METRIC/INCH-POUND

KSC-STD-Z-0006
Revision C

DESIGN OF HYPERGOLIC PROPELLANTS GROUND SUPPORT EQUIPMENT,

STANDARD FOR

November 2, 2021

Engineering of Directorate

National Aeronautics and
Space Administration

John F. Kennedy Space Center

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RECORD OF REVISIONS/CHANGES

REV LTR	CHG NO.	DESCRIPTION	DATE
		Basic issue.	July 29, 1973
A		General revision.	September 15, 1989
B		General revision.	October 25, 1995
C		Replaced canceled references Removed untestable/open-ended requirements Formatting changes for clarification - Moved each shall statement into its own subparagraph - Changed non-requirement explanatory text font to italics	November 2, 2021

CONTENTS

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

A-50	Aerozine-50
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CCSFS	Cape Canaveral Space Force Station
CFR	Code of Federal Regulation
CGA	Compressed Air Gas Association
cm^3	cubic centimeter
CRES	Corrosion-Resisitant Steel
DE	Design Engineering
DOD	Department of Defense
DOT	Department of Transportation
EPA	Environmental Protection Agency
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
GSS	Ground Support Systems
HVDS	hypergolic vapor detection system
ICD	interface control document
JSC	Lyndon B. Johnson Space Center
KMI	KSC mangement instruction
kPa	kilopascal
KSC	John F. Kennedy Space Center
L	liter
L/s	liter per second
lb/in^2	pound per square inch
m	meter
MA	Massachusetts
MAPTIS	Materials And Processes Technical Information System
MAWP	maximum allowable working pressure
MIL	military
mL/h	milliliter per hour
mL/s	milliliter per second
mm	millimeter
MMH	monomethylhydrazine
MPa	megapascal

MSFC	George C. Marshall Space Flight Center
MUA	Material Usage Agreement
N2H4	hydrazine
N2O4	nitrogen tetroxide
NASA	National Aeronautics and Space Administration
NDE	nondestructive evaluation
NDT	nondestructive test
NFPA	National Fire Protection Association
NPT	National Pipe Thread
NSN	national stock number
NY	New York
OMRSD	Operations and Maintenance Requirements and Specifications Document
OSHA	Occupational Safety and Health Administration
P/N	part number
PA	Pennsylvania
PHE	Propellant Handlers Ensemble
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

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). When called out in conjunction with a higher level design standard (e.g. 'shall meet the requirements of KSC-DE-512-SM and KSC-STD-Z-0006') these requirements expand on the requirements in the higher level document. When called out by itself, references to higher level design requirements become a part of this standard (e.g. 'shall comply with KSC-DE-512, section Materials and Processes Requirements, Metals' means that section becomes part of this document.) 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 purpose 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)

NPR 8715.3	NASA General Safety Program Requirements
NPD 1280.1	NASA Integrated Management System Policy
NPR 8715.1A	NASA Safety and Health Handbook Occupational Safety and Health Programs
NPR 8715.1B	NASA Safety and Health Programs

John F. Kennedy Space Center (KSC)

KNPR 8715.3	KSC Safety Procedural Requirements
KNPR 8700.2	KSC System Safety and Reliability Analysis Procedural Requirements
KNPD 8500.1	KSC Environmental Management
KNPR 8500.1	Kennedy Space Center Environmental Requirements
KNPR 8830.1	Facilities and Real Property Handbook

2.1.2 Specifications

John F. Kennedy Space Center (KSC)

KSC-C-123	Surface Cleanliness of Ground Support Equipment 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-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

Military

MIL-PRF-26536	Propellant, Hydrazine
MIL-PRF-26539	Propellant, Dinitrogen Tetroxide
MIL-PRF-27402	Propellant, Hydrazine-Unsymmetrical dimethylhydrazine (50 Percent N_2H_4 50 Percent UDMH)
MIL-PRF-27404	Propellant, Monomethylhydrazine

Military

MIL-STD-101	Color Code for Pipelines and for Compressed Gas Cylinders

2.1.3 Standards

National Aeronautics and Space Administration (NASA)

NASA-STD-5008	Protective Coating of Carbon Steel, Stainless Steel, and Aluminum on Launch Structures, Facilities, and Ground Support Equipment, Standard for
NASA-STD-6001	Flammability, Off gassing, and Compatibility Requirements and Test Procedures
NASA-STD-8719.11	Standard for Fire Protection and Life Safety
NASA-STD-8719.12	Safety Standard for Explosives, Propellants, and Pyrotechnics
NASA-STD-8719.17	NASA Requirements for Ground Based Pressure Vessels and Pressurized Systems

John F. Kennedy Space Center (KSC)

KSC-STD-164	Environmental Test Methods for Ground Support Equipment, Standard for
KSC-STD-E-0002	Hazardproofing of Electrically Energized Equipment, Standard for
KSC-STD-E-0012	Facility Grounding and Lightning Protection, Standard for
KSC-STD-E-0015	Marking of Ground Support Equipment, Standard for
KSC-STD-G-0003	Qualification of Launch Support and Facility Components, Standard for
KSC-STD-Z-0005	Design of Pneumatic Ground Support Equipment, Standard for

John F. Kennedy Space Center (KSC)

KSC-STD-E-0022	Bonding, Grounding, Shielding, Electromagnetic Interference, Lightning and Transient Protection, Design Requirements for Ground Systems

George C. Marshall Space Flight Center (MSFC)

MSFC-STD-486	Standard, Threaded Fasteners, Torque Limits For
MSFC-DWG-20M02540	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	Hazardous Materials Regulations Board, Shipping Container Specifications, Transportation, Subpart C
HF-STD-001	U.S. Department of Transportation Federal Aviation Administration Human Factors Design Standard

Military

MIL-STD-129	Military Marking for Shipment and Storage
MIL-STD-889	Dissimilar Metals
MIL-STD-130	Identification Marking of U.S. Military Property
DESR 6055.09	Defense Explosives Safety Regulation

2.1.4 Drawings

John F. Kennedy Space Center (KSC)

79K03450	Discrete Liquid Level Sensor with Integral Electronics, Specification for
79K35477	Hypergolic Fuel (CH6N2) Leak Detection Transducer, Specification For
79K35476	Hypergolic Oxidizer (N_2O_4) Leak Detection Transducer, Specification For
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)

75M04185	Identification Tag, Tubing and Hose Lines

2.1.5 Publications

John F. Kennedy Space Center (KSC)

KSC GP-425	Fluid Fitting Engineering Standards
KSC GP-435, Volume I	Engineering Drawing Practices, Volume 1 of 2, Aerospace and Ground Support Equipment
KSC-DE-512-SM	Ground Systems Development Standard

(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 of Mechanical Engineers (ASME)

