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C002-DS090265-F1
ENGINEERING DESIGN SHEET SPECIFICATION

PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS

FOR

STRUCTURAL SUPPORT COOLANT LINES

FORMING A PART OF
CEI NUMBER 090290A

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MASTER

AEROJET-GENERAL CORPORATION

SACRAMENTO, CALIFORNIA

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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS
for

STRUCTURAL SUPPORT COOLANT LINES

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 structural support coolant lines (SSCL). The SSCL transports propellant from the pump discharge line and from the cooldown supply line to the pressure vessel closure inlet.

2. APPLICABLE DOCUMENTS

2.1 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

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

DRAWINGS

1136390	Engine Layout
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3. REQUIREMENTS

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

3.1.1 Functional Characteristics.- The SSCL shall transport propellant from the pump discharge line (PDL) and from the cooldown supply line (CSL) to the pressure vessel closure (PV) inlet.

3.1.1.1 Propellant Flow.- The propellant characteristics of the SSCL shall be as shown on Table I.

3.1.1.2 Pressure Drop.-

3.1.1.2.1 Design Point.- The allowable pressure drop of the SSCL at the engine nominal design state point conditions shall be as shown on Table II

3.1.1.2.2 Symmetry, Pressure Drop.- The allowable variation in the pressure drop specified, from the line inlet to the line outlet shall not be greater than 20% between that line interfacing with the structural support coolant valve (SSCV) and that line interfacing with SSCV.

3.1.2 Operability.-

3.1.2.1 Reliability.- The reliability of the SSCL, including joints, shall be a minimum of 0.999989, apportioned into subcategories as shown in Table III.

3.1.2.2 Maintainability.- The time required for manual removal of the SSCL shall not exceed one hour. The time required to manually install the SSCL shall not exceed three hours, not including leak check. The time limitation for remote removal and replacement shall be six hours.

3.1.2.2.1 Maintenance and Repair Cycles.- There shall be no periodic maintenance required on the SSCL.

3.1.2.2.2 Service and Access.-

3.1.2.2.2.1 Checkout.- The SSCL joints shall be capable of being leak checked subsequent to installation, within three hours.

3.1.2.2.2.2 Removal.- The SSCL shall be both manually and remotely removable from the engine assembly in one segment as consisting of all lines pens valves as shown in Figure 1.

3.1.2.3 Useful Life.- The SSCL shall have a minimum useful life of 9 years, allocated as follows:

(a) Rated operating life	
Time, minutes, minimum	600
Cycles, maximum	60
(b) Non-rated operating life	
(1) Transient and in-flight checkout, minutes	2400
(2) Acceptance-thermal cycles from ambient to operating and back to ambient temperature	20
(c) Non-operating life	
(1) Engine assembly to launch pad (less ground storage), months	6
(2) Launch pad, months	6
(3) Space storage (includes (a) and (b)), years	3
(4) Ground storage, years	5

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

3.1.2.4.1 Pump Discharge Line (PDL) Dynamic Output.- The SSCL shall be capable of accepting the PDL dynamic output.

3.1.2.4.2 Pressure Vessel (PV) Dynamic Output.- The SSCL shall be capable of accepting the PV dynamic output.

3.1.2.4.3 Imposed Movements. - The SSCL shall be capable of accepting all relative movements of the PDL and PV without creating harmful loadings on the interfacing components or harmful stresses within the line. All relative movements shall include all tolerances due to fabrication and assembly and all motion due to applied loads and thermal changes.

3.1.2.4.4 Nuclear. - The SSCL shall be capable of functioning within the nuclear environments of Table IV.

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

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

3.1.2.7 Safety. - The SSCL shall be capable of complying with all the safety requirements specified in EC-90218.

3.2 CEI Definition. - Not applicable.

3.3 Design and Construction. - Except as otherwise specified herein, design and construction of the SSCL shall be in accordance with EC-90218, of which this line is a part.

3.3.1 General Design Features. -

3.3.1.1 Joints. -

3.3.1.1.1 Remote Joints. - Remote joints shall be capable of assembly and disassembly by means of either a manipulator or a remote power or signal source in order to permit the human operator to be protected from the NERVA radiation environment. All remote joints shall be also capable of assembly and disassembly by manual means by unprotected personnel.

3.3.1.1.2 Permanent Joints.- Permanent joints shall not contain a static seal to prevent leakage at the interface but shall be permanently bonded as by welding, brazing, or soldering.

3.3.1.2 Envelope.- The total envelope occupied by the line shall be as shown on Figure 1 and drawing 1136390.

3.3.1.3 Weight.- The line total weight, not including the remote joint capability shall be as shown on Figure 1.

3.3.1.4 Loads.- Thermal loads created by the line at its inlet shall be as specified in Table V.

3.3.1.5 Stiffness.- The allowable stiffness of the SSCL at its inlet from the PDL, shall be as specified in Table VI.

3.3.1.6 Leakage.- The allowable leakage of static seal flange joints for the flight engine shall be 1×10^{-1} scc/sec/in. diameter nominal at a test pressure of 50 psi with helium. Leakage shall be disposed of in such a manner that it will not cause a safety hazard.

3.3.1.7 Contamination.- The allowable contamination shall be as specified in CP-90290. Design of all lines, bellows, and subcomponents shall be such as to minimize the existence of entrapped areas which cannot be visually inspected for contaminants.

