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NUCLEAR DIVISION

C002-EC090154-F1

ENGINEERING CRITICAL COMPONENT SPECIFICATION

PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS

FOR

PRESSURE VESSEL & CLOSURE SUBSYSTEM

FORMING A PART OF
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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS for

PRESSURE VESSEL & CLOSURE SUBSYSTEM

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Specification No. EC-90154

1. SCOPE

1.1 Scope.- This specification establishes the performance, design, test and qualification requirements for equipment identified as the pressure vessel and closure subsystem (PVCS).

2. APPLICABLE DOCUMENTS

2.1 Government 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 detail content of Sections 3, 4, 5, and 10 the detail requirements of Section 3, 4, 5, and 10 shall be considered a superseding requirement.

SPECIFICATIONS

NASA

SNPO-C-1

NERVA Program Structural Design Requirements

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

2.2 Aerojet-General Corporation Documents.- The following documents, of the latest issue, 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

CP-90290

Engine, NERVA, 75K, Full Flow

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DRAWINGS

1136390	75K NERVA Flight Engine Full Flow Concept
1136391	75K NERVA Full Flow Engine P & I
1136393	75K NERVA Nuclear and Non-Nuclear System ICD
1136408	75K NERVA Full Flow Engine Component ICD

(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 this equipment shall be in accordance with CP-90290 of which this equipment is a part.

3.1.1 Functional Characteristics.- The PVCS shall meet the functional characteristics herein, within the environments specified in 3.1.2.4.

3.1.1.1 Contain Propellant Fluids.- The PVCS shall be capable of containing the high pressure hydrogen propellant fluid which flows from the nozzle through and around the enclosed reflector to the internal shield. The subsystem shall be capable of functioning as specified at rated operating conditions without degradation before and after being subjected to the transient conditions associated with startup, shutdown and cooldown of the NERVA engine as specified in CP-90290. See 3.2.1.2.2 for fluid flow characteristics.

3.1.1.2 Transmit engine loads.- The PVCS shall be capable of transmitting engine thrust and/or inertia loads between interfaces. See 3.2.1.2.1 for interface loads.

3.1.1.3 Enclose and Support Reactor Assembly. - The PVCS shall be capable of enclosing and supporting the reactor assembly.

3.1.1.4 Mechanical Support. - The pressure vessel closure shall be capable of mechanically supporting instrumentation, the stage pressurization system supply line, reactor control drum actuators, turbine inlet line, turbine discharge line and structural support coolant lines.

3.1.2 Operability. -

3.1.2.1 Reliability. - The PVCS shall have a minimum reliability of 0.999997 such that the PVCS shall successfully meet all the performance requirements specified herein.

3.1.2.2 Maintainability. -

3.1.2.2.1 Maintenance and Repair Cycles. - Periodic maintenance shall not be required.

3.1.2.2.2 Service and Access. - The PVCS shall provide capability for remote and manual replacement of control drum actuators and of fluid lines which are integral to the pressure vessel and closure and below the external disk shield.

3.1.2.3 Useful Life. - The PVCS shall have a minimum useful life as specified in CP-90290.

3.1.2.4 Environmental. - The induced and natural environmental conditions to which the PVCS will be subjected shall be as specified in the following paragraphs.

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3.1.2.4.1 Induced Environment.-

- (a) Nuclear radiation - see Table I
- (b) Acceleration, vibration and shock - see Table II
- (c) Acoustic - see Table II

3.1.2.4.2 Natural Environment.- The natural environment experienced by the PVCS shall be as specified in CP-90290.

3.1.2.5 Transportability.- The PVCS shall be transportable without degradation of performance capability as a separate component, with a reactor assembly installed and as part of the engine assembly for the modes of transportation and attitude of assembly specified in CP-90290.

3.1.2.6 Human Performance.- Not applicable

3.1.2.7 Safety.-

3.1.2.7.1 Flight Safety.- As specified in CP-90290.

3.1.2.7.2 Ground Safety.- As specified in CP-90290.

3.1.2.7.3 Nuclear Safety.- Not applicable.

3.1.2.7.4 Personnel Safety.- As specified in CP-90290.

3.1.2.7.5 Explosive and/or Ordnance Safety.- Not applicable.

3.2 Contract End Item Definition.- The item described in this specification shall be physically, mechanically and functionally suitable for operation with the reactor assembly, thrust structure, and nozzle in accordance with the following subparagraphs.