ASME B1.1	Unified Inch Screw Threads (UN and UNR Thread Form)

American Society of Mechanical Engineers (ASME)

ASME B16.5	Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	Factory-Made Wrought Buttwelding Fittings
ASME B16.21	Nonmetallic Flat Gaskets for Pipe Flanges
ASME B18.2.1	Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
ASME B18.2.2	Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.3	Process Piping
ASME B36.19	Stainless Steel Pipe
ASME B40.100	Pressure Gauges and Gauge Attachments
ASME Y14.100	Engineering Drawing Practices
ASME B31.8	Gas Transmission and Distribution Piping Systems

ASME Boiler and Pressure Vessel Code

Section V	Nondestructive Examination
Section VIII	Rules for Construction of Pressure Vessels
Section IX	Welding, Brazing, and Fusing Qualifications

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

American Society for Testing and Materials (ASTM)

ASTM A36/A36M	Standard Specification for Carbon Structural Steel
ASTM A182/A182M	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
ASTM A240/A240M	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

American Society for Testing and Materials (ASTM)

ASTM A193/A193M	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194/A194M	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A312/A312M	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320/A320M	Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A403/A403M	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 Welding Society (AWS)

AWS - D17.1/D17.1M:2017	Specification for Fusion Welding for Aerospace Applications
AWS 2681	Electron-Beam Welding

Compressed Gas Association, Inc. (CGA)

CGA S-1.2	Pressure Relief Device Standards Part 2 – Portable Containers for Compressed Gases

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

International Electrotechnical Commission

IEC 62305	Protection Against Lighting, Part 1: General Principles, Part 2: Risk Management, Part 3: Physical Damage and Life Hazards, and Part 4: Electrical and Electronic Systems with Structures

International Organization for Standardization

ISO 14952	Space systems – Surface cleanliness of fluid systems
ISO 2861	Vacuum technology - Dimensions of clamped-type quick-release couplings

National Fire Protection Association (NFPA)

NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection
NFPA 30	Flammable and Combustible Liquids Code
NFPA 70	National Electrical Code
NFPA 496	Standard for Purged and Pressurized Enclosures for Electrical Equipment

(Applications 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)

SAE ARP901	Bubble-Point Test Method
SAE AS5202	Port or Fitting End, Internal Straight Thread, Design Standard
SAE AMS2700	Passivation of Corrosion Resistant Steels
SAE AMS5647	Steel, Corrosion-Resistant, Bars, Wire, Forgings, Mechanical Tubing, and Rings 19Cr - 9.5Ni Solution Heat Treated - UNS S30403
SAE AMS5648	Steel, Corrosion and Heat-Resistant, Bars, Wire, Forgings, Tubing, and Rings, 17Cr - 12Ni - 2.5Mo (316) Solution Heat Treated - UNS S31600
SAE AMS5653	Steel, Corrosion and Heat-Resistant, Bars, Wire, Forgings, Mechanical Tubing, and Rings 17Cr - 12Ni - 2.5Mo (0.030 Max C) (316L) Solution Heat Treated

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

3. REQUIREMENTS

3.1 General

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

Requirements are numbered and indicated by the word “shall.” Explanatory or guidance text is indicated in italics.

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

a. All GSE shall be protected against corrosion in accordance with NASA-STD-5008.

   No corrosion protection is preferable in certain circumstances:

   - *Fluid fittings, lines, hoses, and components should not be coated where the GSE is stored predominantly in an air-conditioned environment.*
   - *Where paint would prevent required inspections*
   - *Where paint accumulation could prevent normal operation of sliding surfaces*
   - *Where paint accumulation would prevent normal operation by preventing heat dissipation*
   - *Paint is prohibited on any atmospheric vent orifice or screen. There have been several instances of pneumatic valves failing open because the actuator vent port has been painted over.*

b. The use of dissimilar metals shall comply with MIL-STD-889.

3.1.1.2 Cathodic Protection

Underground systems should not be used; however, if underground systems are required, they should be protected against corrosion by cathodic protection.

a. Underground systems shall be protected against corrosion by cathodic protection.

b. Cathodic protection systems shall comply with ASME B31.8.

c. Cathodic protection systems shall be designed such that a periodic check of current flow can be obtained.

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 or facility, the applicable program requirements and those in NPR 8715.3, 29 CFR 1910, and KNPR 8715.3, and KNPR 8700.2.

a. Safety analyses will be performed in accordance with KNPR 8715.3 and KNPR 8700.2. Safety requirements for servicing facilities shall include, but 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 washes).
b. Emergency personnel safety shower, eyewash, and washdown hoses shall be provided in the vicinity per KNPR 8715.3.
c. Showers shall be sized to accommodate Propellant Handlers Ensemble (PHE) [also known as Self-Contained Atmospheric Protective Ensemble (SCAPE)] operators with a minimum side-to-side dimension not be less than 915 mm (36 inches).

3.1.3.1 Hypergolic Vapor Detection System (HVDS)

The inclusion of instrumentation to detect hypergolic vapor especially in the work area around propellant storage and transfer GSE is required at a fixed point at a minimum where there is a transfer of propellant quantities of 5 gallons or more.

If required HVDS shall be specified in accordance with the latest revisions of 79K35477 for fuel systems and 79K35476 for oxidizer systems.

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 and warning of leaks.

3.1.3.2 Safety Factor

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 ASME -B31.3 and ASME, Boiler and Pressure Vessel Code, section VIII, division 1 or 2 (as applicable), Department of Transportation (DOT) standards in 49 CFR for commodity equipment (see 6.2) or NASA-STD-8719.17.

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.*

3.1.3.3 Test Pressure

a. All pressurized parts shall be pressure tested in accordance with the applicable provisions of ASME B31.3, 49 CFR, or the ASME Boiler and Pressure Vessel Code, as applicable.
b. Test certification shall be provided with all procured components such as hoses, valves, and regulators, etc.
c. 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 ASME B31.3 for alternative pneumatic tests.

3.1.3.4 Operating Pressure

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.

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 (GN2) or helium (GHe) (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.

3.1.3.5 Design Drawings and Specifications

a. Physical interfaces between the newly designed hardware and existing hardware shall be completely defined in the design drawings and specifications.
b. The design drawings shall be prepared in accordance with KSC GP-435, volume I for aerospace and ground support equipment, and volume II for facilities.
c. Design specifications shall follow ASME Y14.100.
d. The design organizations shall provide in document form the detailed, substantiating calculations for the design, and any special erection requirements.

Where applicable, the responsible design organization will 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.

Specifications may be incorporated into the design drawings for commodity or equipment design.

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.

Drip pans and/or aspirators at routine disconnect points should be used to catch drips before they contact the floor or area drain system. It is recommended to include low point drain and purging circuits.

