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C002-EC090218-F1

ENGINEERING CRITICAL COMPONENT SPECIFICATION

PERFORMANCE/DESIGN AND
PRODUCT CONFIRMATION REQUIREMENTS

FOR
PROPELLANT FEED SUBSYSTEM

FORMING A PART OF
CEI NUMBER 090290A

MASTER

PRELIMINARY PROPOSAL ISSUE

DATED 12-15-69

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SACRAMENTO, CALIFORNIA

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Part I of Two Parts
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PERFORMANCE/DESIGN AND QUALIFICATION REQUIREMENTS

for

PROPELLANT FEED SUBSYSTEM

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 the Propellant Feed Subsystem (PFS). The PFS, upon command, provides flow paths for the propellant to various subsystems of the engine.

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 and detail requirements of Sections 3, 4, 5, and 10 shall be considered a superseding requirement.

SPECIFICATIONS

National Aeronautics and Space Administration

SNPO-C-1

Oct. 1967

Structural Design Specification

(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

EC-90117	Propellant Shutoff Valve and Actuator
EC-90121	Turbine Block Valve and Actuator
EC-90149	Turbopump Assembly
EC-90246	Pump Discharge Check Valve and Actuator
EC-90257	Bypass Block Valve and Actuator
EC-90258	Coolant Supply Control Valve and Actuator
EC-90259	Coolant Supply Check Valve
EC-90260	Turbine Discharge Check Valve
EC-90261	Structural Support Block Valve and Actuator
DS-90124	Turbine Inlet Line
DS-90125	Turbine Discharge Line
DS-90135	Pump Discharge Line
DS-90253	Propellant Inlet Line
DS-90262	Cooldown Lines
DS-90263	Storage Tank Pressurization Line and Check Valve
DS-90264	Engine Purge Unit
DS-90265	Structural Support Coolant Line
DS-90266	Turbine Bypass Line
CP-90290	Engine, NERVA, 75K, Full Flow

DRAWINGS

1136408	NERVA Engine Components
1136391	NERVA Flight Engine Flow Diagram

(Copies of the above documents required by suppliers in connection with specific procurement functions should be obtained from the procuring activity.)

3. REQUIREMENTS

3.1 Performance.- The propellant feed subsystem, upon receipt of a command signal, supplies propellant at flow rates and pressures necessary for sustained engine operation. The PFS provides a path for propellant to flow from the propellant tank to the engine pressure vessel and to the structural coolant circuit. The PFS shall also provide a flow path for propellant tank pressurization during steady state and portions of engine start and shutdown operations. The PFS shall be capable of meeting the performance requirements specified herein within the environmental conditions specified in 3.1.2.4 using the propellant and fluids as specified in CP-90290.

3.1.1 Functional characteristics.- The propellant feed subsystem at steady state operation shall be capable of sustaining normal engine operation with two turbopumps operating in parallel or under malfunction conditions, of only one turbopump operating. The requirements for the functional performance of the PFS shall be as shown in Table I and Table II.

3.1.1.1 Transient Conditions.- The startup and shutdown nominal transient conditions (for Mission A - 1st Burn) are shown in Figures 1 through 12 as follows:

Specification No. EC-90218

- (a) PFS to Tank - Figure 1
- (b) PFS to Nozzle - Figure 2
- (c) PFS to Pressure Vessel (in) - Figure 3
- (d) PFS to Pressure Vessel (cut) - Figure 4
- (e) PFS to SSCV (out) - Figure 5
- (f) PFS to Tank (Cooldown) - Figure 6
- (g) PFS to Pressure Vessel (Stem Cool) - Figure 7
- (h) PFS to Pressure Vessel (Cool Bypass) - Figure 8
- (i) PFS to SSCV (in Stem) - Figure 9
- (j) PFS to SSCV (in Bypass) - Figure 10
- (k) PFS to Pressure Vessel (Tank Pressure in) - Figure 11
- (l) PFS to Tank (Tank Pressure out) - Figure 12

3.1.1.2 Flexibility.- The propellant feed subsystem shall be capable of accepting an engine gimbaling displacement of at least 3.0 degrees in any direction at a maximum rate of 0.75 degree per second with a maximum acceleration of 0.5 degree per second squared.