3.2.1 Interface requirements.-

3.2.1.1 Schematic Arrangement.- The physical interface relationships of the PVCS shall be in accordance with the following:

<u>Interface No.</u>	<u>AGC Drawing</u>
(a) 3,4,5,6	1136393 75K NERVA Nuclear & Non-Nuclear System ICD
(b) 1,2,7,8,9	1136408 75K NERVA Full Flow Engine Component ICD

(1) **Interface No. 1 - Pressure Vessel and Closure Subsystem/Nozzle Assembly:** This interface involves structural support for the nozzle assembly and reactor. The mechanical fasteners shall be capable of removal by ground remote handling methods. A seal and an interface seal surface to satisfy the leakage requirements specified in 3.3.1.3 shall be provided.

(2) **Interface No. 2 - Pressure Vessel and Closure Subsystem/Lower Thrust Structure:** This interface involves the structural connection between the pressure vessel closure and the lower thrust structure. The mechanical fasteners shall be capable of removal by ground remote handling methods.

(3) **Interface No. 3 - Pressure Vessel and Closure Subsystem/Nuclear Reactor Support Structure:** This interface involves structural connections to facilitate support of the nuclear reactor within the pressure vessel and closure subsystem.

(4) **Interface No. 4 - Pressure Vessel and Closure Subsystem/NSS Control Drum Actuators:** This interface involves structural connections to provide for penetration of the Control Drum Actuator shafts through the pressure vessel closure. A seal surface to satisfy leakage requirements specified in 3.3.1.3 shall be provided.

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(5) Interface No. 5 - Pressure Vessel and Closure Subsystem/Structural Support Coolant Lines/NSS: This interface involves structural and fluid connections from the structural support coolant lines to the pressure vessel closure and from the Nuclear Subsystem to the pressure vessel closure. A seal surface to satisfy leakage requirements as specified in 3.3.1.3 shall be provided.

(6) Interface No. 6 - Pressure Vessel and Closure Subsystem/Structural Support Bypass Line: This interface involves structural and fluid connections from the structural support bypass lines to the pressure vessel closure and from the nuclear subsystem to the pressure vessel closure. A seal surface to satisfy leakage requirements as specified in 3.3.1.3 shall be provided.

(7) Interface No. 7 - Pressure Vessel and Closure Subsystem/NSS Instrumentation: The interface involves mechanical attachment of an adapter containing electrical connections for diagnostic and control instrumentation for NSS operation and checkout.

(8) Interface No. 8 - Pressure Vessel and Closure Subsystem/Turbine Inlet Line: This interface involves structural and fluid connection of the turbine inlet line to the pressure vessel closure. A seal surface to satisfy leakage requirements as specified in 3.3.1.3 shall be provided.

(9) Interface No. 9 - Pressure Vessel and Closure Subsystem/Turbine Discharge Line: This interface involves structural and fluid connection of the turbine discharge line to the pressure vessel closure. A seal surface to satisfy leakage requirements as specified in 3.3.1.3 shall be provided.

(10) Interface No. 10 - Pressure Vessel and Closure Subsystem/Stage Tank Pressurization Supply Line: This interface involves a structural and fluid connection at the pressure vessel closure for the supply of stage tank pressurization. A seal surface to satisfy leakage requirements as specified in 3.3.1.3 shall be provided.

3.2.1.2 Detail Interface Definition.-

3.2.1.2.1 Interface Loads.- Axial and shear loads and bending and torsion moments for critical loading modes are shown in Table III for each of the mechanical interfaces specified in 3.2.1.1 as having a structural connection function.

3.2.1.2.2 Interface Fluid Flow Characteristics.- Fluid type and conditions (flow rate, pressure, temperature) for the various operating, transient and cooldown modes are shown in Table IV for each of the mechanical interfaces specified in 3.2.1.1 as having a fluid connection function and for the following additional fluid interfaces in accordance with AGC drawing 1136391.

- (a) Interface No. 11 - Pressure Vessel Cylinder/Reflector Inlet Plenum.
- (b) Interface No. 12 - Pressure Vessel Cylinder/Reflector Outer Annulus Gap.
- (c) Interface No. 13 - Pressure Vessel/Reflector Outlet.

3.2.1.2.3 Interface Electrical Characteristics.- Not applicable.

3.2.2 Component Identification.-

3.2.2.1 Government-Furnished Equipment List.- Not applicable.

3.2.2.2 Engineering Critical Component List.- There are no components of the PVCS which are classified as Engineering Critical Components.