3.1.3.6.1 GSE Connect/Disconnect Points

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 MIL-STD-101.

b. A color tag shall be attached to the interface or the structure at the interface should be color coded. 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 or firmly affixed adjacent to the connection (e.g. a panel face).

The color of the band and the tag shall be yellow for fuels and green for oxidizers (secondary warning color in accordance with MIL-STD-101).

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 3.1.3.7.

3.1.3.6.3 Connections to Flight Hardware

The requirements for the connect/disconnect points of payloads and payload-specific support equipment will be governed by the interface control documents (ICD) for the specific flight hardware article.

3.1.3.7 Intermixing Prevention

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.

3.1.3.7.1 Connections to GSE

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) – physical separation of 42” minimum between fuel and oxidizer if possible or designed to prevent cross-connections in accordance with KSC-DE-512-SM Interfaces requirements using different design configurations include threads, flanges, sizes, orientation (male/female, left-hand, right-hand), pins, and keys.

A means of fool-proofing GSE connections by requiring differing line sizes or connection types to further prevent fuel/oxidizer lines from being inadvertently mismated is recommended.

3.1.3.8 Quantity-Distance

Safety requirements for quantity versus distance limitations for the handling and storage of hypergolic propellants shall comply with DESR 6055.09 or NASA-STD-8719.12.

3.1.3.9 Fire Protection

a. All hypergolic designs being used or installed on KSC property will ensure the facility includes provisions for a fire protection in compliance with NFPA 30, NFPA 70, NFPA 15 and NASA-STD-8719.11.
b. 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-0012, KSC-STD-E-0022, and IEC 62305.

3.1.3.11 Hazardproofing

Provisions for hazardproofing of electrical enclosures and equipment to be used in hypergolic propellant systems shall follow KSC-STD-E-0002, KSC-E-165, NFPA 70, and NFPA 496.

For new designs, the use of pneumatic air or inert gas purging in lieu of standard hazard proofing techniques is discouraged when equipment is available that already meets the required hazardous classification (i.e., NFPA 70 Class 1, Division 1 or 2, Group C and/or D and OSHA 1910).

3.1.3.12 Vapor Disposal

The design of GSE for hypergolic propellant systems shall provide for the safe disposal of toxic vapors and 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 (i.e. low-point drains, purge/drain-back points) must be provided where it is not feasible for the system design to preclude all liquid traps. Application of line-clearing purges, slope, and drain location to remove liquid from the transfer GSE prior to disconnect and, therefore, minimize the potential for spillage should be considered.

3.1.3.14 Servicing Areas

a. All hypergol servicing areas with fixed equipment shall be within a contained area that drains to a collection/removal location following 40 CFR PART 264 and the size of the containment will be a minimum of 3 times as large as the largest tank.

   The additional size requirement ensures releases can be diluted to below the flammability limit.

b. If the propellant is stored inside a closed building, the building shall be designed to meet the applicable hazard classification in accordance with International Building Code.

3.1.3.15 Change of Service Commodity

When changing commodity service, precautions should be taken for safety and to prevent commodity degradation.

a. Provisions for draining, flushing, and purging shall be incorporated into the design for changing over from one hypergolic fuel MIL spec type/grade to another OR from one MIL spec grade of oxidizer to another.

b. When a system has potential to be changed over from a fuel service to an oxidizer service (or vice versa) provisions shall be made for draining, flushing, purging, inerting, precision cleaning, and passivation (including being re-tagged and re-labeled) down to the disassembled component level including new soft goods installed. It should also be noted that the system must be sampled and certified for acceptable residual content prior to service.

c. PTFE hoses shall not be allowed to change commodity service.

Blisters have been found to form in Teflon hoses after prolonged exposure to propellant. PTFE hoses are not allowed to change between fuel/oxidizer because these blisters could contain residual propellant even after purging/flushing.

3.1.4 Electrical

Power, control, and instrumentation subsystems shall comply with NFPA 70, KSC-DE-512-SM Electrical/Electronic Design requirements, KSC-E-165, and KSC-E-166.

3.1.5 Ecological Considerations

An analysis shall be performed in accordance with KNPR 8830.1 and KNPD 8500.1.

Consideration must be given to ecological or environmental impacts caused by installation, operation, maintenance, or malfunctions of proposed, new, or altered systems.

3.1.6 Human Engineering

A Human Factors Engineering Assessment (HFEA) incorporates a tailored set of requirements that are specific to the system design. This tailored set shall be in accordance with KSC-DE-512-SM human factors section, which points to FAA HF-STD-001 human engineering standards. The tailored selection of HFEA requirements from FAA HF-STD-001 also considers the intent of 29 CFR 1910, which is also required by KSC-DE-512-SM. GSE at KSC is designed with expert advice from skilled (trained) technicians and engineers which perform operations and maintenance. Further consideration in the design shall be given to the unique aerospace launch processing limitations imposed on individuals, such as PHE/SCAPE suits.

3.1.7 Reliability

a. All GSE designs shall comply with the applicable program reliability requirements or KNPR 8700.2.
b. 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

a. The appropriate qualification testing of new, unqualified components to be used in hypergol systems shall be conducted.

b. 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).

KSC-STD-164, KSC-STD-G-0003, should be referenced for the development of the test requirements.

3.1.8 Special Capabilities

a. For failure modes that could result in a time-critical emergency, provision shall be made for automatic switching to a safe mode of operation.

b. Caution and warning signals shall be provided for these time-critical functions.

3.1.9 Components Selection

a. Equipment and components that have been successfully tested and qualified shall be specified for new design.

b. Design pressure ratings of all components shall be in accordance with ANSI/ASME B31.3 and the ASME Boiler and Pressure Vessel Code. Components designed per AIAA S-080 and S-081 are also acceptable with DE approval.

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. Special valves, soft goods, and stems may be required for hypergol service. The Qualified Hypergol Component List provides a list of components previously used in hypergolic systems. This list is intended as reference only and does not provide official approval for design use.

3.1.9.1 Component Identification

1. 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.

2. 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.

3.1.9.2 Cleaning

a. The cleaning of pipe, tubing, fittings, gaskets, and components shall be in accordance with a KSC-approved cleaning procedure.

b. Fluid components shall be precision cleaned to a minimum of level 300A - for oxidizer services and level 300 of KSC-C-123 for fuel services or equivalent in accordance with ISO 14952, Parts 1 through 6. (Refer to KSC-DE-512-SM Fluid System Cleanliness section for equivalent cleanliness standards.)