3.1.2 Operability.-

3.1.2.1 Reliability.- The probability of operational success of the PFS as it effects mission success shall be 0.999766 or greater.

3.1.2.2 Maintainability.- The propellant feed subsystem shall be designed with provisions to allow a detection of malfunctions. Where redundant components exist, provisions shall be included for isolating the malfunctioned component and utilization of the redundant system/component. Equipment shall be designed to meet the maintainability requirements specified in CP-90290.

3.1.2.2.1 Maintenance and Repair Cycle.- The propellant feed subsystem shall not require scheduled maintenance except for purging.

3.1.2.2.2 Service and Access.- Capability shall be provided for the electrical checkout of all instrumentation, controls and electrical wiring.

3.1.2.3 Useful Life.- Same as CP-90290.

3.1.2.4 Environment.-

3.1.2.4.1 Natural.- The natural environmental requirements for the propellant feed subsystem shall be as specified in CP-90290.

3.1.2.4.2 Induced.-

3.1.2.4.2.1 Dynamic loads.- The propellant feed subsystem shall be capable of a maximum longitudinal acceleration of ± 6.75 g between the frequency range of 3 to 35 Hz and lateral acceleration of ± 4.5 g between the frequency range of 1 to 15 Hz.

3.1.2.4.2.2 Static loads.- The propellant feed subsystem shall be capable of maximum longitudinal acceleration of +5.2 g and -1.0 g and maximum lateral acceleration of ± 1.0 g.

3.1.2.4.3 Other.- The propellant feed subsystem shall be capable of withstanding the engine induced environment as specified in the individual component specifications and CP-90290.

3.1.2.5 Transportability.- The propellant feed subsystem components shall be transportable in any attitude by land, sea, or air without degradation of capability to meet specified operational requirements and shall meet the transportability requirements of CP-90290.

3.1.2.7 Safety.-

3.1.2.7.1 Flight safety.- Maximum effort shall be placed on a design which eliminates single failures or credible combinations of errors, malfunctions, or accidents which as an end result could endanger the safety of the space or ground personnel. In case of a propellant feed subsystem component malfunction, the propellant feed subsystem shall be capable of maintaining engine thrust at 40 percent and an Isp of not less than 500 seconds for a minimum of one hour at any time during the engines operating life.

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

3.1.2.7.3 Nuclear safety.- As specified in CP-90290.

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

3.1.2.7.5 Explosive/ordnance safety.- As specified in CP-90290.

3.2 Contract End Item Definition.-

3.2.1 Interface Requirements.- The Propellant Feed Subsystem shall be functionally, mechanically, and electrically compatible with the other NERVA Engine subsystems.

3.2.1.1 Schematic Arrangement.- The following interfaces, identified on drawing 1136391, exist between the PFS and other applicable subsystems.

3.2.1.1.1 PFS/Nozzle Assembly Subsystem.- Provide propellant flow for nozzle cooling.

3.2.1.1.2 PFS/Pressure Vessel and Closure Subsystem

- (a) Provide heated propellant for driving TPA.
- (b) Provide pressurized propellant to Nuclear Subsystem.
- (c) Provide propellant flow path for Structural support cooling.
- (d) Provide flow path for excess propellant diverted for Structural Support cooling.
- (e) Provide flow path for propellant tank pressurization.

3.2.1.1.3 PFS/Nuclear Subsystem, Structural Support Coolant Valve (SSCV).- Provide propellant for Structural Support cooling.

