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ENGINEERING CRITICAL COMPONENT SPECIFICATION

PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS

FOR

GIMBAL ASSEMBLY SUBSYSTEM

FORMING A PART OF
CEI NUMBER 090290A

PRELIMINARY PROPOSAL ISSUE

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MASTER **AEROJET-GENERAL CORPORATION**

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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS

for

GIMBAL ASSEMBLY SUBSYSTEM

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1. SCOPE

1.1 Scope.- This specification establishes the performance, design, test, and qualification requirements for equipment identified as the Gimbal Assembly Subsystem. This subsystem consists of a gimbal pivot and a gimbal actuator.

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 December 1968 Structural Design Requirements.

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
EC-90152	Thrust Structure Subsystem
DS 90251	Gimbal Actuator Assembly

DRAWINGS

1136390 75K NERVA flight engine full flow concept

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 gimbal assembly subsystem shall meet the functional characteristics specified herein, within the environmental conditions specified in 3.1.2.4.

3.1.1.1 Transmit Engine Loads.- The gimbal assembly subsystem shall be capable of transmitting engine thrust and/or inertia loads specified in Table IV from the middle thrust structure interfaces to the upper structure interfaces.

3.1.1.2 Position Engine Thrust Vector.- In response to a command signal the gimbal assembly subsystem shall be capable of changing and/or maintaining the vector position of the engine thrust within the requirements specified in Table I, Table V, and the following subparagraphs:

3.1.1.2.1 Design Rated Amplitude (DRA).- In response to a command signal, the gimbal assembly subsystem shall be capable of gimbaling the engine from the null position about any axis (a circular pattern) through the minimum DRA as specified in Table I.

3.1.1.2.2 Maximum Amplitude.- The gimbal assembly subsystem shall have mechanical stops limiting the gimbal amplitude (a square pattern) to that specified in Table I.

3.1.1.2.3 Design Rate.- In response to a ramp and error command signal the gimbal assembly subsystem shall be capable of gimbaling the engine at a rate within the limits as specified in Table I.

3.1.1.2.4 Design Acceleration.- In response to a command signal, the Gimbal Assembly Subsystem shall be capable of gimbaling the engine at an acceleration rate within the limits as specified in Table I.

3.1.1.2.5 Response to a Step Input.- The Gimbal Assembly Subsystem shall be capable of responding to a step input corresponding to the DRA. Additional step response characteristics are specified in the following subparagraphs correspond to a step input equivalent to 50 percent of the DRA. Characteristic definitions shall be as specified in Figure 1.

3.1.1.2.5.1 Delay Time (T_D).- The time elapsed, after application of the step input, until the average output reaches 50 percent of its final value shall be as specified in Table I.

3.1.1.2.5.2 Rise Time (T_R).- The projection on the time axis, of that part of the tangent to the average response curve at $t = T_D$, that lies between zero and the final value shall be as specified in Table I.

3.1.1.2.5.3 Percent Overshoot (PO).- The percent overshoot shown as

$$PO = \frac{\text{Maximum Value of Response} - \text{Final Value}}{\text{Final Value}}$$

shall be as specified in Table I.

3.1.1.2.5.4 Settling Time (T_S).- The time elapsed after application of a step input until the response of the system falls to, and remains within, $\pm X\%$ of its final value error shall be as specified in Table I.

3.1.1.2.5.5 Final Value Error (FVE).- The steady state position error shall be as specified in Table I.

3.1.1.2.6 Threshold.- The gimbal assembly subsystem shall achieve a measurable response from a low frequency sinusoidal command signal having a gimbal amplitude corresponding to the amplitude as specified in Table I.

3.1.1.2.7 Snubbing.- The gimbal assembly subsystem shall provide a snubbing capability which initiates a resistance loading within the gimbal angle limits specified in Table I.

3.1.1.2.8 Loss of Power Characteristics.- The gimbal assembly subsystem shall be capable of maintaining the last commanded position in the event of a power loss or when power is not applied during launch and space operation conditions.

3.1.1.2.9 Prelaunch Checkout.- The gimbal assembly subsystem shall be capable of positioning the engine and responding to position change commands during prelaunch operations.

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 0.999984.

3.1.2.2 Maintainability.- The requirements of CP 90290 shall apply in addition to the following:

(a) The time required for repair shall not exceed 2.0 hours.

(b) The maximum time required for preventive and corrective maintenance shall not exceed 0.1 man hours per hour during engine assembly, checkout, and prelaunch operations.

3.1.2.2.1 Maintenance and Repair Cycles.- Maintenance and repair cycles shall be as follows:

(a) Periodic maintenance shall not be required during storage.