   Some mono propellant fuel systems require NVR level A to preclude catalyst poisoning. Stock clean level of many fuel components is only required to be 300.

c. Vent and waste systems shall comply with level 1000A minimum of KSC-C-123 for oxidizer services and level 1000 of KSC-C-123 for fuel services.

d. Systems/piping downstream of the final GSE filter shall be cleaned to level 100A or equivalent in accordance to ISO 14952 or KSC-C-123 for oxidizer services and level 100 for fuel services or the specified by the flight system interface control document.

e. All stainless steel materials in contact with hypergolic systems shall be pickled and passivated prior to cleanliness level verification.

   Recommended pickling and passivation as well as cleaning procedures may be found in manual ASTM A967, SAE AMS2700, and ASTM A380.

f. All hazardous wastes generated during cleaning and processing shall be managed in accordance with KNPR 8500.1.

g. For new design, components such as valves shall be completely disassembled for cleaning and soft goods shall be replaced.

   Flow-through cleaning of assembled components is prohibited for new design except where disassembly will render the component unusable (e.g. stamped relief valves). Flow-through cleaning may fail to remove contaminates and may result in cleaning fluids trapped in the component that will react with hypergols when placed into service.

3.1.10 Special Tools

GSE should be designed to minimize the requirement for special tools.

3.1.11 Welding

a. All welding shall be in accordance with KSC-DE-512-SM Welding requirements section 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.

b. Pipe welds shall be butt weld style. Socket welds are prohibited.

   Socket welds create crevices that trap contaminates when the socket pull-back gap is set properly to allow for expansion. Socket welds are also prone to expansion stress due to improper pull-back.

3.1.12 Nondestructive Examination

a. 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 gauges.

b. 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 in accordance with NASA-STD-6001.

   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

a. 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 shall be performed on all pressure vessels and system piping welds (butt welds, branch connections, nozzle penetrations, etc.) including those welds made by an automatic process.

b. The radiograph inspection flaw/acceptability criteria shall comply with the requirements defined in AWS D17.1, ASTM E1742, AMS2681 or ANSI/ASME B31.3 and ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or 2, specification.

c. Radiographic images shall be labeled/documented by a method that allows future inspectors to correlate each radiograph to the physical weld in the system. Radiographs shall be stored and accessible for the life of the system.

3.1.12.2 Other Inspections

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.

The methods of other nondestructive inspections are specified in KSC-DE-512-SM Nondestructive Evaluation paragraphs. The specific applications for these types of inspections are to be defined in the applicable engineering drawings and specifications.

3.1.13 Color-Coding

Pipe and tubing systems shall be color-coded in accordance with MIL-STD-101.

3.1.14 Bonding and Grounding

a. Bonding and grounding of GSE shall be in accordance with and KSC-STD-E-0022.
b. 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. Special transition joints of clad metal should be considered where dissimilar metals must be used.

3.1.15 Marking of GSE

a. Fixed GSE shall be marked in compliance with KSC-DE-512-SM Identification Markings and Labels, Systems and Equipment requirements, MIL-STD-130, or KSC-STD-E-0015.
b. Mobile equipment shall be marked in accordance with 81K00643 and with the latest DOT specifications.
c. GSE shall be marked with model numbers.
d. Equipment racks shall be marked with rack numbers.
e. Components shall be marked in accordance with 3.1.9.1 except for hoses, which shall be marked in accordance with 3.5.1.3.
f. The piping interfaces of GSE/GSS shall be additionally marked with color bands and color tags as specified in 3.1.3.6.1.

3.1.16 Blanket Pressure

If equipment is designed for a pad pressure, a gauge shall be provided at the pressurization point, sized in accordance with 3.5.6.1.

Providing the capability to apply a nominal 138 kPa [20 pounds per square inch (lb/in2)] blanket GN_2 or GHe pressure for all continuous service GSE is recommended.

3.1.17 Lubricants

Lubricants shall be selected in accordance to KSC-DE-512-SM and the interface control document for the specific flight hardware article.

Personnel training/certification is recommended for proper application of lubricants to fluid / pneumatic systems (fittings, component buildup). Improper application results in one of the most common contaminations of hypergol systems.

3.1.18 Materials

a. All materials used in hypergol systems shall be approved for hypergolic fluids use.

   Refer to Materials and Processes Technical Information System (MAPTIS) for compatibility data.

b. 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. Not everything within this zone needs to have the same degree of hyper compatibility. Where contact with liquid propellant is more likely, such as near sample ports and interfaces designed for disconnection before decontamination, materials that have been tested for strong exothermal reaction with liquid propellant should be specified.

3.1.18.1 Metals

Metals used shall be acceptable for use with the fluid media according to MAPTIS.

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.

Type 316 stainless steel has been shown to be more susceptible than type 304 to attack by MON-3 Nitrogen Tetroxide liquid and vapor. Use of 316 in high surface area components like filter elements could lead to high iron levels in propellant samples. Liquid MMH has a higher rate of decomposition in contact with Type 316 than type 304.

3.1.18.2 Nonmetallic Materials

a. All nonmetallic materials (soft goods) used in hypergol systems that could possibly come in contact with the service propellant shall be evaluated or tested for compatibility with that service propellant in accordance with NASA-STD-6001 Test 15, Reactivity of Materials in Hydrazine, Monomethylhydrazine, Unsymmetrical Dimethylhydrazine, Aerozine 50, Nitrogen Tetroxide, and Ammonia or NASA-STD-6001 Supplemental Test Procedure A.7, Reactivity and Penetration of Materials due to Incidental Exposure to Hydrazine, Monomethylhydrazine, Unsymmetrical Dimethylhydrazine, Aerozine 50, Nitrogen Tetroxide, and Ammonia, as appropriate for the application.

For many materials, compatibility ratings and test results based on NASA-STD-6001 Test 15 are available in the MAPTIS database.

b. The Elastomers section requirements of KSC-DE-512-SM shall be followed.

3.1.19 End Connections

a. All end connections shall be flanged type for greater than 2 inch in diameter nominal pipe sizes unless otherwise approved.

b. Flanged connections shall be raised face with concentric serrations or otherwise approved by spec owner in accordance with ANSI/ASME B16.5.

c. *Connections 1 inch to 2 inch can be either flanged or straight thread fitting (GP-425) as appropriate for the system being connected. Connections smaller than 1 inch should typically be straight thread fittings (GP-425).*

d. All system components shall be removable for maintenance and calibration.

e. If threaded connection is required, straight thread in accordance with SAE AS5202 (MS-33649) shall be used.

(1) Components such as valves that are connected with SAE AS5202 (MS-33649) connectors shall be restrained from rotating.

Boss connections require a low torque which can be loosened by valve handle torque if the valve is not panel mounted or restrained by a physical bracket to prevent rotation.

f. NPT connections shall use safeguarding outlined in ASME B31.3.

NPT connections should not be used if possible.

3.1.20 Allowable Leakage

a. Valves shall be tested for both internal and external leakage at their design pressure.

b. The normal leakage rate shall not exceed that detected by a volumetric bubble leak test using GN2 or GHe.

