and Pressure Vessel Code, section VIII, division 1 or 2, Lethal Service, or the applicable DOT codes for mobile equipment. All ASME-code-stamped vessels shall also be registered with the National Board of Boiler and Pressure Vessel Inspectors. Underground spill containment tanks shall comply with the requirements of EPA standards in 40 CFR 265, subpart J; 40 CFR 264, subpart J; and 40 CFR 280. All pressure vessels shall be documented for certification in accordance with KHB 1710.15 and recertified in accordance with KMI 1710.15, KHB 1710.15, and NHB 1700.6.

3.5.5.1 Materials. - Pressure vessel material shall be stainless steel, ASTM A240, type 304L, unless otherwise approved. It should be noted that use of high-carbon-content stainless steel, such as type 304, is subjected to chromium carbide precipitation during welding and bending activities. This precipitation in many cases leads to a chrome-depleted zone (sensitized) in an area of high residual stress, thus, increasing the potential for general corrosion and stress corrosion in these zones. Therefore, use of low-carbon stainless steel is generally required.

All nonmetal components (gaskets, etc.) shall conform to 79K11948. Use of any other material requires approval of the NASA Materials Science Laboratory.

DOT prohibits the use of any SST material with a molybdenum content exceeding one-half of 1 percent for hydrazine fluid service (refer to 49 CFR 173.276 and ERR 127-1).

3.5.5.2 Installation. - Pressure vessels shall be installed aboveground and shall be provided with a solar shield to reduce heating due to solar radiation. A spill containment dike, which shall be able to contain the entire volume of the pressure vessel, is required.

3.5.5.3 Pressure Vessel Supports. - Pressure vessel saddle support shall be designed in accordance with ASME Boiler and Pressure Vessel Code, appendix G, (sanctioned guidelines, such as developed by L.P. Zick), or shall utilize a detailed (finite element) analysis.

3.5.5.3.1 Anchor Bolts. - Consideration shall also be given to anchor bolt design capability for holddown in the event of deluge water filled bay (buoyant force of vessel), if applicable.

3.5.5.3.2 Expansion Support. - One of the two supports of a stationary vessel shall be capable of providing for expansion and contraction of the vessel. A suitable low-friction solid material such as PTFE shall be placed between sliding surfaces. Slots shall be provided for bolts to accommodate expansion and contraction.

3.5.5.4 Corrosion Allowance. - A 1.6-mm (1/16-inch) additional thickness shall be added to the design wall thickness above the minimum standards required for pressure liquid head and other load conditions. Exceptions to this requirement include mobile vessels regulated by DOT and certain small [1900 L (500 gallons) or less] containers are allowed with DE approval.

3.5.5.5 Ullage. - All pressure vessels shall be designed to allow for a minimum 10-percent ullage space at full load conditions.

3.5.5.6 External Pressure. - All fixed pressure vessels exposed to atmosphere/ winds shall be designed with a minimum external gage pressure load of 13.8 kPa (2 lb/in^2) or absolute pressure load of 115 kPa (16.7 lb/in^2).

3.5.5.7 Maximum Allowable Working Pressure (MAWP). - All stationary hypergolic fuel vessels shall be designed with a minimum gage MAWP of 517 kPa (75 lb/in^2) or an absolute MAWP of 618.5 kPa (89.7 lb/in^2). All stationary insulated oxidizer storage vessels under the roof (i.e., protected from the direct sunlight) shall be designed with a minimum gage MAWP of 517 kPa (75 lb/in^2) or an absolute MAWP of 618.5 kPa (89.7 lb/in^2). All stationary uninsulated oxidizer vessels exposed to the direct sunlight shall be designed with a minimum gage MAWP of 862 kPa (125 lb/in^2) or an absolute MAWP of 964 kPa (139.7 lb/in^2) (this was based on 2.4 m (8 feet) in diameter by 5.8 m (19 feet) in length tank size calculations). All mobile equipment should have a design pressure in accordance with DOT standards in 49 CFR.

