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SPECIFICATION FOR

LOW LEAKAGE PRE-VALVE

ENGINEERING DIRECTORATE
Propulsion Systems Department
Valves, Actuators, &
Ducts Design & Development Branch
ER14

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TABLES

FIGURES

1 SCOPE

This specification contains the component design, performance, verification, and delivery requirements for a development low leakage pre-valve to be used for ground-based testing.

2 DOCUMENTS

2.1 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.2 Applicable Documents

IEST-STD-CC1246	Product Cleanliness Levels – Applications, Requirements, and Determination
MIL-PRF-27201	Propellant Hydrogen
MIL-PRF-27401	Propellant Pressurizing Agent, Nitrogen
MIL-PRF-27407	Propellant Pressurizing Agent, Helium
MIL-STD-130	Identification Marking of U.S. Military Property
MSFC-STD-486	Standard, Threaded Fasteners, Torque Limits for
NASA-STD-4003	Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment
NASA-STD-5012	Strength and Life Assessment Requirements for Liquid-Fueled Space Propulsion System Engines
NASA-STD-5017	Design and Development Requirements for Mechanisms
NASA-STD-5020	Requirements for Threaded Fastening Systems in Spaceflight Hardware
NASA-STD-6008	NASA Fastener Procurement, Receiving Inspection, and Storage Practices for Spaceflight Hardware
NASA-STD-6016	Standard Materials and Process Requirements for Spacecraft
SMC-S-016	Test Requirements for Launch, Upper-Stage and Space Vehicles
TT-I-735	Isopropyl Alcohol

2.3 Definitions and Terms

Shall: Used to indicate a requirement which must be implemented and its implementation verified.

To Be Determined (TBD): A value that is not yet known and will be supplied by the purchaser.

To Be Reviewed (TBR): An approximate value is known, but requires review by the purchaser.

To Be Specified (TBS): A value that will be defined by the supplier and agreed to by the purchaser.

Will: Used to indicate a statement of fact and is not verified.

2.4 Abbreviations and Acronyms

"A"	Analysis (used in Table 7)
ASTM	American Society for Testing and Materials
°F	Degrees Fahrenheit
FS	Factor of Safety
g	Gravity
GHe	Gaseous Helium
GN2	Gaseous Nitrogen
"I"	Inspection (used in Table 7)
IEST	Institute of Environmental Science and Technology
in	Inch
lbm	Pound (mass)
MDP	Maximum Design Pressure
MEOP	Maximum Expected Operating Pressure
MMA	Moving Mechanical Assembly
MS	Margin of Safety
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
PSD	Power Spectrum Density
psia	Pounds per Square Inch (absolute)
SAE	Society of Automotive Engineers
sccs	Standard Cubic Centimeters per Second
scim	Standard Cubic Centimeters per Minute
"T"	Test (used in Table 7)
TBD	To Be Determined
TBR	To Be Reviewed
TBS	To Be Selected

3 COMPONENT REQUIREMENTS

3.1 Item Description

The low leakage pre-valve (referred to from this point forward as the "valve") will be an electrically actuated device with integral position indication used to isolate the propellant tank from the engine.

3.2 Performance Requirements

3.2.1 Operating Fluid

The valve shall meet the performance requirements of section 3.2 during exposure to the following fluids:

- GH2 per MIL-PRF-27201

3.2.2 Pressure

3.2.2.1 Operating Pressure Range

The valve operating pressure range will be 19 to 30 psig.

3.2.2.2 Maximum Expected Operating Pressure (MEOP)

The maximum expected operating pressure will be 30 psig.

3.2.2.3 Maximum Design Pressure (MDP)

The maximum design pressure will be 30 psig.

3.2.2.4 Maximum Differential Pressure

The maximum differential pressure will be 30 psid. This is defined as the pressure difference between the internal pressurized volume of the valve upstream of the valve seat and valve outlet, as well as all internally pressurized volumes and the valve exterior.

3.2.2.5 Proof Pressure

The valve shall meet the performance requirements of section 3.2 after exposing the pressure boundary to a proof pressure differential of 1.5 x MDP for a minimum of five (5) minutes without detrimental yielding.

3.2.2.6 Burst Pressure

The valve shall not rupture when exposed to a burst pressure of 4 x MDP for a minimum of one (1) minute. Permanent deformation is acceptable.