Certain critical system components may require additional elaborate testing with a mass spectrometer to verify the external leak rates. Allowable leak rate should be in accordance with ASME Boiler and Pressure Vessel Code, section V, article 10, Leak Testing and ASME B31.3.

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 GN2) 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 3.1.3.6 and 3.1.3.7).

3.2.2.1.1 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.

Liquid hypergol manifold piping should be designed for use with a single specification or grade of propellant. Vent manifold piping may be shared amongst similar commodities (A-50 and MMH can use the same vent). Vapor interaction or residual liquid accumulation will degrade a product beyond specification limits.

Use of a liquid separator is recommended between liquid and vapor portions of the system.

3.2.2.2 Storage Propellant Pressure Vessels

a. Storage vessels shall be located aboveground and shall incorporate solar heat shields to reduce solar heating.

b. 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 and additional minimum of 3x spill volume of water (per AIAA SP-084-1999 dilution ratio for hydrazine fuels in case of land spills).

   For the separation distance of fuel and oxidizer vessels, see 3.1.3.7.

3.2.2.3 Waste Tanks

a. Waste tank design and operating criteria shall be determined by the type of waste (hazardous/nonhazardous) to be maintained within the specified tank.

b. 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.

c. Underground waste tanks and ancillary piping shall have secondary containment systems with leak detection capability.

   Underground tanks should be avoided.

3.2.2.4 Vent Stacks

a. All hypergolic vent effluent (except for emergency venting) shall be scrubbed prior to venting to the atmosphere.

b. 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.

c. Hazardous waste generated during a scrubbing operation shall be managed in accordance with KNPR 8500.1.

   A liquid separator vessel is recommended where liquid could enter the vapor system due to a single point component failure or an operational error.

3.2.2.5 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 that complies with KSC-STD-E-0012.

3.3 Mobile Equipment

For the purpose of this standard, mobile equipment are be divided into two types: (1) mobile equipment for highway use and (2) mobile equipment for non-highway use. Furthermore, for the purpose of this standard, all roadways (between restricted facilities) within the confines of KSC and the CCSFS are considered to be highways.

3.3.1 Mobile Equipment for Highway Use

Mobile equipment for highway use (see 6.2) shall be designed to meet one of the following:

a. The requirements set by DOT standards for carriage by public highway in 49 CFR, subpart C.

b. Designed for draining, flushing and purging inert until external toxic vapor test results are less than the toxic vapor limit for the commodity prior to transport out of controlled areas over KSC and CCSFS roadways.

c. Designed to fit in DOT approved containers (i.e. UN1A2 stainless steel drums).

For all off-site shipments, non-DOT-compliant equipment will be rendered inert or be transported inside UN1A2 stainless steel drums.

3.3.2 Mobile Equipment for Non-Highway Use

Hazardous materials may not be transported on KSC roadways unless packaging is in accordance with 49 CFR or of a listed DOT exemption.

a. Mobile equipment for non-highway use shall be designed to meet the intent of applicable specification requirements.

b. DOT noncompliance equipment shall be designed to be capable of being drained and purged prior to transport out of controlled areas onto KSC and CCSFS roadways.

3.4 Portable Equipment

a. All portable equipment shall be designed to meet the applicable drawing and specification requirements.

b. Portable equipment designed for use as storage or for transportation of hypergol propellants or hypergol waste shall meet applicable requirements for packaging as set by DOT regulations in 49 CFR.

c. 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.

d. Further consideration in the design shall be given to the limitations imposed on individuals dressed in PHE/SCAPE units in accordance with KSC-DE-512-SM.

3.5 Components

a. The selection of components shall be in accordance with the requirements defined in 3.1.9.

b. Specific requirements for components, in addition to the ones defined in the following paragraphs, shall be identified in the applicable engineering drawings and specifications.

c. Components shall have flange- (raised face with concentric serrations or otherwise approved by spec owner), welded, or threaded connections in accordance with KSC-GP-425.

d. Swagelok fittings shall not be used due to tendency to trap propellant in the interface fittings, sleeves, and B-nuts.

National Pipe Thread (NPT) connections should not be used if possible. For pipe fittings, follow the ASME B31.3 Appendix G mitigations.

JIC 37-degree female flare fittings should be avoided if possible. The female flare angle can be as much as 40 degrees which can damage GP-425/AS4395 flare fitting nose seal groove.

3.5.1 Hoses

3.5.1.1 Construction Features

a. 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 consist of a flexible 300-series SST convoluted hose reinforced with 300-series SST braid (80K57897).

b. PTFE hoses shall not be used in oxidizer systems where liquid could be allowed to remain in the hose for long periods of time.

Convoluted metal hoses are suggested for use primarily in systems exposed externally to rocket exhaust plumes and out-of-reach locations where routine testing/inspections would be very difficult, and for hoses where permeation may be of concern.

3.5.1.2 End Connections

Hoses shall be provided with 300-series SST end fittings of the coupling-nut, 37-degree flared type, or flanges with raised face and concentric serrations or otherwise approved by spec owner in accordance with ANSI/ASME B16.5 or with KC159 hubs.

3.5.1.3 Marking/Identification

1. 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.

2. 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

a. Hose assemblies shall require hydrostatic testing at the time of fabrication. (Refer to NASA-STD-8719.17 for flexible hose PVS requirements.)
b. Carbon-filled, Teflon-lined flexible hoses shall not be used in permanent installations without specific provisions for routine inspection, testing, and replacement.

   PTFE -lined flexible hoses in continuous hypergol service blister over time and the life cycle is considered to be 2 years; therefore, Teflon hose assemblies should be replaced every 2 years.

c. All flex hoses 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.
d. If the hose cannot be inspected in place over the entire length, it shall be removed and inspected.
e. 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

a. The cognizant design organization shall establish any special inspection criteria for hoses.
b. 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. (Refer to SAE ARP1658 for hose inspections.)
c. 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

a. Flex hose installations designed for 1.03 megapascals (MPa) (150 psi gauge) or greater shall incorporate hose restraints in accordance with 80K51846 and KNPR 8715.3.
b. Eyebolts or other anchor points shall be provided for the attachment of required hose restraints.
c. Anchor points shall be capable of withstanding any loads that could occur should the hose break during service.

d. Hose restraints shall not be connected to flight hardware unless tie-points are specifically provided for the hose restraint.

3.5.1.5.2 Flow-Induced Vibration

Designs utilizing convoluted, unlined bellows or flexible metal hoses shall include analysis in accordance with MSFC-SPEC-3746 or MSFC-DWG-20M02540, 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.

This is primarily a problem with in-door or confined space locations where the hoses are in continuous service and when a high vacuum level needs to be maintained.