3.2.1.2 Detailed Interface Definition.-

3.2.1.2.1 Mechanical Interface.- Mechanical interfaces shall be as shown in Drawing 1136408.

3.2.1.2.2 Electrical Interface.- Electrical interfaces shall be as shown in Drawing 1136408.

3.2.1.2.3 Fluid Interface.- Fluid interfaces shall be as shown in Tables I and II.

3.2.2 Component Identification.-

3.2.2.1 Government-Furnished Property List.- The PFS incorporates no government-furnished equipment or materials.

3.2.2.2 PFS Component List.- The components of the propellant feed subsystem are shown as follows:

(a)	EC-90117	Propellant Shutoff Valve and Actuator
(b)	EC-90149	Turbopump Assembly
(c)	EC-90246	Pump Discharge Check Valve and Actuator
(d)	EC-90122	Bypass Control Valve and Actuator
(e)	EC-90257	Bypass Block Valve and Actuator
(f)	EC-90121	Turbine Block Valve and Actuator
(g)	EC-90258	Coolant Supply Control Valve and Actuator
(h)	EC-90259	Coolant Supply Check Valve
(i)	EC-90260	Turbine Discharge Check Valve
(j)	EC-90261	Structural Support Block Valve and Actuator
(k)	DS-90124	Turbine Inlet Line
(l)	DS-90135	Pump Discharge Line
(m)	DS-90125	Turbine Discharge Line
(n)	DS-90253	Propellant Inlet Line
(o)	DS-90262	Cooldown Lines
(p)	DS-90263	Stage Tank Pressurization Line and Check Valve
(q)	DS-90264	Engine Purge Unit
(r)	DS-90265	Structural Support Coolant Lines
(s)	DS-90266	Turbine Bypass Line

3.3 Design and construction.-

3.3.1 General design features.- The external configuration of the propellant feed subsystem shall be within the following envelope:

Length	275 inches
Width	100 inches
Height	60 inches

3.3.1.1 Structural criteria.- The propellant feed subsystem structural criteria design shall be in accordance with SNPO-C-1.

3.3.1.2 Leakage.- The propellant feed subsystem shall be designed to minimize fluid joints where leakage could occur. The maximum leakage shall be less than 400 standard cubic inches of hydrogen per minute during engine operating and non-operating conditions.

3.3.1.3 Weight.- The weight of the propellant feed subsystem shall not exceed 4035 pounds.

3.3.1.4 Cleanliness.- The propellant feed subsystem shall satisfy the cleanliness requirements of CP 90290 and shall be designed to handle any unlimited flow rate of 600 microns or less particles throughout its operating life. The estimated weight to be handled is 220 grams of materials with the density of aluminum.

3.3.1.5 Monitoring.- The propellant feed subsystem shall have adequate instrumentation to detect the approach of a failure and to detect deteriorating performances.

Specification No. EC-90218

3.3.1.6 Electrical power.- All electrical components within the propellant feed subsystem shall operate at 28 ± 2 volts direct current.

3.3.1.7 Purging.- The propellant feed subsystem shall have provisions for purging.

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.- As specified in CP-90290.

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

3.3.11 Storage.- The PFS 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 CP-90290.

TABLE I

PROPELLANT CHARACTERISTICS
Rated, Steady-State

<u>Item</u>	<u>Pressure (psia)</u>		<u>Temperature (°R)</u>		<u>Flow (lb/sec)</u>	
	<u>Normal Mode</u>	<u>Malfunction Mode</u>	<u>Normal Mode</u>	<u>Malfunction Mode</u>	<u>Normal Mode</u>	<u>Malfunction Mode</u>
(a) PFS to Tank	30	30	40	40	89.6	89.8
(b) PFS to Nozzle	1423	1718	61.1	67.3	68.5	69.3
(c) PFS to Pressure Vessel (in)	1253	1561	262	269	89.2	89.2
(d) PFS to Pressure Vessel (out)	660	660	236	235	89.2	89.3
(e) PFS to SSCV (out)	1410	1706	61.1	67.3	20.6	20.0
(f) PFS to Tank (Cooldown)	30	30	40	40	0.0	0.0
(g) PFS to Pressure Vessel (Stem Cool)	1324	1682	61.1	67.3	5.3	5.3
(h) PFS to Pressure Vessel (Cool Bypass)	1312	1619	61.1	66.4	15.3	14.7
(i) PFS to SSCV (in Stem)	1326	1630.7	61.1	67.3	5.3	5.3
(j) PFS to SSCV (in Bypass)	1325	1631.7	61.1	67.3	15.3	14.7
(k) PFS to Pressure Vessel (Tank Pressure in)	1253	1561	262	269	0.5	0.5
(l) PFS to Tank (Tank Pressure out)	1252	1252	261	261	0.5	0.5