3.2.3 Leakage

3.2.3.1 External Leakage

The valve shall have an external leakage rate less than or equal to 1×10^{-6} sccs GHe over the operating pressures in paragraph 3.2.2.1 and maximum differential pressure specified in paragraph 3.2.2.4.

3.2.3.2 Internal Leakage

The valve shall have an internal leakage rate less than or equal to 0.6 scim GH_2 over the operating pressure specified in paragraph 3.2.2.1 supplied to the inlet of the valve and maximum differential pressure specified in paragraph 3.2.2.4. Internal leakage is defined as flow from the inlet to outlet port of the valve.

3.2.4 Flow & Pressure Drop

The valve shall have a pressure drop of less than 5 psid while flowing 84 lbm/sec LH_2 at an inlet pressure of 30 psig and a temperature of -430 °F.

3.2.5 Operating Characteristics

3.2.5.1 Response Time

3.2.5.1.1 Opening Response Time

The valve shall move from the fully closed to fully open position in less than or equal to 60 seconds, over the range of operating voltage defined in paragraph 3.2.6.1 and operating pressure defined in paragraph 3.2.2.1 while flowing at the flow rate specified in paragraph 3.2.4.

3.2.5.1.2 Closing Response Time

The valve shall move from the fully open to fully closed position in less than or equal to 60 seconds, over the range of operating voltage defined in paragraph 3.2.6.1 and operating pressure defined in paragraph 3.2.2.1 while flowing at the flow rate specified in paragraph 3.2.4.

3.2.6 Electrical Characteristics

3.2.6.1 Actuation Operating Voltage

The voltage supplied to the valve for actuation will be 22 to 32 VDC.

3.2.6.2 Position Sensor Current

The position sensor of the valve shall output a 4 to 20 mA range signal.

3.2.6.3 Power

The valve actuator power consumption shall be 250 W maximum over the actuation operating voltage range specified in paragraph 3.2.6.1 and operating temperature specified in paragraph 3.4.1.

3.2.7 Physical Characteristics

3.2.7.1 Envelope Dimensions

The valve shall occupy a physical envelope no larger than specified in Figure 1 and Figure 2. All dimensions shown are in inches.

Figure 1: Envelope (Side View)

Figure 2: Envelope (End View)

3.2.7.2 Mass

The valve shall have a mass of equal to or less than TBD lbm.

3.2.7.3 Lifting Point

The valve shall contain lifting features to allow moving of the valve by lifting equipment if the mass of the valve exceeds TBD lbm.

3.2.7.4 Position Indicator

The position sensor of the valve shall indicate the valve moving mechanism that directly controls the flow through the valve over the entire range of motion of travel.

3.2.8 Life

3.2.8.1 Shelf Life

The valve shall meet the performance requirements of section 3.2 for a minimum of five (5) years after hardware delivery and prior to removal from packaging.

3.2.8.2 Service Life

The valve shall meet the performance requirements of section 3.2 for a minimum of five (5) years after removal from packaging.

3.2.8.3 Cycle Life

3.2.8.3.1 Actuation Cycles

The valve shall meet the performance requirements of section 3.2 for a minimum of 50 operating close/open/close cycles after delivery.

3.2.8.3.2 Proof Pressure Cycles

The valve shall meet the performance requirements of section 3.2 after exposure to a minimum of five (5) proof pressure cycles. A proof pressure cycle is defined as 0 psia to proof pressure to 0 psia.

3.3 Component Interfaces

3.3.1 Fluid Interfaces

3.3.1.1 Inlet Interface

The valve inlet interface shall be a bolted joint interface per Figure 3. All dimensions shown are in inches.

Figure 3: Inlet Interface

3.3.1.2 Outlet Interface

The valve outlet interface shall be a bolted joint interface per Figure 3. All dimensions shown are in inches.

Figure 4: Outlet Interface

3.3.2 Electrical Interfaces

The valve electrical interfaces shall be per Figure 5.

Figure 5: Electrical Interfaces

3.3.3 Mounting Interface

The valve shall contain thru hole mounting provisions to allow bolting of the valve to vehicle structure per Figure 6.

Figure 6: Mounting Interface

3.3.4 Orientation

The valve shall meet the performance requirements of paragraph 3.2 while mounted in any orientation.