3.5.5.8 Inspection Period. - All pressure vessels shall be inspected at least once a year using a nondestructive evaluation (NDE) program.

3.5.6 Instrumentation.

3.5.6.1 Pressure Gages.

3.5.6.1.1 Limitations. - All pressure gages shall conform to the requirements of ANSI/ASME B40.1, except as specified herein. Pressure gages that are part of a cylinder regulator assembly (such as used with cutting, welding, or other industrial type application) are exempt from these requirements, as are gages associated with pneumatic controllers, positioners, and other standard process control equipment, provided the parts of the gage that come in contact with the fluid are compatible in accordance with 79K11948.

3.5.6.1.2 Selection. - Pressure gages shall be selected so the normal working pressure falls within the middle half of the scale range, except for gages used in applications that require a wide range of operating pressure. For these applications, the pressure gages shall be selected so the maximum pressure that can be applied will not exceed the scale range of the gage.

3.5.6.1.3 Construction Features. - Pressure gages shall conform to ANSI/ASME B40.1 and shall be of one-piece, solid-front, full-diameter, pressure-relief back case construction, utilizing an optically clear shatterproof window made of high-impact noncracking plastic, heat-treated glass, or laminated glass. Gages shall be designed for flush-bolted front-panel mounting.

All pressure gages shall be provided with a Bourdon tube bleeder (or equivalent) device to facilitate cleaning. All material normally in contact with the service fluid shall be type 304 or 316 SST, except the Bourdon tube bleed screw may be made from any of the 300-series stainless steels. Gages of the liquid-filled case type shall not be used.

3.5.6.1.4 Pressure Connections. - The pressure connection shall be the low-back type with an MS-33649-4 threaded port.

3.5.6.2 Liquid Sensors. - Liquid sensors, suitable for indicating the presence/absence of liquid, shall be provided as dictated by system requirements. Metals that could come in contact with the service medium shall be type 304 or 316 SST. Liquid level indicators that contain welded portions (typically magnetic float type) shall be constructed from type 304L or 316L SST. The use of glass-faced or radiation source-emitting liquid level indicators is prohibited without approval from DE. Temperature-type liquid level sensors shall be in accordance with

79K03450. Other types not recommended (due to historical nonoperational and continuous maintenance problems) for hypergol service include capacitance, conductive, and pressure/density types.

3.5.6.3 Temperature Sensors. - Temperature sensors shall be the transducer type or the direct-reading gage type. Temperature sensors shall be in accordance with 79K03040 or 79K03449.

3.5.6.4 Liquid Level Sensors. - For new facilities, suitable, remote-reading liquid level indicators or gages calibrated for indicating the contents of a tank shall be provided. Magnetic gages or fused-glass level indicators are acceptable.

NOTE

Remote liquid level indicators are not required for diluted hypergol collection systems.

For fixed facility installation, consideration shall be given for routing the remote liquid level sensor output through a logic controller to an alarm device as an early warning leak detection device. If the level drops below the input parameters coupled with temperature dependencies, alarms shall be activated.

3.5.6.5 Flowmeters. - Flowmeters should be the volumetric (unidirectional or bidirectional) measuring type as required by the system design. The entire flowmeter assembly (except the pickup coil) shall be type 304 or 316 SST or type 304L or 316L SST (if welded). Vortex shedding type and turbine type flowmeters are also acceptable. A bypass shall be provided for turbine-type flowmeters to avoid overspinning the bearing while purging. Adequate downstream and upstream straight lengths of run must be provided in accordance with the manufacturer's recommendations.

3.6 Piping and Fittings. - All hypergol piping design shall be in accordance with ANSI/ASME B31.3, category M.

3.6.1 Pipe. - Pipe shall conform to ANSI/ASME B36.19. The pipe material shall comply with ASTM A312, type 304L or 316L SST. Only seamless, cold-drawn pipes shall be used for hypergol services. For pipe sizes not available as seamless pipe, pipes conforming to ASTM A312 welded are acceptable, provided the longitudinal seam is 100 percent X-rayed.