3.5.2 Valves

3.5.2.1 Shutoff Vales

Manual 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 Design Engineering. "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.

These valves are primarily manually operated and used where accurate flow control is required.

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

a. Relief valves shall be the adjustable, spring-loaded type with soft seat.

b. Pilot-operated safety valves shall not be used on hypergolic systems without the written approval of Design Engineering. Safety relief valves are generally used in hypergol systems.

c. Relief devices shall not be placed below the liquid level on vessels and should be avoided on liquid-filled transfer panels (i.e. tubing/valve assemblies).

d. *Relief devices should be located on the pressurization system supplying the vessel or panel. Note – DOT non-bulk containers (e.g. DOT4BW cylinders) do not have pressure relief devices.*

e. Liquid-filled systems shall be evaluated for potential external heat and pump systems effects that could impart energy into the lines causing over pressurization.

f. Relief valve outlets on fixed equipment shall be connected to a venting system designed to decrease the chance of personnel exposure if the relief valve is activated or leaks.

3.5.2.4.1 Relief Valve Sizing

a. Relief valves shall be designed and sized in accordance with ASME Boiler and Pressure Vessel Code, section VIII, division 1.

b. 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

a. 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.

b. Consideration shall be given to relief valve weight and thrust for support design.

3.5.2.4.3 Isolation Block Valve

a. 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.

b. The design for this valve location shall provide a means of locking the valve open with a positive inhibit.

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

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

b. Check valves shall be designed into the piping system immediately adjacent to all pressurant/purge (normally GN2 or GHe) interface connection points.

To preclude hypergol migration, the design constraints of KSC-STD-Z-0005 are applicable.

3.5.2.6 Electrically Operated Solenoid Valves

Electrically operated solenoid valves meeting the approved required NFPA classification (e.g. Class 1, Div I, Groups C & D, etc.) may be used as determined on a case-by-case basis.

Pneumatically operated valves are preferable.

Both primary and secondary valve seals must satisfy materials requirements.

A system where solenoid valves are held open for more than a few minutes should include an induction electrical device to lower the supply voltage after opening and be monitored. Solenoid valves can heat up and if a system is liquid locked, they can result in line rupture due to heating or burn personnel.

3.5.3 Filters

a. 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.

b. 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.

c. 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).

d. 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.

e. Filter element material shall meet the requirements of section 3.1.18, Materials, 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 or higher as specified by particular application requirements.

f. Except for final filter and interface filters, the degree of contamination tolerance (degradation) shall be well documented in OMRSD requirements. Element retest or replacement interval should be determined based on assumed particulate load and past test results.

g. Determination of the largest pore or hole size of filter elements shall be in accordance with SAE ARP901.

   Wire mesh filter elements should be used whenever possible.

   All filters should be designed with replaceable elements.

SAE ARP901 bubble point test does not accurately measure filtration performance for depth type filter elements such as sintered metal. If these elements are to be reused, element acceptance criteria must be specified.

h. Connections for a differential pressure measuring device across the filter itself or within its associated piping shall be provided where the system pressure could exceed the filter element collapse pressure if fully clogged.

i. Tee type filter housings shall be equipped with a bottom drain. Note that use of the NPT drain connection is not allowed.

NOTE

Where filtration levels require validation, complete pre-tested and assembled units must be installed. In-place replacement of filtration elements is not allowed.

Tee-type filters are preferred over inline types where "in-place" maintenance (i.e. filter media replacement) is acceptable, since the tee-type filter elements can be replaced without disconnecting fluid system fittings.

3.5.4 Pumps

a. Pumps shall be the centrifugal type.

For hypergol centrifugal pumps, special consideration should be given to the seals, drive mechanism, piping inlet/outlet configuration (recommended straight lengths and reductions), and priming configuration with a bypass.

b. 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.

c. Pumps shall not use dynamic seals or allow contact of pumping media with elements of the pump motor. Magnetically coupled pumps are recommended where feasible for application.

d. Pump materials shall be entirely stainless steel (type 304 or 316, or type 304L or 316L if welded).

e. Pumps shall be hazard proofed in accordance with 3.1.3.10.

f. All component materials (seals, gaskets, packings, and O-rings) shall be acceptable for use with the pumped media according to MAPTIS. Use of any other material requires approval of the NASA Materials Science Laboratory.

3.5.4.1 Propellant Transfer Pumps

a. Pumps shall be specifically designed for pumping hypergolic propellants.

b. Titanium NTO pumps shall not be use due to explosion hazard.

c. Pump volute/casing shall not be painted for corrosion control to ensure heat dissipation.

3.5.5 Pressure Vessels

a. 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.

b. All ASME-code-stamped vessels shall also be registered with the National Board of Boiler and Pressure Vessel Inspectors.

c. Underground spill containment tanks shall comply with the requirements of EPA standards in 40 CFR 265, 40 CFR 264, and 40 CFR 280.

d. All pressure vessels shall be documented for certification or recertified in accordance with NASA-STD-8719.17.

   Pressure vessels used for storing hypergol propellants should have all connections located above the liquid level if possible. This will decrease the chance of a liquid leak.

3.5.5.1 Materials

Pressure vessel material shall comply with the Materials section of this standard where contact with fluid media is possible.

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

a. Pressure vessels shall be installed aboveground and shall be provided with a solar shield to reduce heating due to solar radiation.

b. A spill containment system shall contain a minimum of 110% of the largest tank contents within the area.

c. If a water deluge system is required, then the necessary spill containment system capacity shall be a minimum of three times the water capacity of the largest tank to contain the deluge water.

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 utilize a detailed (finite element) analysis.

3.5.5.3.1 Anchor Bolts

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

3.5.5.3.2 Expansion Support

a. One of the two supports of a stationary vessel shall be capable of providing for expansion and contraction of the vessel.
b. A suitable low-friction solid material such as PTFE shall be placed between sliding surfaces.
c. 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 gauge pressure load of 13.8 kPa (2 lb/in^2) or absolute pressure load of 115 kPa (16.7 lb/in^2) or follow the American Society of Civil Engineers (ASCE) wind codes (whichever yields the most conservative stringent result).

3.5.5.7 Maximum Allowable Working Pressure (MAWP)

a. All stationary hypergolic fuel vessels shall be designed with a minimum gauge MAWP of 517 kPa (75 psig) or an absolute MAWP of 618.5 kPa (89.7 psia).
b. All stationary insulated oxidizer storage vessels under the roof (i.e., protected from the direct sunlight) shall be designed with a minimum gauge MAWP of 517 kPa (75 psig) or an absolute MAWP of 618.5 kPa (89.7 psia).
c. All stationary uninsulated oxidizer vessels exposed to the direct sunlight shall be designed with a minimum gauge MAWP of 862 kPa (125 psig) or an absolute MAWP of 964 kPa (139.7 psia) (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 Gauges

3.5.6.1.1 Limitations

All pressure gauges shall conform to the requirements of ANSI/ASME B40.100, except as specified herein. Pressure gauges 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 gauges associated with pneumatic controllers, positioners, and other standard process control equipment, provided the parts of the gauge that come in contact with the fluid have been selected in accordance with Section 3.1.9.1.

