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ENGINEERING CRITICAL COMPONENT SPECIFICATION

PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS

FOR
THRUST STRUCTURE SUBSYSTEM

FORMING A PART OF
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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS

for

THRUST STRUCTURE SUBSYSTEM

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Specification EC-90152

1. SCOPE

1.1 Scope.- This specification establishes the performance, design, test, and qualification requirements for equipment identified as the Thrust Structure Subsystem.

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	19 Dec 1968	NERVA Program Structural Design Requirements
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(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	NERVA Nuclear Rocket Engine
EC-90214	Instrumentation and Control Subsystem
EC-90218	Propellant Feed Subsystem
EC-90243	External Shield Subsystem
EC-90244	Gimbal Assembly Subsystem
DS-90267	Upper Thrust Structure
DS-90268	Middle Thrust Structure
DS-90269	Lower Thrust Structure
DS-90270	Shield Spacer
EC-90271	Structural Support Coolant Assembly

DRAWINGS

1136390	75K NERVA Flight Engine Full Flow Concept
1136403	75K NERVA Flight Engine 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.- The Thrust Structure Subsystem shall meet the functional characteristics specified herein, within the environmental conditions specified in 3.1.2.4.

3.1.1 Functional Characteristics.-

3.1.1.1 Transmit Engine Loads.- The Thrust Structure Subsystem shall be capable of transmitting the engine thrust and/or inertia loads from the interface with the pressure vessel to the interface with the propellant tank or ground test engine adapter.

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3.1.1.2 Transmit TVS loads.- The Thrust Structure Subsystem shall be capable of transmitting loads produced through operation of the thrust vector system.

3.1.1.3 Structural Support.- The Thrust Structure Subsystem shall provide structural support for and transmit inertia load from the following engine subsystems:

- (a) Instrumentation and Control Subsystem - EC-90214
- (b) Propellant Feed Subsystem - EC-90218
- (c) External Shield Subsystem - EC-90243
- (d) Gimbal Assembly Subsystem - EC-90244
- (e) Structural Support Coolant Assembly - EC-90271

3.1.2 Operability.-

3.1.2.1 Reliability.- The probability that this subsystem shall successfully fulfill its operating requirements shall be a minimum of 0.999990.

3.1.2.2 Maintainability.-

3.1.2.2.1 Maintenance and repair cycles.- The structure shall not require periodic maintenance during storage or operational use.

3.1.2.2.2 Service and access.- Service and access requirements shall be as follows:

- (a) Access shall be provided to allow remote and manual repair and replacement of all valves, control drum actuators, turbopumps, and gimbal actuators as specified for the modular concept and manual replacement of valve actuators.

(b) Provisions shall be made for orientation and guiding of the interface during remote installation and removal of the engine from the test stand and for remote attachment to the test stand.

3.1.2.3 Useful Life.- As specified in CP-90290.

3.1.2.4 Environmental.- The Thrust Structure Subsystem shall be subjected to the natural environments specified in CP-90290 in addition to the following induced environments:

(a) Nuclear Radiation: Fast neutron flux and gamma kerma rate data as specified in CP-90290.

(b) Acceleration, Vibration, and Shock: At the Thrust Structure Subsystem/Stage interface as specified in CP-90290.

(c) Acoustics: Sound levels as specified in CP-90290.

3.1.2.5 Transportability.-

3.1.2.5.1 Shipping.- The Thrust Structure Subsystem shall be transportable as part of the thrust structure module and as part of the engine assembly for the modes of transportation and attitude of assembly as specified in CP-90290.

3.1.2.5.2 Handling.- Attachment supports shall be provided to lift the thrust structure module and the engine assembly during preassembly and assembly of the engine.

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3.1.2.6 Human performance.- Not applicable.

3.1.2.7 Safety.-

3.1.2.7.1 Flight Safety.- Flight safety requirements shall be as follows:

(a) The Thrust Structure Subsystem shall be capable of operating in flight without single failure or credible combinations of errors and/or failures which endanger the safety of space personnel.

(b) Under degraded conditions the Thrust Structure Subsystem shall be capable of functioning at an operating environment associated with 40 percent engine thrust and for a minimum of one hour at any time during the engine operating life.