3.4 Environments

3.4.1 Operating Temperature

The valve shall meet the leakage requirements of paragraph 3.2.3.4 during and after exposure to an operating temperature ranging from -454°F to +120°F. Note, the temperatures shown are "Allowable Flight Temperatures" and do not include acceptance and qualification test margin, which is addressed in section 4 of this specification.

3.4.2 Non-Operating Temperature

The valve shall meet the performance requirements of paragraph 3.2 after exposure to a non-operating temperature ranging from -65°F to +140°F. Note, the temperatures shown are "Allowable Flight Temperatures" and do not include acceptance and qualification test margin, which is addressed in section 4 of this specification.

3.4.3 Humidity

The valve shall meet all performance requirements after exposure to humidity levels between 0 and 100%.

3.4.4 Random Vibration

While in the closed position, the valve shall meet the leakage requirement specified in paragraph 3.2.3.2 during and all performance requirements after exposure to the random vibration levels specified in Table 1 for three minutes minimum in each of the three orthogonal axes.

Table 1: Random Vibration Levels

Qualification Level			Acceptance Level	
Frequency (Hz)	**PSD (g^2/Hz)**		**Frequency (Hz)**	**PSD (g^2/Hz)**
20	0.026		20	0.013
50	0.16		50	0.08
800	0.16		375	0.08
2000	0.026		2000	0.026
Overall	**14.1 g_{rms}**		**Overall**	**10.0 g_{rms}**

3.4.5 Inertial Loads

While in the closed position, the valve shall meet the structural requirements specified in paragraph 3.5.3 during exposure to the inertial loads of ±TBD g's.

3.4.6 External Pressure

The valve shall meet all performance requirements while exposed to an external pressure of 16 psia to 1E-6 torr.

3.5 Design and Construction

3.5.1 Material and Construction Standards

The valve shall comply with NASA-STD-6016 requirements regarding materials and construction for a non-human-rated mission.

3.5.2 Fluid Compatibility

The valve shall be compatible with the following fluids:

- GN2 per MIL-PRF-27401
- LN2 per MIL-PRF-27401
- GH2 per MIL-PRF-27201
- GHe per MIL-PRF-27407, Type 1, Grade A
- Isopropyl Alcohol per TT-I-735, Grade A
- Operating fluids per paragraph 3.2.1

3.5.3 Structural Design

The valve shall meet the requirements of NASA-STD-5012 "Strength and Life Assessment Requirements for Liquid-Fueled Space Propulsion System Engines".

3.5.4 Threaded Joints

Threaded joints within the valve shall meet the requirements of NASA-STD-5020 "Requirements for Threaded Fastening Systems in Spaceflight Hardware".

3.5.5 Mechanisms

The valve shall meet the requirements of NASA-STD-5017 "Design and Development Requirements for Mechanisms".

3.5.6 Electrical Bonding

The valve shall meet NASA-STD-4003 "Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment", Class S and H, measured between the valve housing and mounting interface.

3.5.7 Fasteners

Fasteners shall comply with NASA-STD-6008 and MSFC-STD-486.

3.5.8 External Cleanliness

The valve external cleanliness shall meet the requirements of IEST-STD-CC1246E "Product Cleanliness Levels –Applications, Requirements, and Determination", Level VC-0.5-1000 Particulate Cleanliness.

3.5.9 Internal Cleanliness

The valve internal cleanliness shall meet the requirements of IEST-STD-CC1246E "Product Cleanliness Levels –Applications, Requirements, and Determination", Level TBD Particulate Cleanliness.

3.5.10 Interchangeability

The valve shall be directly interchangeable in form, fit, and function with other valves of the same part number.

3.6 Part Marking and Identification

The valve shall be identified per MIL-STD-130 "Identification Marking of U.S. Military Property" and, at a minimum, include the following:

- Manufacturer
- Manufacturer Part Number
- Serial Number

3.7 Traceability

3.7.1 Serialization

All non-standard parts shall be serialized with a unique serial number.

4 VERIFICATION

Supplier shall conduct a verification program that demonstrates the hardware design is qualified and meets all requirements contained in this document.

Supplier shall provide documentation showing conformance to this specification.

4.1 Inspection

Verification by inspection includes visual inspection of the physical hardware, a physical measurement of a property of the hardware, or the documentation search demonstrating hardware of an identical design has demonstrated fulfillment of a requirement.

