Technical Center

NUCLEAR DIVISION

C002-EC090117-F1

ENGINEERING CRITICAL COMPONENT SPECIFICATION

PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS

FOR

PROPELLANT SHUTOFF
VALVE & ACTUATOR

MASTER

FORMING A PART OF
CEI NUMBER 090290A

PRELIMINARY PROPOSAL ISSUE

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AEROJET-GENERAL CORPORATION

SACRAMENTO, CALIFORNIA

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Part I of Two Parts
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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS

for

PROPELLANT SHUTOFF VALVE AND ACTUATOR

Replace page(s) with the latest revised page(s) noted below. Revised paragraph(s) are identified with the latest revision letter (or number) in the margin.

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1. SCOPE

1.1 Scope.- This specification establishes the performance, design, test and qualification requirements for equipment identified as Propellant Shutoff Valve and Actuator, hereinafter referred to as PSOV assembly, consisting of a valve and an electro-mechanical actuator system. The PSOV assembly is to be used to permit flow of liquid hydrogen to the turbopump assembly during engine operation and to prevent flow prior to and after engine operation.

2. APPLICABLE DOCUMENTS

2.1 Aerojet-General Corporation Documents.- The following documents, of exact issue shown, form a part of this specification to the extent specified herein. In the event of conflict between documents referenced herein and other detail content of Sections 3, 4, 5, and 10, the detail requirements of Sections 3, 4, 5, and 10 shall be considered a superseding requirement.

SPECIFICATIONS

EC-90218	Propellant Feed Subsystem
CP-90290	Engine, NERVA, 75K, Full Flow

(Copies of above documents required by suppliers in connection with specific procurement functions should be obtained from the procuring activity.)

3. PERFORMANCE

3.1 Performance.- Except as otherwise specified herein, performance requirements for this equipment shall be in accordance with EC-90218, Propellant Feed Subsystem, of which this equipment is a part. The PSOV assembly

shall be capable of meeting these requirements within the environmental conditions specified in 3.1.2.4.

3.1.1 Functional Characteristics.- The PSUV assembly shall respond to an opening or closing command signal from the engine control system and shall be capable of remaining in the commanded position, open or closed, within the limits and under the conditions specified herein.

3.1.1.1 Opening Characteristics.- The PSUV assembly shall be capable of opening from a fully closed, or any intermediate position, to a fully open position within 3.0 ± 2.0 seconds after receipt of an "OPEN" command signal when the following conditions prevail:

3.1.1.1.1 Inlet Conditions.- The PSUV assembly shall be capable of opening as specified in 3.1.1.1 with the inlet conditions of Table I, all cases.

3.1.1.1.2 Electrical Supply Conditions.- The PSUV assembly shall be capable of opening as specified in 3.1.1.1 or closing as specified in 3.1.1.3 over the pressure and temperature range specified when provided with 28 ± 2 VDC at the electrical connector interface.

3.1.1.2 Open Position Characteristics.- After responding to an "OPEN" command signal the PSUV assembly shall be capable of remaining in a fully open position for a period not exceeding 30 minutes or until commanded to close. The PSUV assembly shall be capable of fully opening after having been closed for a period of time not in excess of 6 months.

3.1.1.2.1 Flow and Fluid Conditions.- When in the open position the PSUV assembly shall be capable of flowing liquid hydrogen at the rates and conditions specified in Table I, all cases.

3.1.1.3 Closing Characteristics.- While flowing liquid hydrogen as specified in Table I, all cases, the PSUV assembly shall be capable of closing within $3.0^{+0.0}_{-2.0}$ seconds after receipt of a "CLOSE" command signal.

3.1.1.4 Closed Position Characteristics.- After responding to a "CLOSE" command signal with the fluid conditions of Table I, all cases, the PSUV assembly shall be capable of remaining in a fully closed position without the use of electrical power for a period not exceeding 6 months or until commanded to open. When in the closed position the pressure at the outlet interface shall not exceed 40 psia.

3.1.1.5 Pressure Loss Limitations.- While flowing liquid hydrogen under the conditions specified in Table I, Case II, the pressure loss through the valve shall not exceed 0.15 psi.

3.1.2 Operability.-

3.1.2.1 Reliability.- The reliability requirements of the PSUV assembly shall be .999710 or greater.

3.1.2.2 Maintainability.- The PSUV assembly shall be capable of being maintained within the following time allocations.

(a) Removal from engine, checkout and replacement time -- the time required shall not exceed four hours.