3.6.2 Pipe Fittings. - Pipe Fittings shall conform to ANSI/ASME B16.9 and ANSI/ASME B16.5. The fitting material shall comply with ASTM A403, type

304L or 316L SST. Socket weld and pipe thread fittings are not permitted. Also, welded fittings (e.g., tees or elbows) with a WP designation are not allowed unless X-rayed. Therefore, all fittings must be seamless (WPS) or welded and X-rayed (WPX) type.

3.6.3 Flange Connections. - Flanged connections shall utilize weld neck lap joint or blind type flanges. Socket weld flanges are not permitted. An all SST, flared, lapped type joint flange should be used only where needed for fit-up orientation.

3.6.3.1 Flanges. - Flanges shall be raised face with concentric serrations in accordance with ANSI/ASME B16.5. Flange material shall comply with ASTM A182, type 304L or 316L SST.

3.6.3.2 Gaskets. - Flange gaskets shall conform to ANSI/ASME B16.21 and shall be installed between flanges at all flanged connections. Gasket material shall be in accordance with 79K11948. Use of any other material will require pre-qualification.

3.6.3.3 Studs. - Stud threads shall conform to ANSI/ASME B1.1, UNC series. Stud material shall be ASTM A320 grade B8 (304) or B8M (316) SST.

3.6.3.4 Nuts. - Nuts shall be 194 heavy, hex type and conform to ANSI/ASME B18.2.2. Material shall be ASTM A194 grade 8 (304) SST or ASTM grade B8M (316) SST.

3.6.3.5 Bolts. - Bolts shall conform to ANSI/ASME B18.2.1. The bolt material shall be ASTM A193 or ASTM A320 grade B8 (304) SST or grade B8M (316) SST.

Torque values for 300-series stainless steel CRES-threaded fasteners for end flanged bolting shall be in accordance with MSFC-STD-486. Bolt lubricants shall be Krytox 240AC, Tribolube 16, or Braycote 601, or an approved equal.

3.6.3.6 Washers. - Type 304 or 316 SST star or lock washers shall be used on all studs and bolts at flanged connections.

3.6.3.7 Bonding. - The bonding and grounding of each flange joint shall conform to KSC-STD-E-0012 and NFPA 70.

3.6.4 Pressure-Energized Type Flanged Joints. - Pressure-energized, self-energized-type flanged joints may be used in place of face-seal-type flanged joints for improved performance, reliability, and ease of use. Acceptable pressure-energized connectors are E-Con by Reflange, Inc., Houston, Texas and Value-Lok by Taper-Lok Corporation, Houston, Texas.

3.6.5 Threaded Connections. - The use of threaded connections shall be restricted to those connections that require conversion from pipe to tubing; however, pipe (e.g., tapered) threads shall not be used. The design shall include disconnecting points in the vicinity of welded KC-NPT fittings to provide for the easy removal of components.

3.6.6 Welding. - All welding of stainless steel pipe and fittings shall comply with KSC-SPEC-Z-0016 and KSC-SPEC-Z-0020 or with the ANSI/ ASME B31.3 and ASME Boiler and Pressure Vessel Code, section VIII, division 1 or 2 (weld requirements for lethal service), as applicable.

3.6.7 Supports and Anchors. - Pipe, pipe accessories, supports, anchors, braces, etc., shall be installed in conformance with ANSI/ASME B31.3 and shall be compatible with hypergolic vapors.

3.6.8 Protective Coatings. - Stainless steel pipe, fittings, supports, anchors, braces, etc., shall be painted in accordance with KSC-STD-C-0001 for the painting of stainless steel tubing and fittings. AR-7, or an approved equal, is the preferred coating material for this application.