3.3.1.8 Nuclear Shielding.- Secondary nuclear shielding shall be provided as part of the SSCL in the segment routed around the disk shield. The secondary shield shall consist of material having a thickness of 0.24 inches with a density of 0.3 lb/cu in., shaped to the contour of the SSCL.

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.- Not applicable.
- 3.3.10 Identification and Marking.- As specified in CP-90290.
- 3.3.11 Storage.- The SSCL 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
PROPELLANT FLOW CHARACTERISTICS

<u>Inlet Conditions (from PDL)</u>	<u>Normal Operating Mode (Two Pumps)</u>	<u>Malfunction Operating Mode (One Pump)</u>	<u>Specification Maximum</u>
Pressure (psia)	1426	1721	2193
Temperature (°R)	61	7.3	67.5
Flow Rate (lb/sec)	20.6	20.0	21

<u>Inlet Conditions (from CSL)</u>	<u>Normal Operating Mode (Two Pumps)</u>	<u>Malfunction Operating Mode (One Pump)</u>	<u>Specification Maximum</u>
Pressure (psia)	1324	1629	2115
Temperature (°R)	61.1	67.3	67.5
Flow Rate (lb/sec)	5.3	5.3	5.3

TABLE II

PRESSURE DROP (psid)

	<u>Normal Operating Mode (Two Pumps)</u>	<u>Malfunction Operating Mode (One Pump)</u>
Inlet to SSC	16.3 + .5	16.3 + .5
SSCV to Outlet (Coolant)	0.2 + .01	0.2 + .01
SSCV to Outlet (Bypass)	5.4 + .2	5.4 + .2

TABLE III

RELIABILITY APPORTIONMENT

<u>Segment</u>	<u>Reliability</u>
Remote Joints (each)	0.999997
Remote Joints (6 total)	0.999996
Bellows (each)	0.999994
Bellows (9 total)	0.999994
Line Segments (total)	<u>0.999999</u>
TOTAL	0.999989

TABLE IV
STRUCTURAL SUPPORT COOLANT LINE NUCLEAR ENVIRONMENT
FLIGHT ENGINE - NO SHIELD - UNPERTURBED

Description	Location Station	(in.) R	γ	γ	In Al γ	Thermal Neutron		Fast Neutron		Epy Thermal	
			Kerma Rate Rads/Hr	Kerma Rate Rads (10 Hr Exp)		Flux n/cm ² -sec	Fluence n/cm ²	Flux n/cm ² -sec	Fluence n/cm ²	Flux n/cm ² -sec	Fluence n/cm ²
SSCV	70.7	18.5	2.6+6	2.6+7	3.3-4	1.2+9	4.3+13	2.4+11	8.6+15	2.4+11	8.6+15
SSCL Bellow No. 1	78.6	24.0	2.8+6	2.8+7	3.4-4	1.4+9	5.0+13	2.6+11	9.4+15	2.2+11	7.9+15
SSCL Bellow No. 2	78.6	45.4	8.4+6	8.4+7	1.0-3	6.3+10	2.3+15	1.1+12	4.0+16	2.7+12	9.7+16
SSCV Act No. 1	64.0	25.6	2.1+6	2.1+7	2.6-4	9.0+8	3.2+13	1.6+11	5.8+15	1.6+11	5.8+15
SCBL Bellow No. 1	60.0	20.5	2.1+6	2.1+7	2.6-4	8.4+8	3.0+13	1.6+11	5.8+15	2.4+11	8.6+15
SCBL Bellow No. 2	66.0	31.0	2.1+6	2.1+7	2.5-4	4.5+9	1.6+14	2.4+11	8.6+15	3.5+11	1.3+16
SCIL Bellow	73.1	54.0	1.2+7	1.2+8	1.4-3	8.4+10	3.0+15	1.5+12	5.4+16	4.2+12	1.5+17

GROUND ENGINE

SSCV	4.0+6	5.0-4	2.8+11
SSCL Bell #1	4.2+6	5.1-4	3.0+11
Bell #2	9.8+6	1.2-3	1.1+12
SSCV Act. #1	3.5+6	4.3-4	2.0+11
SCBL Bell #1	3.5+6	4.3-4	2.0+11
Bell #2	3.5+6	4.2-4	2.0+11
SCIL Bell	2.6+6	1.6-3	1.5+12

TABLE V

THERMAL LOADS

	<u>Axial Load</u> <u>(lb)</u>	<u>Shear Load</u> <u>(lb)</u>	<u>Bending Moment</u> <u>(lb-in.)</u>	<u>Torsion</u> <u>(lb-in.)</u>
(a) Nominal	500	500	500	500
(b) Maximum	1000	1000	1000	1000

TABLE VI

ALLOWABLE STIFFNESS

	<u>K_{Axial}</u> <u>(lb/in.)</u>	<u>K_{Shear}</u> <u>(lb/in.)</u>	<u>$\frac{M}{\theta}$ Bending</u> <u>(lb-in./deg)</u>	<u>$\frac{M}{\theta}$ Torsion</u> <u>(lb-in./deg)</u>
(a) Nominal	1000	1000	3000	1000
(b) Maximum	2000	2000	6000	2000