(b) Periodic maintenance or repair shall not be used to attain the reliability specified in 3.1.2.1 or the operating life specified in 3.1.2.3.

3.1.2.2.2 Service and Access. - The gimbal assembly subsystem shall be designed so manual maintenance and repair, including parts replacement, can be accomplished with standard hand tools and without adjustment or modification of any mating engine components.

(b) The gimbal assembly subsystem shall have a capability for remote malfunction detection and fault isolation.

(c) The gimbal actuator assembly shall be capable of modular removal and replacement by both ground and space remote handling methods.

3.1.2.3 Useful Life. - As specified in CP-90290 and Table II.

3.1.2.4 Environmental. - The gimbal assembly shall be capable of meeting the natural environmental requirements of CP-90290 and the following induced environments:

(a) Nuclear radiation - See Table III

(b) Acceleration, vibration and shock - See Table IV

(c) Acoustic - See Table IV

3.1.2.5 Transportability. - Transportability requirements shall be as follows:

(a) The Gimbal Assembly Subsystem shall be transportable as individual components, as part of the thrust structure module, and as part of the engine assembly for the modes of transportation and attitude of assembly specified in CP-90290.

(b) A lockout capability shall be provided to maintain position during all phases of shipping, handling, and storage.

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) Maximum effort shall be placed on a design which eliminates single failure or credible combinations of errors and/or failures which endanger the safety of space and/or ground personnel and/or equipment.

(b) Under degraded conditions subsystem design shall provide for continuous engine operation at approximately 40 percent thrust 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 and/or Ordnance Safety.- Not applicable

3.2 CEI Definition.- The Gimbal Assembly Subsystem described in this specification shall be physically, mechanically, and functionally suitable for operation with the thrust structure subsystem, the engine power supply and the nuclear vehicle command/control system.

3.2.1 Interface Requirements.-

3.2.1.1 Schematic Arrangement.- The physical interface relationships of the gimbal assembly subsystem shall be in accordance with Drawings 1136403, 1136408 and the following:

3.2.1.1.1 Interface No. 1 - Gimbal Pivot/Upper Thrust Structure.- This interface involves structural connection between the gimbal pivot and the upper thrust structure. Mechanical fastening shall be provided.

3.2.1.1.2 Interface No. 2 - Gimbal Actuator/Upper Thrust Structure.- This interface involves the structural connection between the two gimbal actuator linear drive mechanisms and the upper thrust structure oriented on the engine pitch and yaw axes. Mechanical fastening capable of complying with the service requirements of 3.1.2.2.2 shall be provided.

3.2.1.1.3 Interface No. 3 - Gimbal Pivot/Middle Thrust Structure.- This interface involves the structural connection between the gimbal pivot and the middle thrust structure. Mechanical fastening shall be provided.

3.2.1.1.4 Interface No. 4 - Gimbal Actuator/Middle Thrust Structure.- This interface involves the structural connection between the two gimbal actuators and the middle thrust structure oriented on the engine pitch and yaw axes. Mechanical fastening capable of complying with the service requirements of 3.1.2.2.2 shall be provided.

3.2.1.2.3.1 Interface Loads.- Axial and shear loads and bending and torsion moments for critical loading modes shall be as specified in Table V for each of the mechanical interfaces specified in 3.2.1.2.1 as having a structural connection function.

3.2.1.2.3.2 Interface Electrical Characteristics.- Voltage and current requirements shall be as specified in Table VI for each of the electrical interfaces specified in 3.2.1.2.2.

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 Gimbal Assembly Subsystem which are classified as Engineering Critical Components.

3.2.2.3 Logistics Critical Components.- There are no components of the Gimbal Assembly Subsystem which are classified as Logistics Critical Components.

3.2.2.4 Design Critical Components List.- Design of the gimbal assembly subsystem shall include the following design critical component.

<u>Specification No.</u>	<u>Nomenclature</u>	<u>Part No.</u>
DS-90251	Gimbal Actuator	

3.3 Design and Construction.- Except as otherwise specified herein, design and construction of this equipment shall be in accordance with CP 92090 of which this equipment is a part.

3.3.1 General Design Features.-

3.2.1.1.5 Interface No. 5 - Gimbal Actuator/Instrumentation and Control Subsystem.- This interface involves the command signal provided by the I&C subsystem to the actuator amplifier which controls the required amplitude and rate of change of thrust vector position.

3.2.1.1.6 Interface No. 6 - Gimbal Actuator/Engine Power Supply.- This interface involves the source of power from the engine power supply to operate the actuator motor in accordance with commanded signals.

