NUCLEAR DIVISION

C002-DS090124-F1
ENGINEERING DESIGN SHEET SPECIFICATION

PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS

FOR
TURBINE INLET LINE

FORMING A PART OF
CEI NUMBER 090290A

PRELIMINARY PROPOSAL ISSUE

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SACRAMENTO, CALIFORNIA

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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS
for

TURBINE INLET LINE

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1. SCOPE

1.1 Scope.- This specification establishes the performance, design, test and qualification requirements for equipment identification as turbine inlet qualification for line (TIL). The TIL transports propellant from the pressure vessel discharge to the turbine inlet and to the inlet of the turbine bypass line.

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

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

3.1.1 Functional Characteristics. - The TIL shall transport propellant from the pressure vessel (PV) discharge to the turbine inlet and to the inlet of the turbine bypass line (TBL).

3.1.1.1 Propellant Flow. - The propellant characteristics of the TIL 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 TIL 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 turbine inlet shall not be greater than 20% between that line interfacing with TPA #1 and that line interfacing with TPA #2.

3.1.2 Operability. -

3.1.2.1 Reliability. - The reliability of the TIL, including joints, shall be a minimum of 0.999977, apportioned into subcategories as shown in Table III.

3.1.2.2 Maintainability. - The time required for manual removal of the TIL upper segment or the TIL lower segment shall not exceed one hour. The time required to manually install the upper or lower segments 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 TIL.

3.1.2.2.2 Service and Access.-

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

3.1.2.2.2.2 Removal.- The TIL shall be both manually and remotely removable from the engine assembly in three segments as follows: (a) Two segments each consisting of that length from the TBL inlets to the turbine-bypass valve (TBL) inlet and (b) Lower segment consisting of that length from the PV to the TBV inlet. The three segments shall be as shown in Figure 1.

3.1.2.3 Useful Life.- The TIL 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 TIL shall be as specified in EC-90218 in addition to the following:

3.1.2.4.1 Turbopump Dynamic Output.- The TIL shall be capable of accepting the turbopump dynamic output.

3.1.2.4.2 Nozzle Dynamic Output.- The TIL shall be capable of accepting the nozzle dynamic output.

3.1.2.4.3 Imposed Movements.- The TIL shall be capable of accepting all relative movements of the turbopump and the 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 TIL shall be capable of functioning within the nuclear environments of Table IV.

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

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

3.1.2.7 Safety.- The TIL 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 TIL 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 be a maximum of 175 pounds.

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.-

3.3.1.5.1 Allowable.- The allowable stiffness of the TIL at its outlet (to TPA) shall be as specified in Table VI.

3.3.1.5.2 Symmetry.- The allowable variation in the stiffness specified above between the #1 TPA flange and the #2 TPA flange shall not be greater than 20%.

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 TIL in the segment routed around the disk shield. The secondary shield shall consist of material having a thickness of 0.25 inches with a density of 0.3 lbs/cu.in., shaped to the contour of the PDL.

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 TIL 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</u>	<u>Normal Operating Mode (Two Pumps)</u>	<u>Malfunction Operating Mode (One Pump)</u>	<u>Spec. Maximum</u>
Pressure (psia)	1253	1561	2033
Temperature (°R)	262	269	320
Flow Rate (lb/sec)	89.2	89.2	93
<u>Outlet Conditions (to TBL)</u>	<u>Normal Operating Mode (Two Pumps)</u>	<u>Malfunction Operating Mode (One Pump)</u>	<u>Spec. Maximum</u>
Pressure (psia)	1245	1555	2030
Temperature (°R)	260	269	320
Flow Rate (lb/sec)	13.5	13	20

TABLE II

PRESSURE DROP (psid)

	<u>Normal Operating Mode (Two Pumps)</u>	<u>Malfunction Operating Mode (One Pump)</u>
TIL Inlet to TBV Inlet	$8 \pm .2$	8 ± 0.2
TBV Outlet to TIL Outlet	$2 \pm .1$	1 ± 0.1

TABLE III

RELIABILITY APPORTIONMENT

<u>Segment</u>	<u>Reliability</u>
Remote Joints (each)	.999998
Remote Joints (6 total)	.999991
Bellows (each)	.999997
Bellows (4 total)	.999988
Line Segments (Total)	<u>.999998</u>
TOTAL	.999977

TABLE IV
TURBINE INLET LINE NUCLEAR ENVIRONMENT
FLIGHT ENGINE - NO SHIELD - UNPERTURBED

Description	Location (in)		γ	γ	In Al γ	Thermal Neutron		Fast Neutron		Epy Thermal	
	Station	R	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
TIL	74.1	61.5	1.8 + 7	1.8 + 8	-2.2 - 3	1.1 + 11	4.0 + 15	1.6 + 12	5.8 + 16	4.8 + 12	1.7 + 17
Flange	56.5	21.5	2.0 + 6	2.0 + 7	2.4 - 4	7.7 + 8	2.8 + 13	1.5 + 11	5.4 + 15	1.5 + 11	5.4 + 15
Bellows #1	56.5	26.5	1.8 + 6	1.8 + 7	2.3 - 4	9.0 + 8	3.2 + 13	1.5 + 11	5.4 + 15	1.5 + 11	5.4 + 15
Elbow	56.5	56.5	7.3 + 6	7.3 + 7	8.9 - 4	5.4 + 10	1.9 + 15	9.1 + 11	3.2 + 16	2.4 + 12	8.6 + 16

GROUND ENGINE

TIL	1.9 + 7	2.4 - 3	1.6 + 12
Flanges	3.4 + 6	4.1 - 4	1.9 + 11
Bellows 1	3.2 + 6	4.0 - 4	1.9 + 11
Elbow	8.7 + 6	1.0 - 3	9.5 + 11

TABLE V

THERMAL LOADS

<u>TIL Inlet</u>	<u>Axial Load (lb)</u>	<u>Shear Load (lb)</u>	<u>Bending Moment (lb-in.)</u>	<u>Torsion (lb-in.)</u>
(a) Nominal	70	60	700	0
(b) Maximum	140	120	1400	0
<u>TIL Outlet (to TBV)</u>				
(a) Nominal	40	30	1200	1300
(b) Maximum	80	60	2400	2600
<u>TIL Outlet (to TPA)</u>				
(a) Nominal	30	130	3700	800
(b) Maximum	60	260	7400	1600

TABLE VI

ALLOWABLE STIFFNESS

	<u>K_{Axial} (lb/in)</u>	<u>K_{Shear} (lb/in)</u>	<u>$\frac{M}{\theta}$ Bending (lb-in/deg)</u>	<u>$\frac{M}{\theta}$ Torsion (lb-in/deg)</u>
(a) Nominal	2400	1700	37,000	13,000
(b) Maximum	4800	3400	74,000	26,000