3.5.6.1.2 Selection

a. Pressure gauges shall be selected so the nominal operating pressure falls between 20 to 80% of full scale.
b. Pressure gauges shall be selected so the maximum pressure that can be applied will not exceed the scale range of the gauge.

3.5.6.1.3 Construction Features

a. Pressure gauges shall conform to ANSI/ASME B40.100.
b. Pressure gauges shall be of one-piece, solid-front, full-diameter, pressure-relief back case construction, utilizing an optically clear shatterproof window made of high-impact non-cracking plastic, heat-treated glass, or laminated glass.
c. Gauges shall be designed for flush-bolted front-panel mounting with exception of some DOT-type mobile equipment.
d. All pressure gages shall be provided with a Bourdon tube bleeder (or equivalent) device to facilitate cleaning.
e. 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.
f. Gauges of the liquid-filled case type shall not be used.

3.5.6.1.4 Pressure Connections

The pressure connection should be the low-back type with SAE AS5202 threaded port.

Gauge protectors shall not be used in conjunction with pressure gauges.

NPT connections should not be used if possible; however, if they are used mitigations outlined in ASME B31.3 should be followed.

3.5.6.2 Liquid Sensors

a. Glass-faced or radiation source-emitting liquid level indicators shall not be used without approval from DE.
b. Temperature-type liquid 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

a. Temperature sensors shall be the transducer type or the direct-reading gauge type.
b. Selection of sensors and transducers shall be in accordance with KSC-DE-512-SM Sensors and Transducers requirements.

Skin mounted thermocouples or RTDs are another option if used on thin-walled tubing. Accuracy is affected if installed on a thick fitting or other component.

3.5.6.4 Liquid Level Sensors

Glass-faced or radiation source-emitting liquid level indicators shall not be used without approval from DE.

Capacitance, conductive, and pressure/density types are not recommended due to historical nonoperational and continuous maintenance problems.

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

Liquid level sensors are not required on DOT-type vessels since fill level is normally determined by weight.

3.5.6.5 Flowmeters

A bypass shall be provided for turbine-type flowmeters to avoid overspinning the bearing while purging.

Mass, volumetric, vortex shedding type and turbine type flowmeters are acceptable as required by the system design.

Adequate downstream and upstream straight lengths of run must be provided in accordance with the manufacturer's recommendations.

The use of calorimetric and thermal flow meters are prohibited where they could come in contact with hypergolic vapors as these types use heated elements which could cause propellant decomposition and rapid pressure increase.

3.6 Piping and Fittings

All hypergol piping design shall be in accordance with ANSI/ASME B31.3, category M.

3.6.1 Pipe

a. Pipe shall conform to ANSI/ASME B36.19.
b. The pipe material shall comply with ASTM A312, type 304L, 316L SST, AL6XN or others approved by DE or acceptable for use with the hypergol according to MAPTIS.
c. 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

a. Pipe Fittings shall conform to ANSI/ASME B16.9 and ANSI/ASME Bl6.5.
b. The fitting material shall comply with ASTM A403, type 304L or 316L SST.
c. Socket weld fittings shall not be used.
d. Fittings shall comply with KSC-DE-512-SM – Metallic Fittings.

NPT fittings are not recommended.

Welded fittings (e.g., tees or elbows) with a WP (welded pipe) designation are not allowed unless X-rayed. Therefore, all fittings must be seamless (WPS) or welded and X-rayed (WPX) type in accordance to AWS - D17.1and AWS 2681.

3.6.3 Flange Connections

Flanged connections shall be 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

a. Flanges shall be raised face with concentric serrations or otherwise approved by spec owner in accordance with ASME B16.5.
b. Flange material shall comply with ASTM A182, type 304L or 316L SST.

3.6.3.2 Gaskets

a. Flange gaskets shall conform to ANSJ/ASME B16.21.
b. Gaskets shall be installed between flanges at all flanged connections.
c. Gasket material shall be acceptable for use with the hypergol according to MAPTIS. Use of any other material will require pre-qualification.

Filled-Teflon type gaskets are preferred over virgin-Teflon due to the latter's tendency to cold-flow and be more-prone to leakage during cold-weather events.

Refer to 80K58950 for hypergolic gasket drawing.

3.6.3.3 Studs

a. Stud threads shall conform to ASME B1.1, UNC series.
b. Stud material shall be ASTM A320 grade B8 (304) or B8M (316) SST.

3.6.3.4 Nuts

a. Nuts shall be hex type and conform to ASME B18.2.2.
b. Material shall be ASTM A194 grade B8 (304) SST or ASTM grade B8M (316) SST.

3.6.3.5 Bolts

a. Bolts shall conform to ASME B18.2.1.
b. The bolt material shall be ASTM A193 or ASTM A320 grade B8 (304) SST or grade B8M (316) SST.
c. Torque values for 300-series stainless steel CRES-threaded fasteners for end flanged bolting shall be in accordance with MSFC-STD-486.
d. Bolt lubricants shall be Krytox 240AC, Braycote 601, or an approved equal.

3.6.3.6 Washers

Type 304 or 316 SST 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-0022 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

a. The use of threaded connections shall be restricted to those connections that require conversion from pipe to tubing; however, pipe (e.g., tapered) threads should be avoided.

b. 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-DE-512-SM Welding requirements and ANSI/ ASME B31.3 and ASME Boiler and Pressure Vessel Code, section VIII, division 1 or 2 (weld requirements for category M service), as applicable.

3.6.7 Supports and Anchors

a. Pipe, pipe accessories, supports, anchors, braces, etc., shall be designed and installed in conformance with ANSI/ASME B31.3.

b. Pipe, pipe accessories, supports, anchors, braces, etc. shall be able to withstand incidental exposure to hypergolic vapors without structural degradation.

3.6.8 Protective Coatings

Stainless steel pipe, fittings, supports, anchors, braces, etc., shall be coated in accordance with NASA-STD-5008.

3.7 Tubing and Fittings

3.7.1 Tubing

Tubing shall conform to KSC-DE-512-SM Parts, Stainless-Steel Tubing or Super Austenitic Stainless-Steel Tubing.

3.7.2 Tube Fittings

a. Tube fittings for mechanical connections shall conform to KSC-F-124 and KSC-GP-425 or equivalent and approved by DE.

b. For vacuum systems, connections shall follow ISO 2861 or equivalent and approved by DE.

c. All seals for tube fittings shall be PTFE.

d. Crush washers shall not be used except at flight hardware connections when the flight-side valve requires use of a crush washer in accordance with manufacturer's specifications and/or drawings.