3.2.1.2 Detailed Interface Definition

3.2.1.2.1 Mechanical Interfaces.- The dimensional interface relationship of the Gimbal Assembly Subsystem with other engine equipment (interfaces 1 through 4) shall be in accordance with Drawing 1136408.

3.2.1.2.2 Electrical interfaces.- The dimensional interface relationship of electrical interfaces which the gimbal assembly subsystem has with other engine equipment, shall be in accordance with Drawing 1136408.

3.2.1.2.3 Functional Interface.-

3.3.1.1 Configuration.- The gimbal assembly subsystem configuration envelope and gimbal center location shall be governed by the requirements of AGC Drawing 1136390.

3.3.1.2 Structural Criteria.- The Gimbal Assembly Subsystem design shall comply with structural criteria specified in SNPO-C-1.

3.3.1.3 Physical Properties.- The maximum weight of the Gimbal Assembly Subsystem shall not exceed 600 pounds.

3.3.1.4 Structural Stiffness.- The Gimbal Assembly Subsystem when combined by the thrust structure subsystem and the external shield (spacer) shall meet the stiffness specified in EC-90152.

3.3.1.5.1 Position Control.- The Gimbal Assembly Subsystem shall have a closed loop position indication for comparison with the command signal.

3.3.1.5.2 Rate Control.- The gimbal assembly subsystem shall have a closed loop rate indication to maintain the gimbaling rate within the maximum limit specified in Table I.

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 and 3.1.2.2.2.

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 Gimbal Assembly Subsystem 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. Functional Requirements

<u>Characteristic</u>	<u>Requirement</u>
Design Rated Amplitude, Any Axis, deg, min.	± 3.00
Maximum Amplitude, Pitch and Yaw Axes, deg (Mechanical Locking)	± 4.00
Design Rate, deg/sec, min	0.75
max	1.00
Design Acceleration, deg/sec ² , min	0.50
max	0.75
Delay Time, sec, min	1.0
max	1.3
Rise Time, sec, min	1.5
max	2.0
Percent Overshoot	25.00
Settling Time, sec, max	6.0
Xs Factor	5.0
Final Value Error, deg	± 0.10
Threshold, deg	± 0.05
Snubbing, deg, min	± 3.75

TABLE II. Cycle and Energized Life

<u>Condition</u>	<u>Total Cycles</u>	<u>Total Energized Time, Hours</u>
Prelaunch	100	5
In-Flight Checkout	100	5
In-Flight Operating	300	10

NOTES: 1) Cycles are accrued during energized time.

2) In-Flight checkout includes both during and between missions.

TABLE III. Induced Nuclear Radiation

Description	Location		Flight*		Ground Engine*	
	Sta	R	Gamma Kerma Rate Rads/Hr.	Fast Neutron Flux n/cm ² -sec	Gamma Kerma Rate Rads/Hr.	Fast Neutron Flux n/cm ² -sec
Gimbal Actuator Assembly (Midpoint)	22.5	41.0	2.0×10^6	9.9×10^{10}	3.4×10^6	1.4×10^{11}
Gimbal Center Location	23.0	0	2.0×10^6	1.4×10^{11}	3.4×10^6	1.9×10^{11}

* No external Shield, unperturbed

TABLE IV. Induced Dynamics Environment

Mode	<u>Acceleration, g's</u>		<u>Vibration, g's</u>		Shock	Acoustic
	<u>Axial</u>	<u>Lateral</u>	<u>Axial 3-35 Hz</u>	<u>Lateral .1-15 Hz</u>		
(a) Launch	5.2	± 1.0	± 2.25	± 1.5		As specified in CP-90290
(b) Operation						

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TABLE V. Interface Loads

<u>Description</u>	<u>Mode</u>	<u>Load, kips</u>		<u>Moment, in.-kips</u>	
		<u>Axial**</u>	<u>Shear</u>	<u>Bending</u>	<u>Torsion</u>
Gimbal Pivot Interfaces	L	256	<u>±</u> 36	204	-
Gimbal Actuator Assembly Interfaces	L	69	0	0	0

* L = Launch, F = Flight operations
 ** Positive loading indicates tension

TABLE VI. Interface Electrical Characteristics

<u>Description</u>	<u>Voltage, volts d.c.</u>	<u>Current, amps</u>
Gimbal Actuator Assembly/Engine Power Supply	28 $\pm$ 4	50 A
Gimbal Actuator Assembly/I&C Subsystem	0 - 10	0 - 200 MA

NOTE: Maximum power consumption - 2000 watts under any condition.

Figure 1
Time-Domain Performance