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ENGINEERING CRITICAL COMPONENT SPECIFICATION

**PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS**

FOR

**PUMP DISCHARGE CHECK
VALVE AND ACTUATOR**

WASER

**FORMING A PART OF
CEI NUMBER 090290A**

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AEROJET-GENERAL CORPORATION

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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS

for

PUMP DISCHARGE CHECK VALVE & ACTUATOR

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1. SCOPE

1.1 Scope.- This specification establishes the performance, design, test and qualification requirements for equipment identified as Pump Discharge Check Valve and Actuator, hereinafter referred to as PDKV Assembly. The PDKV Assembly shall be capable of preventing backflow to the pump during engine malfunction operating mode.

2. APPLICABLE DOCUMENTS

2.1 Aerojet-General Corporation Documents.- The following documents, of the 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 detailed content of Sections 3, 4, 5, and 10 the detailed 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. REQUIREMENTS

3.1 Performance.- Except as otherwise specified herein, performance requirements for the PDKV shall be in accordance with EC-90218, Propellant Feed Subsystem, of which the PDKV is a part. The PDKV shall be capable of meeting these requirements within the environmental conditions specified in 3.1.2.4, and shall also be capable of being closed by an actuator on command in case of excessive leakage or failure of the Propellant Shutoff Valve, PSOV.

3.1.1 Functional Characteristics.- The PDKV shall be flow actuated and shall be capable of preventing backflow to the PSUV within the limits and under the conditions specified herein.

3.1.1.1 Forward Flow Characteristics.-

3.1.1.1.1 Cracking Pressure.- The PDKV shall crack open when pressure, applied at the inlet port with a rise rate of 50 to 100 psi per second, reaches a cracking pressure of 2(+2,-0) psid. Cracking pressure is defined as that point at which a sudden or momentary reduction in rise rate occurs.

3.1.1.1.2 Fluid Conditions.- The PDKV shall be capable of operating when liquid hydrogen exists at the PDKV at temperatures and pressures shown in Table I.

3.1.1.1.3 Pressure Differential Rise Rate Conditions.- The PDKV shall be capable of operating with a forward flow pressure differential rise rate of 75 ± 25 psid per second.

3.1.1.1.4 Full Open Characteristics.- The PDKV shall be capable of opening to a full open position when flow through the valve is as specified in Table I, Cases I, II, and IV. The PDKV shall be capable of fully opening after having been closed for a period of time not in excess of 6 months.

3.1.1.1.4.1 Flow Conditions.- When in the open position the PDKV shall be capable of flowing liquid hydrogen as specified in Table I.

3.1.1.2 Reverse Flow Characteristics.-

3.1.1.2.1 Closing Characteristics.- The PDKV shall begin to close when the pressure differential is reduced and shall be completely closed at 0(+4,-0) psid.

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3.1.1.2.2 Fluid Conditions.- When in the closed position the PDKV shall be capable of withstanding the pressure and temperatures shown in Table I for all cases of operating conditions.

3.1.1.2.3 Pressure Differential Rise Rate Condition.- The PDKV shall be capable of withstanding a reverse pressure differential rise rate of 800 ± 200 psid per second.

3.1.1.3 Actuator.- The PDKV shall be designed with an actuator which shall, on command, provide the force required to limit the forward flow when the PDKV is pressurized, with liquid hydrogen, at the valve side inlet to a pressure of 30 ± 5 psia and at a temperature of $40 \pm 3^\circ\text{R}$. The actuator shall not be used to open or close the PDKV under normal operating conditions and shall not hinder the proper functioning of the PDKV. The actuator shall be capable of opening or closing when provided with 28 ± 2 VDC at the electrical connector interface. The actuator shall be capable of closing the valve against tank head pressure of 30 ± 5 psia.

3.1.1.4 Pressure Loss Limitation.- While flowing liquid hydrogen under the conditions specified in Table I, Case I, the total pressure loss through the PDKV shall not exceed 14 psi.

3.1.2 Operability.-

3.1.2.1 Reliability.- The reliability requirement of the PDKV shall be a minimum of .999980.

3.1.2.2 Maintainability.- The PDKV 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 two 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 PDKV assembly with interconnecting lines shall be provided.

(c) The PDKV on an engine shall be capable of being manually maintained and repaired, including replacement of parts, with standard hand tools.

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

3.1.2.3 Useful Life.- The useful life of the PDKV assembly shall be a minimum of 9 years or a total of 205 cycles of operation, allocated as specified below. A cycle consists of travel from full closed to full open and return to full closed position.