TABLE II

PROPELLANT CHARACTERISTICS
Throttled and Maximum

Item	Pressure (psia)		Temperature (°R)		Flow (lb/sec)	
	Throttled Mode*	Maximum	Throttled Mode*	Maximum	Throttled Mode*	Maximum
(a) PFS to Tank	30	25	40	42	53.8	93
(b) PFS to Nozzle	729.6	2190	51.7	67.5	36.9	71
(c) PFS to Pressure Vessel (in)	628.7	2033	277.2	320	53.5	93
(d) PFS to Pressure Vessel (out)	407.3	670	261.1	315	53.5	80
(e) PFS to SSCV (out)	721	2192	51.7	67.5	14.8	21
(f) PFS to Tank (Cooldown)	30	30	40	40	0	0
(g) PFS to Pressure Vessel (Stem Cool)	674	2114	51.7	67.5	5.3	5.3
(h) PFS to Pressure (Cool Bypass)	671.2	671.2	51.7	51.7	9.5	9.5
(i) PFS to SSCV (in	681	2116	51.7	67.5	5.3	5.3
(j) PFS to SSCV (in (Bypass)	679	2105	51.7	67.5	9.5	15.7
(k) PFS to Pressure Vessel (Tank Pressure in)	628.7	2033	277.2	320	0.2	0.55
(l) PFS to Tank (Tank Pressure Out)	627.7	628.7	276.2	277.2	0.2	0.2

*Maximum duration: 30 seconds

PSOV to TANK

STATE POINT No 2

15K NERVA FULL FLOW ENGINE NO 1136390

MISSION A-L-M, 1ST BURN 1457 SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME
SPEC TREE NO
PLOTTED BY: CHECKED BY:

23 27 52 1500 1513 1543 1554
BOOST FLAP
PRESTATE DAMP TO FULL POWER THROTTLING PUMP TAIL OFF

LEGEND
1 FLOW RATE
2 PRESSURE
3 TEMPERATURE
4 TPA SPEED
5 PUMP EFFICIENCY
6 TURBINE EFFICIENCY
7 VALVE POSITION
8 THRUST
9 I_{sp}

Figure 1a
14

PUMP DISCH. LINE to Nozzle

STATE POINT No 18

151Z NERVA FULL FLOW ENGINE NO 1136390

MISSION A-L-M, 1ST BURN 1451 SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME
SPEC TREE NO
PLOTTER BY: CHECKED BY:

27 27 52 1503 1513 1543 1554
PRESTART DUMP TO FULL POWER THROTTLING PUMP TAIL OFF

- LEGEND
- 1 FLOW RATE
 - 2 PRESSURE
 - 3 TEMPERATURE
 - 4 TPA SPEED
 - 5 PUMP EFFICIENCY
 - 6 TURBINE EFFICIENCY
 - 7 VALVE POSITION
 - 8 THRUST
 - 9 I_{sp}

Figure 2a
15

P.V. CLOSURE to TURB. INLET LINE

STATE POINT NO 26

1517 NERVA FULL FLOW ENGINE NO 1136390

MISSION A-L-M, 1ST BURN 1451 SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME	
SPEC TREE NO	
PLOTTED BY	CHECKED BY

LEGEND

1 FLOW RATE	
2 PRESSURE	
3 TEMPERATURE	
4 RPM SPEED	
5 PUMP EFFICIENCY	
6 TURBINE EFFICIENCY	
7 VALVE POSITION	
8 THRUST	
9 Isp

Figure 3a

TURBINE DISCH. LINE to P.V. Closure / N.S.S..

STATE POINT No 40

Figure 4a

STRUCTURAL SUPPORT COOLANT LINE / STRUCTURAL SUPPORT COOLANT VALVE

STATE POINT NO. 9

1512 NERVA FULL FLOW ENGINE NO 1136390

MISSION A-L-M, 1ST BURN 1451 SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME
SPEC TREE NO 1137101E
PLOTTED BY: CHECKED BY:

Figure 5a

TANK to COOLDOWN SUPPLY LINE

STATE POINT NO 57

NERVA FULL FLOW ENGINE NO 1136390

MISSION A-L-M, 1ST BURN 1457 SEC ISS. STUP=52, SHDN=45 SEC, CST=71.6 HR

Figure 6a

STRUCT. SUPPORT COOL. LINE to P.V. CLOSURE

STATE POINT NO 13

151Z NERVA FULL FLOW ENGINE NO 1136390

MISSION A-L-M, 1ST BURN 1457 SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME
SPEC TREE NO
PLOTTED BY
CHECKED BY

27 27 52 1500 1513 1543 1554
BOOTSTRAP
PRE-START RAMP TO FULL POWER THROTTLING PUMP TAIL OFF

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TRA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 I_{sp}

STRUCTURAL SUPPORT Bypass Line to R.V. Closure

STATE POINT No 59

Figure 8a

STEM SUPPORT OUTLET to SSBV₁(2)

STATE POINT NO. 11

15K NERVA FULL FLOW ENGINE NO. 1136390

MISSION A-L-M, 1ST BURN 1457 SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME SSBV STEM

SPEC TREE NO.