(b) Active maintenance time -- the maximum time required for preventive and corrective maintenance shall not exceed 0.1 man-hours per hour during engine assembly and operations.

3.1.2.2.1 Maintenance and Repair Cycles.-

(a) Periodic maintenance, other than an inert gas purge, shall not be required during storage.

(b) Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.

3.1.2.2.2 Service and Access.-

(a) Capability for remote malfunction detection and fault isolation shall be provided.

(b) Capability for remote and manual replacement of the PSOV assembly shall be provided.

(c) The PSOV assembly on an engine shall be capable of being manually maintained and replaced with the use of standard hand tools.

(d) Provisions shall be made for purging the PSOV assembly with inert gas through the engine purge system.

3.1.2.3 Useful Life.- The useful life of the PSOV assembly shall be a minimum of 9 years or a total of 225 cycles of operation, allocated as specified below. A cycle consists of travel from full closed to full open and return to full closed position.

(a) Rated Operating Life.- Subsequent to non-rated operating life and non-operating life (3.1.2.3b and c), the PSOV assembly shall operate at rated conditions as specified in 3.1.1.1 and 3.1.1.3. (Note: The rated operating life shall occur during a 3-year space storage period). 100 cycles

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(b) Non-Rated Operating Life

(1) Acceptance and pre-installation checkout
(Ambient Temperature and Pressure)	50 cycles
(2) Acceptance and Pre-installation Checkout
(Cryogenic)	25 cycles
(3) Pre-Launch Checkout
(Ambient Temperature and Pressure)	50 cycles

(c) Non-Operating Life

(1) Engine Assembly to Launch Pad
(Less Ground Storage), Months:	6
(2) Launch Pad, Months:	6
(3) Maximum Accumulated Space Storage Time, Years:
(Space Storage Between Firings - 6 Months)	3
(4) Ground Storage, Years:	5

3.1.2.4 Environmental.- The environments experienced by the PSUV assembly shall be as specified in EC-90218 in addition to the following:

(a) Internal temperature, °R	See Table I
(b) Internal Pressure, psia	See Table I
(c) Radiation	
(1) Gamma Dose, rads, max. (10 hours)	7.2×10^6
(2) Fast neutron fluence, N/Cm ² (E > 1 Mev), max	2×10^{15}

3.1.2.4.1 Dynamic Loads.- The PSOV assembly shall withstand dynamic loads resulting from launch vehicle operations and from engine operation as specified below:

(a) Launch Vehicle Operations

(1) Longitudinal dynamic amplitude over
Frequency range from 3 to 35 Hz.	$\pm 6.75g$ Max.
(2) Lateral dynamic amplitude over
Frequency range from 0.1 to 15 Hz.	$\pm 4.5g$ Max.

(b) Engine Operation.- Random vibration along each of three mutually perpendicular axes at levels indicated below for thirty minutes in each axis:

<u>20 to 200 Hz</u>	<u>200 to 800 Hz</u>	<u>800 to 2000 Hz</u>
Linear Increase	At $1.5g^2/Hz$	Linear Decrease
From 0.03 to		From 1.5 to
$1.5 g^2/Hz$		$0.06 g^2/Hz$
(3db/Octave)		(3db/Octave)

3.1.2.4.2 Static Loads.- The PSOV assembly shall withstand static loads resulting from launch vehicle acceleration for a minimum of five minutes along the following axes:

<u>Along X-Axis</u>	<u>Along Y-Axis</u>	<u>Along Z-Axis</u>
$5.2g - 1.0g$	$\pm 1.0g$	$\pm 1.0g$

NOTE: The X-Axis shall be parallel with the vehicle longitudinal axis.

3.1.2.5 Transportability.- The PSUV assembly shall be capable of meeting the transportability requirements specified in EC-90218.

3.1.2.6 Human Performance.- The PSUV assembly shall be capable of meeting the human performance requirements specified in EC-90218.

3.1.2.7 Safety.- The PSUV assembly shall be capable of complying with the safety requirements specified in EC-90218. The PSUV assembly shall close in the event of an electrical power failure.

3.2 Contract End Item Definition.- Not applicable.

3.3 Design and Construction.- Except as otherwise specified herein, design and construction of the PSUV assembly shall be in accordance with EC-90218 of which this equipment is a part. The PSUV assembly shall be designed and constructed in a manner such that the functional characteristics of 3.1.1 and the operability requirements of 3.1.2 can be achieved.