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(a) Rated Operating Life: Subsequent to non-rated operating life and non-operating life (3.1.2.3 b & c) the PDKV shall operate at rated conditions as defined in paragraph 3.1.1.1 and 3.1.1.3, cycles: 80

(Note: The rated operating life shall occur during a 3-year space storage period.)

(b) Non-rated Operating Life

(1) Acceptance and pre-installation checkout at ambient temperature and pressure, cycles: 50

(2) Acceptance and pre-installation checkout at fluid conditions specified in Table I, cycles: 25

(3) Pre-launch checkout at ambient temperature and pressure, cycles: 50

(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 3
(Space storage between firings -6 months)

(4) Ground storage, years 5

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

(a) Internal temperature, °R	See Table I
(b) Internal pressure, psia	See Table I
(1) Gamma dose, RADS, max (10 hours)	4×10^7
(2) Fast neutron fluence, N/cm^2 ($E > 1 \text{ Mev}$), max	2.1×10^{16}

3.1.2.4.1 Dynamic Loads.- The PDKV assembly shall withstand dynamic loads resulting from launch vehicle operations and from engine operations as follows:

(a) <u>Launch Vehicle Operations</u>	
(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 PDKV 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 PDKV assembly shall be capable of meeting the transportability requirements specified in EC-90218.

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

3.1.2.7 Safety.- The PDKV assembly shall be capable of complying with the safety requirements specified in EC-90218. The PDKV assembly shall be capable of closing, on command, against the fluid conditions specified in 3.1.1.3. In the deenergized mode, or in a malfunction condition, the actuator shall not hinder the valve from functioning as a check valve.

3.2 Contract End Item Definition.- Not applicable.

3.3 Design and Construction.- Except as otherwise specified herein, design and construction of the PDKV assembly shall be in accordance with the EC-90218 of which the PDKV assembly is a part. The PDKV assembly shall be designed and constructed in a manner such that the functional characteristics of 3.1.1, 3.1.1.3 and the operability requirements of 3.1.2 can be achieved.

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

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

3.3.1.2 Weight.- The weight of the PDKV assembly shall not exceed 125 pounds for a dual configuration or 60 pounds for an inline type, see Figure 1.

3.3.1.3 Position Indication.- The PDKV assembly shall be equipped with a position indicator to provide position indication which will be an integral part of the actuation system, over the full range of valve travel.

3.3.1.4 Leakage.-

3.3.1.4.1 Internal Leakage (Forward Flow).- While the actuator is in the energized closed position, the PDKV assembly shall not leak in excess of 1 standard cubic foot per second of helium, when the PDKV assembly is pressurized at the inlet with a pressure of 30 ± 5 psia and at a temperature of $40^\circ \pm 3^\circ\text{R}$, with the outlet at ambient pressure conditions. Forward flow internal leakage is defined as the leakage through the PDKV from the inlet of the PDKV to the outlet when the PDKV is in the energized closed position.

3.3.1.4.2 Internal Leakage (Reverse Flow).- Internal leakage in the reverse flow direction shall not exceed 5 standard cubic feet per minute with fluid outlet pressure and temperature conditions as specified in Table I. Reverse flow internal leakage is defined as leakage through the closed PDKV from the outlet side to the inlet side of the PDKV.

3.3.1.4.3 External Leakage.- The external joint leakage shall not exceed 0.01 standard cubic centimeter per second per inch joint diameter of static seal or 10 standard cubic centimeters per inch joint diameter of dynamic seal at the pressure and temperature conditions as 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 Actuator Electrical Power.- The electrical power consumption shall not exceed 375 watts while closing per 3.1.1.3 and shall not exceed 100 watts while maintaining the closed position.

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

3.3.1.7 Cleanliness.- The PDKV 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 PDKV 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

PDKV FUNCTIONAL REQUIREMENTS

<u>Function</u>	OPERATING CONDITION			
	Case I Nominal <u>Steady State</u>	Case II Malfunction <u>Steady State</u>	Case III Throttling <u>Steady State</u>	Case IV Expected <u>Maximum</u>
Inlet, psia	1460	1867	745.0	2232.0
Inlet Temp, °R	61.1	67.3	51.7	67.5
Flow Rate, lb/sec	44.6	89.3	26.7	93.0
Outlet, psia	1447	1810	736.0	2163
Outlet, Temp, °R	61.1	67.3	51.7	67.5

(b) Dual Type

NOTE: 4.00 inch I.D. Inlet - Outlet Port

(a) Inline Type

Figure 1

PDKV Assembly Dimensional Envelope