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/Ordnance Safety.- Not applicable

3.2 CEI Definition.- The Thrust Structure Subsystem described in this specification shall be physically, mechanically, and functionally suitable for operation with the Pressure Vessel and Closure Subsystem, External Shield Subsystem, Gimbal Assembly Subassembly, Propellant Feed Subsystem, and Propellant Tank Thrust Cone.

3.2.1 Interface Requirements.-

3.2.1.1 Schematic Arrangement.- The physical interface relationships of the Thrust Structure Subsystem shall be in accordance with Drawings 1136403 and 1136408.

3.2.1.2 Detailed Interface Definition.- The mechanical and functional interface relationships of the Thrust Structure Subsystem shall be in accordance with the following.

3.2.1.2.1 Mechanical Interfaces.- The dimensional interface relationship of the thrust structure subsystem with other engine equipment shall be in accordance with the following data and subparagraphs.

<u>Interface No.</u>	<u>AGC Drawing</u>
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1	1136403 75K NERVA Flight Engine ICD
2 through 15	1136408 75K NERVA Full Flow Engine Component ICD

3.2.1.2.1.1 Interface No. 1 - Upper Thrust Structure/Stage Interface Structure (ETS-1).- This interface involves structural connections to support engine assembly at the stage interface structure. The structural connectors shall be manually installed fasteners for interfacing with the stage and remotely operated capability for interfacing with the ETS-1 test stand adapter. Orientation and guidance capability shall be provided to accomplish the engine installation requirements with the test stand adapter as specified in 3.1.2.2.2(b).

3.2.1.2.1.2 Interface No. 2 - Upper Thrust Structure/Gimbal Pivot.- This interface involves the structural connection between the Upper Thrust Structure and the gimbal. Mechanical fastening shall be provided.

3.2.1.2.1.3 Interface No. 3 - Upper Thrust Structure/Gimbal Actuator

This interface involves the structural connection between the Upper Thrust Structure and the forward end of the Gimbal Actuator of the Gimbal Assembly Subsystem oriented on the engine pitch and yaw axes. Mechanical fastening shall be provided.

3.2.1.2.1.4 Interface No. 4 - Middle Thrust Structure/Gimbal Pivot.-

This interface involves the structural connection between the Middle Thrust Structure and the gimbal. Mechanical fastening shall be provided.

3.2.1.2.1.5 Interface No. 5 - Middle Thrust Structure/Gimbal Actuator

This interface involves the structural connection between the Middle Thrust Structure and the aft end of the Gimbal Actuator of the Gimbal Assembly Subsystem oriented on the engine pitch and yaw axes. Mechanical fastening shall be provided.

3.2.1.2.1.6 Interface No. 6 - Middle Thrust Structure/External Shield.-

Subsystem.- This interface involves the structural connection between the Middle Thrust Structure and the External Shield Subsystem. The mechanical fasteners shall be used at the interface.

3.2.1.2.1.7 Interface No. 7 - Lower Thrust Structure/External Shield.-

This interface involves the structural connection between the Middle Thrust Structure and the External Shield Subsystem. The mechanical fasteners shall be used at the interface.

3.2.1.2.1.8 Interface No. 8 - Lower Thrust Structure/Pressure Vessel

Closure.- This interface involves the structural connections between the Lower Thrust Structure and the pressure vessel closure. The mechanical fasteners shall be capable of removal by ground remote handling methods.

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3.2.1.2.1.9 Interface No. 9 - Middle Thrust Structure/Turbopump.- This interface involves the structural connections between the Middle Thrust Structure and the two turbopumps to provide support for the propellant feed subsystem. Mechanical fastening shall be provided.

3.2.1.2.1.10 Interface No. 10 - Upper Thrust Structure/Cooldown Line.- This interface involves the structural connection between the Upper Thrust Structure and the cooldown line to support the line during engine gimbaling and to provide position orientation for engine installation to the stage (ETS-1) interface. Mechanical fasteners shall be provided.

3.2.1.2.1.11 Interface No. 11 - Middle Thrust Structure/Cooldown Line.- This interface involves the structural connection between the Middle Thrust Structure and the cooldown line to support the line during engine gimbaling. Mechanical fastening shall be provided.