3.7.3 Welding

The welding of stainless steel tubing shall comply with the automatic welding requirements of KSC-DE-512-SM Welding requirements and Superaustenitic Stainless-Steel Tubing requirements.

3.7.4 Brazing

a. Brazing shall not be performed on hypergolic propellant systems.
b. 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.

3.7.7 Protective Coatings

For installation in an uncontrolled environment, stainless steel tubing, fittings, supports, anchors, braces, etc., shall be coated in accordance with NASA-STD-5008.

In temperature / humidity controlled environments, no coating should be used to minimize risk of contamination and masking of leaks.

3.8 Structural Design

3.8.1 Materials

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

3.8.1.1 Carbon Steel

a. Carbon steel materials shall comply with ASTM A36, A572 Grade 50, or other grade approved by M&P.

b. The use of carbon steel shall be restricted to structure. Its use in wetted systems is strictly prohibited.

c. Structural steel shall be coated in accordance with NASA-STD-5008, zone 3 or 4.

Iron Oxide may cause ignition of hydrazine, MMH, or A-50 and carbon steel will be readily corroded by N_2O_4.

d. Carbon steel sheeting shall not be used as equipment covering or shielding.

3.8.1.2 Stainless Steel

a. Stainless steel materials shall be type 304L SST for all applications requiring welding. Type 316L SST may be utilized for forged and rolled applications.

b. Stainless steel shall comply with SAE AMS5647, SAE AMS5648, or SAE AMS5653.

3.8.1.3 Aluminum

a. Use of Aluminum materials shall be approved by DE.

b. Aluminum materials shall be tempered alloy 6061-T6 or 6063-T6 or 5052-H32 for bent members or other approved by M&P.

3.8.1.4 Caulk Materials

Caulking materials used within incidental exposure areas (Class I / Division II zone) a 100-percent silicon rubber (such as GE RTV-103 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.

3.8.2 Welding

All welding of metal plates and shapes shall be in conformance with KSC-DE-512-SM Welding section requirements.

3.8.3 Protective Coatings

Protective coatings for metal plates and shapes will 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 NASA-STD-5008.

3.8.3.2 Stainless Steel

Stainless steel materials shall be painted in accordance with NASA-STD-5008.

3.8.3.3 Aluminum

Aluminum materials shall be painted in accordance with NASA-STD-5008.

4. QUALITY ASSURANCE PROVISIONS

4.1 Design and Development Controls

a. The designer shall ensure the following are specified to ensure engineering quality and fulfill the design intent:

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

   (2) Identification and data retrieval requirements

   (3) Identification of critical hardware characteristics necessary for procurement and fabrication

   (4) Performance and/or tolerance limits

   (5) Applicable specifications for cleanliness/contamination control

   (6) Applicable process specifications, standards, and procedures

   (7) Limited-life characteristics

   (8) Acceptance/rejection criteria

   (9) Handling, storage, preservation, marking, labeling, packaging, packing, and shipping requirements

   (10) Equipment to be placed under integrity and configuration control

   (11) Material certification and mill reports on critical items as identified by the designer

   (12) Soft-good material certifications on critical items as identified by the designer

   (13) Hydrostatic (or equivalent) test records / certification

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

c. 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.

d. Quality assurance of procurement and manufacturing shall be accomplished by in-process inspections and acceptance tests.

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

f. 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.

g. All functional components shall be serialized for traceability of component performance from testing back to component acceptance tests.

h. Identification tags shall be of sufficient durability to preclude obliteration under field conditions.

4.2 System Tests

4.2.1 Assembled System Leak Test

a. Mandatory pneumatic leak testing, above the design operating pressure, of all completely assembled and cleaned vessel pipe/tubing sections, with components installed, shall be completed prior to introduction of the propellant unless any of the following exemptions apply in accordance to ASME B31.3:

   (1) Previously certified, placed in service, and unmodified heritage equipment

   (2) PVS in normal fluid service that meets the following:

   - Components are listed in ASME B31.3 Table 326.1 or Appendix D, meet at least one criterion for unlisted components in ASME B31.3 Section 304.7.2 Unlisted Components, or meet the requirements of another applicable NCS.
   - All pipe and tube assemblies have been individually hydrostatically tested to 1.5 times the assembly or component's maximum allowable working pressure.
   - All joints created during assembly are mechanical (i.e. not joined by welding or brazing).
   - The fully assembled PVS is leak tested to maximum expected operating pressure.

b. All mechanical joints (e.g., gasket joints, seals, threaded joints, valve bonnets, etc.) and weld seams shall be visually bubble-tight, utilizing approved soap solution and techniques.

c. Isolation valves shall be checked for internal leakage and functionality.

NOTE

On certain critical systems, 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. Typical activation validation processes should consist of the following minimum steps unless otherwise approved by the appropriate design organization (including emergency operations):

a. Field validation of as built configuration matches the design.
b. Low pressure pneumatic functional flow test.
c. Cold flow at operational conditions using a fluid with similar properties to the hypergolic fluid.
d. Hot flow using the actual hypergolic commodity at operational conditions.

4.3 Contractual Requirements

When this standard is invoked in a contract, the quality requirements of NPD 1280.1 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.

a. All applicable carrier rules shall be complied with.
b. Containers shall be marked to conform to MIL-STD-129R.

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 supply and servicing of space vehicles and associated operations.

6.2 Definitions

a. Fixed Equipment. GSE and/or GSS designed to remain in place, attached to permanent foundations.
b. Mobile Equipment. GSE and/or GSS designed to be moved from place to place, usually on wheels, skids, etc.
c. Portable Equipment. GSE and/or GSS designed to be carried or moved, usually by the users.

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.

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-PRF-27402.

g. MMH. A hypergol propellant, monomethylhydrazine (CH3NHNH2), conforming to MIL-PRF-27404.

h. N2H4. A hypergolic propellant (hydrazine) conforming to MIL-PRF-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. N2O4. A hypergolic propellant (Dinitrogen tetroxide) conforming to MIL-PRF-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 non-catastrophic 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.l, 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. (DOT Equipment)

NOTICE: The Government drawings, specifications, or data are prepared for the official use by, or on behalf of, the United States Government. The Government neither warrants these Government drawings, specifications, or other data, nor assumes any responsibility or obligation, for their use for purposes other than the Government project for which they were prepared or provided by the Government, or any activity directly related thereto. The fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded, by implication or otherwise, as licensing in any manner the holder or any other person or corporation nor conveying the right or permission, to manufacture, use, or sell any patented invention that may relate thereto.

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