3.7 Tubing and Fittings.

3.7.1 Tubing. - Tubing shall conform to KSC-SPEC-Z-0007.

3.7.2 Tube Fittings. - Tube fittings for mechanical connections shall conform to KSC-F-124 and GP-425. All seals for tube fittings shall be PTFE. Crush washers shall not be used.

3.7.3 Welding. - The welding of stainless steel tubing shall comply with the automatic welding requirements of KSC-SPEC-Z-0020.

3.7.4 Brazing. - Brazing shall not be performed on hypergolic propellant systems, and braze-type fittings/joints shall not be used in hypergolic propellant systems.

3.7.5 Fabrication and Installation. - Fabrication and installation of tubing, tube fittings, supports, clamps, etc., shall comply with KSC-SPEC-Z-0008.

3.7.6 Lubrication. - Lubrication of tube fittings shall be in accordance with KSC-SPEC-Z-0009.

3.8 Steel Plates and Shapes.

3.8.1 Materials. - Steel plates and shapes shall be used for appurtenances and supports only. Materials for metal plates and shapes shall comply with the following requirements.

3.8.1.1 Carbon Steel. - Carbon steel materials shall comply with ASTM A36, Structural Grade Steel. The use of carbon steel shall be restricted to equipment support systems. Its use in wetted systems shall be strictly prohibited. In all cases, structural steel shall be coated in accordance with KSC-STD-C-0001, zone 3 or 4. It should be noted that carbon steel may cause ignition of hydrazine, MMH, or A-50 and will be readily corroded by N_2O_4. Carbon steel sheeting shall not be used as equipment covering or shielding.

3.8.1.2 Stainless Steel. - Stainless steel materials shall be type 304L SST for all applications requiring welding. Type 316L SST may be utilized for forged and rolled applications. Stainless steel shall comply with QQ-S-763.

3.8.1.3 Aluminum. - Aluminum materials shall not normally be used in hypergolic propellant systems; however, where their use is approved by DE, they shall be tempered alloy 6061-T6 or 6063-T6 and shall comply with QQ-A-200/8 and QQ-A-250/11.

3.8.2 Welding. - All welding of metal plates and shapes shall be in conformance with KSC-SPEC-Z-0020.

3.8.3 Protective Coatings. - Protective coatings for metal plates and shapes shall comply with the following requirements.

3.8.3.1 Carbon Steel. - Carbon steel materials, when permitted for use, shall be coated with an inorganic zinc-rich primer in accordance with KSC-STD-C-0001.

3.8.3.2 Stainless Steel. - Stainless steel materials shall be painted in accordance with KSC-STD-C-0001. Stainless steel tubing shall be coated with AR-7.

3.8.3.3 Aluminum. - Aluminum materials shall be painted in accordance with KSC-STD-C-0001.

3.9 Caulk Materials. - A 100-percent silicon rubber (such as GE103 and Dow Corning 732) shall be used as a general-purpose sealant.

NOTE

Dow Corning 3145, or equal, is approved for use in sealing electrical component housings.

4. QUALITY ASSURANCE PROVISIONS

4.1 Design and Development Controls. - The designer shall ensure the following are specified as necessary to ensure engineering quality and fulfill the design intent:

a. Inspection and test criteria (including specific nondestructive test methods, test equipment, environmental conditions, and sample size)

b. Identification and data retrieval requirements

c. Identification of critical hardware characteristics necessary for procurement and fabrication

d. Performance and/or tolerance limits

e. Applicable specifications for cleanliness/contamination control

f. Applicable process specifications, standards, and procedures

g. Limited-life characteristics

h. Acceptance/rejection criteria

i. Handling, storage, preservation, marking, labeling, packaging, packing, and shipping requirements

j. Equipment to be placed under integrity control

When ASME/ANSI/AWS welding standards are utilized, certified weld procedures, welder performance qualification, and the grade level of the inspector shall be specified.