PLOTTED BY: CHECKED BY:

27 27 52 1509 1513 1543 1554
 BOOTSTRAP PRESTART RAMP TO FULL POWER THROTTLING PUMP TAIL OFF

LEGEND
 1 FLOW RATE
 2 PRESSURE
 3 TEMPERATURE
 4 PPA SPEED
 5 PUMP EFFICIENCY
 6 TURBINE EFFICIENCY
 7 VALVE POSITION
 8 THRUST
 9 I_{sp}

Bypass Port Outlet to SSBV₃₋₄

STATE POINT No 16

1512 NERVA FULL FLOW ENGINE NO 1136390

MISSION A-E-M, 1ST BURN 145T SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME
SPEC TREE NO
PLOTTED BY
CHECKED BY

27 27 52 1500 1513 1543 1554
BOOST/STAMP PRESTART RAMP TO FULL POWER THROTTLING PUMP TAIL OFF

LEGEND
1 FLOW RATE
2 PRESSURE
3 TEMPERATURE
4 TPA SPEED
5 PUMP EFFICIENCY
6 TURBINE EFFICIENCY
7 VALVE POSITION
8 THRUST
9 I_{sp}

Figure 10a

P.V. CLOSURE to STAGE PRESSURIZATION Supply Line

STATE POINT No 49

TANK PRESS. SUPPLY LINE to TANK

STATE POINT NO 58

151K NEDVA FULL FLOW ENGINE NO 136390

MISSION A-L-M, 1ST BURN 1451 SEC SS. STUP=52, SHDN=45 SEC, CST=71.6 HR

PART NAME	
SPEC TREE NO	
PLOTTED BY	CHECKED BY

Figure 12a

STATE POINT No 2

75 K NERVA FULL FLOW ENGINE No 1136390

MISSION A-L-M, ST-BURN 1457 SEC SS, STUP=52, SHDN=45 SEC, CST=71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TPA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 ISP

PART NAME _____
 SPEC TREE NO _____
 PLOTTED BY _____ CHECKED BY _____

END OF PUMP
TAILOFF

1734.6

COOL DOWN

END OF COOLDOWN

PULSE FLOW -1 -2 -3 -4 -5 -6 -7 -8 -9 -10

TRICKLE FLOW

1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 19570.1

TIME - SECONDS

12-5-62

Figure 1b

STATE POINT No 18

TS-2 NERVA FULL FLOW ENGINE No 1136390

MISSION A-LFM, 1ST BURN 1451 SEC SS, STOP-52, SHDN=45 SEC, CST=71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TPA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 ISP

PART NAME	
SPEC TREE NO	
PLOTTED BY	CHECKED BY

Figure 2b

STATE POINT No 26

75 K NERVA FULL FLOW ENGINE No 1136390

MISSION A-L-M, 1ST BURN 1457 SEC SS, STOP 52, SHDN 45 SEC, CST = 71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TPA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 Isp

PART NAME

SPEC TREE NR

PLOTTED BY

CHECKED BY

END OF PUMP
TAILOFF

1734.6

COOL DOWN

END OF COOLDOWN

PULSE FLOW -1
TRICKLE FLOW -2

Figure 3b

STATE POINT No. 9

15 K NERVA FULL FLOW ENGINE No. 1136390

MISSION: A-L-M, 1ST BURN 1457 SEC SS, STUP=52, SHDN=45 SEC, CST=71.6 HR.