3.2.2.3 Logistics Critical Components.- There are no components of the PVCS which are classified as Logistics Critical Components.

3.2.2.4 Design Critical Components List.- There are no components of the PVCS which are classified as Design Critical Components.

3.3 Design and Construction.-

3.3.1 General Design Features.-

3.3.1.1 Configuration.- The PVCS configuration envelope shall be as specified in AGC drawing 1136390.

3.3.1.2 Structural Criteria.- The design of the PVCS shall comply with structural criteria specified in SNPO-C-1.

3.3.1.3 Leakage.- Leakage considerations shall be as specified in CP-90290. External joint leakage shall not exceed 0.01 standard cubic centimeters per second per inch of seal diameter when pressurized to 50 psia with ambient gaseous helium.

3.3.1.4 Physical Properties.- The maximum dry weight of PVCS shall not exceed 1600 pounds.

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.

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3.3.8 Workmanship.- As specified in CP-90290.

3.3.9 Electromagnetic Interference.- Not applicable.

3.3.10 Identification and Marking.- As specified in CP-90290.

3.3.11 Storage.- The PVCS 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
INDUCED NUCLEAR RADIATION

Description	Location Sta R		Flight *		Ground (Component)*		Ground (Engine)*	
			Gamma Kerma Rate Rads/Hr	Fast Neutron Flux n/cm ² -sec	Gamma Kerma Rate Rads/Hr	Fast Neutron Flux n/cm ² -sec	Gamma Kerma Rate Rads/Hr	Fast Neutron Flux n/cm ² -sec
Closure - top	105.3	0	8.0×10^6	5.0×10^{11}	1.3×10^7	-	9.4×10^6	5.0×10^{11}
Closure - Cylinder Joint	117.0	26.4	6.5×10^6	3.6×10^{11}	4.4×10^7	-	7.9×10^6	3.6×10^{11}
Cylinder - Core Center	177.0	26.4	3.5×10^9	2.1×10^{14}	3.5×10^9	-	3.7×10^9	2.1×10^{14}
Cylinder - aft, near nozzle joint	203.7	26.4	9.2×10^8	4.8×10^{13}	1.1×10^9	-	1.1×10^9	4.8×10^{13}

* No external shield, unperturbed

TABLE II

INDUCED DYNAMICS ENVIRONMENT

Mode	<u>Acceleration, g's</u>		<u>Vibration, g's</u>		Shock	Accoustic
	Axial	Lateral	Axial	Lateral		
			3 - 35 Hz	.1 - 15 Hz		
Launch	5.2	1.0	± 4.5	± 3.0	Same as CP-90290	Same as CP-90290

TABLE III
INTERFACE LOADS

PCVS Interface	Description	Mode*	Loads, kips		Moment, in-kips	
			Axias**	Shear	Bending	Torsion
1	PVCS/Nozzle	L	79.5	+ 13.9	+ 666.7	
2	PVCS/LTS	L	90	+ 17.3	+ 988.8	
3	PVCS/NR Support Structure					
4	PVCS/NSS Control Drum Actuators					
5	PVCS/SSCL/NSS					
6	PVCS/SSBL/NSS					
7	PVCS/NSS Instru- mentation					
8	PVCS/TIL					
9	PVCS/TDL					
10	PVCS/Stage Tank Pressurization Supply Line					

* L = Launch, F = Flight Operations

** Positive loading indicates tension

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TABLE IV

INTERFACE FLUID FLOW CHARACTERISTICS

PCVS Interface	Description	Nominal Steady State			Malfunction*		
		Fluid Temp °R	Fluid Press psia	Flow Rate lbs/sec	Fluid Temp °R	Fluid Press psia	Flow Rate lbs/sec
11	PV Cyl/Reflector Inlet Plenum	193	1329	7.5	200	1628	7.5
12	PV Cyl/Reflector Outer Annulus Gap at Core Center	226	1282	7.5	232	1587	7.5
13	PV Cyl/Reflector Outlet	258	1280	7.5	264	1585	7.5
5	PCVS/SSCL	61.1	1324	5.3	67.3	1629	5.3
6	PCVS/SSBL	61.1	1312	15.3	66.4	1619	14.7
8	PVCS/TIL	262	1253	89.2	269	1561	89.2
9	PVCS/TDL	236	660	89.3	235	660	89.3
10	PVCS/Stage Tank Pressurization Supply Line	262	1253	0.5	269	1561	0.5

* Turbopump malfunction - turbopump operating

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