The quality assurance methodology for GSE shall be based on a closed-loop system beginning with the evaluation of engineering design to define quality requirements for inclusion in the engineering documentation. Quality assurance of procurement and manufacturing shall be accomplished by inprocess inspections and acceptance

tests. Quality assurance shall include the functions of quality engineering, inspection, quality program control, quality procurement control, and a corrective action system.

Quality assurance objectives shall be attained by imposing control procedures that are flexible and consistent, placing maximum emphasis on inspection of all major, physical, and performance characteristics to correlate deliverable hardware with inspection requirements and updated technical documentation. All functional components shall be serialized for traceability of component performance from testing back to component acceptance tests. Identification tags shall be of sufficient durability to preclude obliteration under field conditions.

4.2 System Tests.

4.2.1 Assembled System Leak Test. - Mandatory pneumatic leak testing, at design pressure, of all completely assembled and cleaned vessel pipe/tubing sections, with components installed, shall be completed prior to introduction of the propellant. Test gas shall utilize a minimum concentration of 10-percent helium. All mechanical joints (e.g., gasket joints, seals, threaded joints, valve bonnets, etc.) and weld seams shall be visually bubbletight, utilizing approved soap solution and techniques. Isolation valves shall be checked for internal leakage and functionality.

NOTE

On certain critical systems (such as hoses hooked up to the Shuttle or payload), leak check verification at joints and of valving shall be checked utilizing portable mass spectrometer detection probe methods to verify lower range leakage rates.

4.2.2 System Validation and Functional Test. - System validation and functional test of each component, including continuity test, shall be performed in accordance with the performance test requirements of system specifications.

4.3 Contractual Requirements. - When this standard is invoked in a contract, the quality requirements of NHB 5300.4(1B) are imposed and may be amended by the statement of work.

5. PREPARATION FOR DELIVERY

Items to be shipped shall be securely packaged and packed in appropriate shipping containers, which will provide adequate protection against damage or degradation of any kind during shipment. All applicable carrier rules shall be complied with. Containers shall be marked to conform to MIL-STD-129.

6. NOTES

6.1 Intended Use. - This standard is intended to establish uniform engineering practices and methods and to ensure the inclusion of essential requirements in the design and construction of hypergolic propellant ground support equipment used at KSC for the fueling of space vehicles.

6.2 Definitions. - For the purposes of this standard, the following definitions shall apply.

a. Fixed Equipment. GSE designed to remain in place, attached to permanent foundations.

b. Mobile Equipment. GSE designed to be moved from place to place, usually on wheels, skids, etc.

c. Portable Equipment. GSE designed to be carried or moved by an individual, usually the user.

d. Pressure Vessel. A container for containment of pressure, either internal or external, as defined in ASME Boiler and Pressure Vessel Code, section VIII, division 1, paragraph UG-1.

e. Waste Tank. A tank used to contain waste materials at atmospheric pressure.

f. Aerozine-50. A hypergolic propellant consisting of 50-percent hydrazine and 50-percent unsymmetrical dimethylhydrazine (UDMH) and conforming to MIL-P-27402.

g. MMH. A hypergol propellant [monomethylhydrazine (CH_3NHNH_2)] conforming to MIL-P-27404.

h. N_2H_4. A hypergolic propellant (hydrazine) conforming to MIL-P-26536.

i. Hypergolic Propellant. A fluid that may be either a fuel or oxidizer. When mixed together, a hypergolic fuel and oxidizer ignite spontaneously.

j. N_2O_4. A hypergolic propellant (nitrogen tetroxide) conforming to MIL-P-26539.

k. Critical Function. An overall function that, if lost, would cause a Category 1, 1S, or 2 failure regardless of redundancy.

(1) Category 1. A failure that could cause loss of life or launch vehicle, which includes failures that could cause catastrophic loss of payload (fire, explosion).

(2) Category 1S. A failure in a safety or hazard monitoring system that could cause the system to fail to detect, combat, or operate when needed during the existence of a hazardous condition and could allow loss of life or launch vehicle.