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TDA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 TSP

PART NAME	
SPEC TREE NR	
PLOTTED BY	CHECKED BY

END OF PUMP
TAILOFF

1734.6

COOL DOWN

END OF COOLDOWN

Figure 5d

STATE POINT No 57

75K NERVA FULL FLOW ENGINE No 1136390

MISSION A-L-M, 1ST BURN 1457 SEC SS, STOP=52, SHDN=45 SEC, CST=71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TPA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 Isp

PART NAME

SPEC TREE NO

PLOTTED BY

CHECKED BY

END OF PUMP
TAILOFF

1734.6

COOL DOWN

END OF COOLDOWN

PULSE FLOW -1
TRICKLE FLOW -2

-3 -4 -5 -6 -7 -8 -9 -10

FLOW RATE-LB/SEC

PRESSURE-PSIA

TEMPERATURE-°F

4
3
2
1
0

40
30
20
10
0

50
40
30
20
10
0

1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 19570.1

TIME-SECONDS

12-5-65

Figure 6b

STATE POINT NO 13

75 K NERVA FULL FLOW ENGINE NO 1136390

MISSION A-L-M, 1ST BURN 145T SEC SS, STOP=52, SHDN=45 SEC, CST=71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TDA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 Isp

PART NAME	
SPEC TREE NO	
PLOTTED BY	CHECKED BY

END OF PUMP
TAILOFF

1734.6

COOL DOWN

END OF COOLDOWN

PULSE FLOW -1
TRICKLE FLOW -2

-2

-3

-4

-5

-6

-7

-8

-9

-10

2

2

2

3

3

3

5
4
3
2
1
0

40
30
20
10
0

1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 20570.1

TIME-SECONDS

12-E-63

STATE POINT No 59

75K NERVA FULL FLOW ENGINE No 1136390

MISSION A-L-M, 1ST BURN 145T SEC SS, STUP-52, SHDN=45 SEC, CST-71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TPA SPEED
- 5 PUMP EFFICIENCY
- 6 ENGINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 Isp

PART NAME	
SPEC TREE NO	
PLOTTED BY	CHECKED BY

END OF PUMP
TAILOFF

1734.6

C O O L D O W N

PULSE FLOW -1
TRICKLE FLOW -2

-3 -4 -5 -6 -7 -8 -9 -10

1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 19570.1

TIME-SECONDS

12-5-69

Figure 8b

STATE POINT No 11

75 K NERVA FULL FLOW ENGINE No T136390

MISSION: A-G-M, 1ST BURN 1457 SEC SS, STUP=52, SHDN=45 SEC, CST=71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TDA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 ISp

PART NAME	
SPEC TREE NO	
PLOTTED BY	CHECKED BY

END OF PUMP
TAILOFF

1734.6

COOL DOWN

END OF COOLDOWN

PULSE FLOW -1
TRICKLE FLOW -2

-3 -4 -5 -6 -7 -8 -9 -10

6 60 60
5 50 50
4 40 40
3 30 30
2 20 20
1 10 10
0 0 0

1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 19570.1
TIME-SECONDS

12-5-62

Figure 9b
34

STATE POINT No 16

75 K NERVA FULL FLOW ENGINE No 1136390

MISSION A-L-M, 1ST BURN 1457 SEC SS, STOP=52, SHDN=45 SEC, CST=71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TDA SPEED
- 5 PUMP EFFICIENCY
- 6 TURBINE EFFICIENCY
- 7 VALVE POSITION
- 8 OTH CLUST
- 9 IS

PART NAME
SPEC TREE NO
PLOTTER BY: CHECKED BY:

END OF PUMP
TAILOFF

END OF COOLDOWN

COOL DOWN

PULSE FLOW -1 -2 -3 -4 -5 -6 -7 -8 -9 -10

TRICKLE FLOW

1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 20570.1

TIME SECONDS

12-8-69

035/31-11-12-1969
Figure 10b

Specification No. EC-90218

STATE POINT No 49

75 K NERVA FULL FLOW ENGINE No 1136390

MISSION A-L-M, 1ST BURN 1457 SEC SS, STUP-52, SHDN-45 SEC, CST = 71.6 HR

LEGEND

- 1 FLOW RATE
- 2 PRESSURE
- 3 TEMPERATURE
- 4 TPA SPEED
- 5 PUMP EFFICIENCY
- 6 ENGINE EFFICIENCY
- 7 VALVE POSITION
- 8 THRUST
- 9 Isp

PART NAME	
SPEC TREE NO	
PLOTTED BY	CHECKED BY

Figure 11b

STATE POINT No 58

Specification No. EC-90218

Figure 12b