4.1.1 Visual Inspection

Visual inspection of the physical component shall be performed by a qualified inspector to certify that the component has the properties/configuration specified in the requirement.

4.1.2 Physical Measurement

Physical measurement of hardware property (i.e. mass, dimensions, etc.) demonstrating the hardware meets specific requirement.

4.1.3 Documentation Search

Verification of requirements based on similarity shall include supporting rationale and documentation and shall be approved by the purchaser.

4.2 Analysis

Verification by analysis involves the use of engineering analysis, qualitative assessment, computer modeling and/or simulation to ensure compliance to requirement(s). If necessary, analysis combined with test results may be used to provide this evidence.

4.3 Test

Verification by test (e.g., functional, environmental) is the actual operation to ensure that the performance characteristics of the valve are in accordance with the requirement(s). Testing will also include methods to verify requirements such as material compatibility which may or may not be performed with an end item. All acceptance and qualification testing shall be performed in accordance with SMC-S-016 and NASA-STD-5017, using the bounding test criteria for each test. For determining SMC-S-016 required testing, the valve would be categorized as: Electrical/Electronic, Moving Mechanical Assembly (MMA), and pressure component.

4.3.1 Test Restrictions

Any deviation from SMC-S-016 or NASA-STD-5017 must be approved by the purchaser.

4.3.2 Equipment Failure During Testing

The test will be stopped if equipment fails during testing in cases where this failure will result in damage to the valve. A complete record shall be maintained and included in the test report.

4.3.3 Valve Failure During Testing

In the event of a valve failure during test, the test will be stopped, the configuration made safe and maintained to the extent practical, and the purchaser notified. A complete record shall be maintained and included in the test report.

4.3.4 Modification of Valve

Modification of the valve shall not be permitted once acceptance and/or qualification testing has started.

4.3.5 Acceptance Testing

Perform acceptance testing on each valve per paragraph 4.3, with tailoring and clarification to test requirements defined below.

4.3.5.1 Proof Pressure

The proof test shall include the required environmental correction factor if performed at room temperature.

4.3.5.2 Thermal

Thermal cycle test shall be performed in lieu of thermal vacuum testing. Non-operating temperature, one cycle, to be performed prior to operating temperature testing. Hot and cold temperature plateaus shall be held for a minimum of four (4) hours at the acceptance temperature levels. Pressurization of the valve when not performing leakage tests is not required.

4.3.6 Qualification Testing

Perform qualification testing on each valve per paragraph 4.3, with tailoring and clarification to test requirements defined below.

4.3.6.1 Proof Cycle Life

The proof cycle life test shall include the required environmental correction factor if performed at room temperature.

4.3.6.2 Thermal

Thermal cycle test shall be performed in lieu of thermal vacuum testing. Non-operating temperature, one cycle, to be performed prior to operating temperature testing. Hot and cold temperature plateaus shall be held for a minimum of four (4) hours at the qualification temperature levels. The "hot and cold temperature plateaus" are 18 °F beyond the operating and non-operating temperatures shown in paragraphs 3.4.1 & 3.4.2, except the minimum operating temperature test does not require margin. Performance testing shall be performed at the first, third and last thermal cycles as part of the minimum and maximum temperature dwells in order to detect performance degradation. Pressurization of the valve when not performing leakage tests is not required.

4.3.6.3 Actuation Cycle Life

The valve application is a non-manned system for determining qualification margin requirements per NASA-STD-5017. Performance tests shall be conducted every 25% of the total qualified cycles to provide trending data.

4.3.6.4 Burst Pressure

The burst pressure test shall include the required environmental correction factor if performed at room temperature.

4.4 Verification Matrix

Verification shall be accomplished per Table 2.