3.3.1 General Design Features.- The PSUV assembly shall be designed to satisfy the following criteria.

3.3.1.1 Dimensional.- The envelope dimensions of the PSUV assembly shall not exceed the dimensions shown in Figure 1.

3.3.1.2 Weight.- The weight of the PSUV assembly shall not exceed 150 pounds.

3.3.1.3 Position Indication.- The PSUV assembly shall be equipped with a position indicator to provide position indication over the full range of valve travel.

3.3.1.4 Leakage.-

3.3.1.4.1 Internal Leakage.- While in the closed position and with fluid pressure and temperature conditions as specified in Table I, the PSUV assembly shall not leak from the inlet to the outlet of the valve in excess of 10 standard cubic centimeters per second of GH_2 with a minimum valve outlet pressure of 1×10^{-6} mm Hg.

3.3.1.4.2 External Leakage.- The external joint leakage shall not exceed 0.01 standard cubic centimeters per second per inch joint diameter of static seal, or 1.0 standard cubic centimeter per second per inch joint diameter of dynamic seal, at the pressure and temperature conditions specified in Table I for all cases. Hydrogen leakage rate is defined as equivalent to a helium leakage rate at $520 \pm 50^\circ\text{R}$.

3.3.1.5 Electrical Power.- The electrical power consumption shall not exceed 3,000 watts while opening as specified in 3.1.1.1, 300 watts while in the open position per 3.1.1.2, and 300 watts while closing per 3.1.1.3.

3.3.1.6 Electrical Interface.- The PSUV assembly shall be equipped with an electrical connector to interface with an electrical power supply, position command signal, and position instrumentation harness.

3.3.1.7 Cleanliness.- The PSUV assembly shall satisfy the cleanliness requirements of CP-90290 and shall be designed to permit a flow rate with fluid containing particles no larger than 600 microns in size, 200 grams in weight, and 168 pounds per cubic foot in density.

- 3.3.2 Selection of Specifications and Standards.- As specified in CP-90290.
- 3.3.3 Materials, Parts and Processes.- As specified in CP-90290.
- 3.3.4 Standard and Commercial Parts.- As specified in CP-90290.
- 3.3.5 Moisture and Fungus Resistance.- As specified in CP-90290.
- 3.3.6 Corrosion and Metal Parts.- As specified in CP-90290.
- 3.3.7 Interchangeability and Replaceability.- As specified in CP-90290.
- 3.3.8 Workmanship.- As specified in CP-90290.
- 3.3.9 Electromagnetic Interference.- As specified in CP-90290.
- 3.3.10 Identification and Marking.- As specified in CP-90290.
- 3.3.11 Storage.- The PSUV assembly shall be capable of performing as specified herein subsequent to storage while protected from the ground environmental conditions specified in 3.1.2.4 for a period not exceeding the ground storage life specified in 3.1.2.3.

TABLE I

PRESSURE, TEMPERATURE, AND FLOW CONDITIONS
IN
PSOV ASSEMBLY
FOR
VARIOUS ENGINE OPERATING CONDITIONS

	Case I	Case II	Case III TPA	Case IV	Case V Maximum Expected Operation	Case VI
	<u>Chilldown</u>	<u>Normal Operation</u>	<u>Malfunction Operation</u>	<u>Throttling Operation</u>		<u>Normal Shutdown</u>
Inlet Pressure (psia)	30	30	30	30	25*	30
Inlet Temperature (°R)	40	40	40	40	42.0	40
Flow Rate (lb/sec)	44.8	44.8	89.8	26.9	93	44.8

*Maximum tank pressure for valve design shall be 33 psia.

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Figure 1

PSOV Assembly Dimensional Envelope

ERRATA SHEET

PROPELLANT SHUTOFF VALVE AND ACTUATOR

THE FOLLOWING CHANGES HAVE BEEN MADE IN COPIES OF THIS SPECIFICATION TRANSMITTED TO SHPO-C.

The following requirements have been identified as OBJECTIVES:

<u>Page No.</u>	<u>Paragraph No.</u>	<u>Requirement</u>
6	3.1.2.3(b)	Non-Rated Operating Life
6	3.1.2.3(c)	Non-Operating Life

The following requirements have been changed as follows:

<u>Page No.</u>	<u>Paragraph No.</u>	<u>Correction</u>
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