3.2.1.2.1.12 Interface No. 12 - Middle Thrust Structure/Structural Support Coolant Line.- This interface involves the structural connection between the Middle Thrust Structure and the structural support coolant line to support the two structural support coolant control valves and four structural support coolant block valves. Mechanical fastening with capability for remote handling removal and replacement shall be provided.

3.2.1.2.1.13 Interface No. 13 - Middle Thrust Structure/Turbine Bypass Line.- This interface involves the structural connection between the Middle Thrust Structure and the turbine bypass line to support the two bypass control valves and the two bypass block valves.

3.2.1.2.1.14 Interface No. 14 - Thrust Structure Subsystem/Stage Tank Pressurization Supply Line.- This interface involves the structural connections for support of the stage tank pressurization supply line within the Thrust Structure Subsystem. Mechanical fastening shall be provided. Position orientation shall be provided at the engine interface with the stage pressurization supply line.

3.2.1.2.1.15 Interface No. 15 - Thrust Structure Subsystem/Wiring Harness.- This interface involves the support of the Wiring Harness within the Thrust Structure Subsystem.

3.2.1.2.2 Functional interfaces.- Interface loads consisting of axial and shear loads and bending and torsional moments for critical loading modes shall be as specified in Table I for each of the mechanical interfaces specified in 3.2.1.2.1 as having a structural connection function.

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 Thrust Structure Subsystem which are classified as Engineering Critical Components.

3.2.2.3 Logistics Critical Components.- There are no components of the Pressure Vessel and Closure Subsystem which are classified as Logistics Critical Components.

3.2.2.4 Design Critical Components List.- Design of the Thrust Structure Subsystem shall include the following design critical components:

<u>Specification No.</u>	<u>Nomenclature</u>	<u>Part No.</u>
DS-90267	Upper Thrust Structure	
DS-90268	Middle Thrust Structure	
DS-90269	Lower Thrust Structure	
DS-90270	Shield Spacer	

3.3 Design and Construction.-

3.3.1 General Design Features.- The Thrust Structure Subsystem configuration shall conform to the envelope requirements of Drawing 1136390.

3.3.1.1 Structural Criteria.- The Thrust Structure Subsystem design shall comply with the structural criteria specified in SNPU-C-1.

3.3.1.2 Physical properties.- The maximum weight of the thrust Structure Subsystem for the specified configuration shall not exceed 1800 pounds.

3.3.1.3 Structural Stiffness.- The Thrust Structure Subsystem, consisting of an upper, Middle and lower thrust structure, when combined with the External Subsystem Shield and Gimbal Assembly Subsystem to form the Thrust Structure Assembly shall meet the stiffness requirements specified in Table II.

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.

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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 Thrust Structure Subassembly 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

INTERFACE LOADS

TSSS Interface	Description	Mode*	Loads, kips		Moment, kip-in	
			Axial**	Shear	Bending	Torsion
1	UTS/Stage Interface Structure	L	145	+28	+3,673	—
2	UTS/Gimbal Pivot	L	216 60	+26.5	0***	0
3	UTS/Gimbal Actuator Drive Mechanism	L	+ 78	0	0***	0
4	MTS/Gimbal Pivot	L	216 60	+ 26.5	0***	0
5	MTS/Gimbal Actuator Drive Mechanism	L	+78	0	0***	0
6	MTS/External Shield	L	109	+ 21	+ 1,633	-
7	LTS/External Shield	L	96.5	+ 18.5	+ 1,435	-
8	LTS/Pressure Vessel Closure	L	90	+ 17.2	+ 989	-
9	MTS/Turbopump					
10	UTS/CDL					
11	MTS/CDL					
12	MTS/SSCL					
13	MTS/TBL					
14	TSSS/Stage Tank Pressurization Supply Line					

* L = launch, F = flight operations

** Positive loading indicates tension

*** Moment at gimbal plane is transmitted as a couple

TABLE II

THRUST STRUCTURE ASSEMBLY STIFFNESS

<u>Coefficient</u>	<u>Minimum</u>
Axial/deflection, lb/in.	
Shear/deflection, lb/in.	
Shear/rotation, lb/rad	
Moment/rotation, lb-in./radian	
Torque/rotation, lb-in./radian	