Table 2: Verification Cross Reference Matrix Requirements

Section 3 Requirement Paragraph No.	Title	Verification		
		Development	Acceptance	Qualification
3.2	**Performance Requirements**			
3.2.1	Operating Fluid		I	A
3.2.2	**Pressure**			
3.2.2.1	Operating Pressure Range		———	———
3.2.2.2	Maximum Expected Operating Pressure (MEOP)		———	———
3.2.2.3	Maximum Design Pressure (MDP)		———	———
3.2.2.4	Maximum Differential Pressure		———	———
3.2.2.5	Proof Pressure		T	A,T
3.2.2.6	Burst Pressure		I	A,T
3.2.3	**Leakage**			
3.2.3.1	External Leakage		T	T
3.2.3.2	Internal Leakage		T	T
3.2.4	Flow and Pressure Drop		T	A,T
3.2.5	**Operating Characteristics**			
3.2.5.1	**Response Time**			
3.2.5.1.1	Opening Response Time		T	A,T
3.2.5.1.2	Closing Response Time		T	A,T
3.2.6	**Electrical Characteristics**			
3.2.6.1	Actuation Operating Voltage		———	———
3.2.6.2	Position Sensor Current		T	I,T
3.2.6.3	Power		T	A,T
3.2.7	**Physical Characteristics**			
3.2.7.1	Envelope Dimensions		I	I
3.2.7.2	Mass		I	I
3.2.7.3	Lifting Provisions		I	I
3.2.7.4	Position Indicator		I	I
3.2.8	**Life**			
3.2.8.1	Shelf Life		I	A
3.2.8.2	Service Life		I	A
3.2.8.3	**Cycle Life**			
3.2.8.3.1	Actuation Cycles		I	A,T

Section 3 Requirement Paragraph No.	Title	Verification		
		Development	Acceptance	Qualification
3.2.8.3.2	Proof Pressure Cycles		I	A,T
3.3	**Component Interfaces**			
3.3.1	**Fluid Interfaces**			
3.3.1.1	Inlet Interface		I	I
3.3.1.2	Outlet Interface		I	I
3.3.2	Electrical Interfaces		I	I
3.3.3	Mounting Interface		I	I
3.3.4	Orientation		I	A
3.4	Environments			
3.4.1	Operating Temperature		T	A,T
3.4.2	Non-Operating Temperature		T	A,T
3.4.3	Humidity		I	A
3.4.4	Random Vibration		T	A,T
3.4.5	Inertial Loads		I	A
3.4.6	External Pressure		T	A,T
3.5	**Design and Construction**			
3.5.1	Material and Construction Standards		I	A,I
3.5.2	Fluid Compatibility		I	A,I
3.5.3	Structural Design		I	A
3.5.4	Threaded Joints		I	A
3.5.5	Mechanisms		T	A,T
3.5.6	Electrical Bonding		T	T
3.5.7	Fasteners		I	A,I
3.5.8	External Cleanliness		T	T
3.5.9	Internal Cleanliness		T	T
3.5.10	Interchangeability		I	I
3.6	Part Marking and Identification		I	I
3.7	**Traceability**			
3.7.1	Serialization		I	I
3.8	Reliability		I	A

5 PREPARATION FOR DELIVERY

5.1 Methods of Preservation and Packaging

Unless otherwise specified in the contract or purchasing order, valves procured to this specification shall be packaged, packed, and marked for shipment as specified herein.

A copy of the supplier's handling/transportation and safety procedures and cleanliness certification of compliance shall be included with the valve.

5.1.1 Retention of Cleanliness

After cleaning, and while the valve is still in a controlled clean room area, the vehicle interface tube shall be capped off or enclosed using antistatic Nylon material conforming to **TBS**.

The valve should then be secured in place with clean-room tape to a specification approved by the purchaser.

The valve shall then be bagged using a 2 mil minimum antistatic Nylon inner bag cleaned to Cleanliness Level TBD or better per IEST-STD-CC1246E. This inner bag shall be evacuated and the bag ends heat sealed closed. It shall then be outer-bagged with 4 mil minimum Nylon or Polyethylene transparent antistatic material cleaned to Cleanliness Level TBD or better per IEST-STD-CC1246E.

A non-shedding identification tag shall be placed between the inner and outer bags and it shall display the following caution note as a minimum: 'Open in Clean Room Environment only.'

A humidity indicator shall also be placed between the inner and outer bags.

5.1.2 Storage

The valve shall be capable of being stored for a minimum of that stated in paragraph 3.2.7.1 without requiring repair, maintenance, or retesting at the end of storage.

5.1.3 Protective Coverings

The valve shall be provided with protective covering to prevent contamination during transportation outside clean areas and where necessary to protect against damage in handling, tube caps shall be fitted at the inlet and outlet ports of the valve.