(3) Category 2. A failure that could cause loss (damage) of a launch vehicle system, which includes failures that could cause noncatastrophic loss (damage) to a payload.

l. Maximum Allowable Working Pressure (MAWP). The maximum pressure permissible at the top of the vessel while in its normal operating position at its operating pressure and at the maximum temperature specified for that pressure in accordance with ASME Boiler and Pressure Vessel Code, section VIII, division 1, paragraph UG-98.

m. Design Pressure. The most severe condition of coincident internal or external pressure and temperature. (Refer to the ASME Boiler and Pressure Vessel Code, section VIII, division 1, paragraph UG-21, and ANSI/ASME B31.3, paragraph 301.2.)

n. Pressure Relief Valve. A pressure relief device designed to reclose and prevent the further flow of fluid after normal conditions have been restored (ASME Boiler and Pressure Vessel Code, section VIII, division 1, paragraph UG-125, footnote 42).

o. Safety Valve. A pressure relief valve actuated by inlet static pressure and characterized by rapid opening or pop action (ASME Boiler and Pressure Code, section VIII, division 1, paragraph UG-125, footnote 43).

NOTE

This type of relief valve is not approved for use on hypergolic systems.

p. Relief Valve. A pressure relief valve actuated by inlet static pressure having a gradual lift generally proportional to the increase in pressure over opening pressure. It may be provided with an enclosed spring housing suitable for closed discharge system application and is primarily used for liquid service.

NOTE

Hypergol systems relieve vapors; therefore, relief valves are generally not used.

q. Safety Relief Valve. A pressure relief valve characterized by rapid opening or pop action or by opening in proportion to the increase in pressure over the opening pressure, depending on the application. (See ASME Boiler and Pressure Vessel Code, section VIII, division 1, paragraph UG-125, footnote 43.)

NOTE

This type of safety relief valve is used in hypergol systems.

r. Pilot-Operated Pressure Relief Valve. A pressure relief valve in which the major relieving device is combined with and controlled by a self-actuating auxiliary pressure relief valve. (See ASME Boiler and Pressure Vessel Code, section VIII, division 1, paragraph UG-125, footnote 43.)

NOTE

Generally, pilot-operated pressure relief valves are not used in hypergol systems. Pilot-operated safety valves shall not be used in hypergolic systems without the written approval of DE.

s. Ground Support Equipment (GSE). All equipment necessary to support the operations of receiving, handling, assembly, test, checkout, servicing, and launch of space vehicles. As used herein, GSE includes the facilities;

fixed, mobile, and portable equipment (other than commodity equipment); storage vessels and waste tanks; and vent stacks.

t. Proof Pressure. The hydrostatic proof pressure determined by either the yield or burst method. The yield test may only be used if the ratio of minimum yield to ultimate strength is 0.625 or less, as specified in ASME Boiler and Pressure Vessel Code, section VIII, division 1. (Not to be confused with standard hydrostatic testing.)

u. Set Pressure. The value of increasing inlet static pressure at which a pressure relief valve displays one of the operational characteristics as defined under "opening pressure," "popping pressure," "start-to-leak pressure" (ANSI/ASME B95.1, paragraph 7.32). The set pressure shall not exceed MAWP and/or design pressure.

v. Firetight. Zero leakage to atmosphere through the bonnet/stem under external fire conditions.

w. Commodity Equipment. Mobile or portable support equipment designed to be used in the transportation and supply of propellant commodities.

Custodian:

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Kennedy Space Center, Florida 32899

Preparing Activity:

John F. Kennedy Space Center
Mechanical GSE Division
Engineering Development Directorate

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER KSC-STD-Z-0006, Rev. B	2. DOCUMENT DATE October 25, 1995

3. DOCUMENT TITLE
Design of Hypergolic Propellants Ground Support Equipment, Standard for

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)*	7. DATE SUBMITTED

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