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RN-DR-0177

PROPELLANT-FEED SUBSYSTEM

BOOK 2:

VALVES

NERVA Program

Contract SNP-1

December 1969

MASTER

NUCLEAR ROCKET OPERATIONS

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RN-DR-0177

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December 1969

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CLASSIFICATION CATEGORY

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W.E. Stephens

CLASSIFYING OFFICER

12/15/69

DATE

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I. PURPOSE

This document is one of a series of Departmental Reports which will document NERVA design and performance requirements at engine, subsystem, and component levels. These reports are intended to provide a single source for maintenance and documentation of design criteria and functional performance requirements, and may be used to display a continual assessment of overall design maturity. They also provide the basic data for component specification preparation, and will be used to document traceability of all design and performance criteria.

These reports will be revised and updated periodically to incorporate significant new design and/or performance requirements.

II. DESIGN REQUIREMENTS SHEETS

The Design Requirements Sheets in this document cover the

PROPELLANT FEED SYSTEM (VALVES)

as described in the NERVA Engine Specification Tree, AGC Drawing 1137101, "E" Change. The sheets are organized into two principle categories: Section 1.0 provides design requirements criteria generated externally (e.g., environments) to the component; Sections 2.0 through 6.0 provide component functional performance requirements for steady state, startup, throttling, shutdown, and cooldown operations. Requirements are provided for both nominal and malfunction performance conditions.

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

PROPELLANT SHUTOFF VALVE AND ACTUATOR (PSOV)

EC-90117

The following data are included in this issue:

	<u>Sheet</u>	<u>Revision</u>
1.0 Design Criteria		
1.1 Reliability Allocation	1	0
1.2 Maintainability	2	0
1.3 Useful Life	3	0
1.4 Nuclear Environment	4	0
1.5 Thermal Environment	5	0
1.6 Natural Environment	6	0
1.7 Dimensional Interfaces	7	0
1.8 Mechanical Interfaces	8	0
1.9 Electrical Interfaces	9	0
1.10 Functional Interfaces	10	0
1.11 Handling & Shipping	11	0
1.12 Test & Checkout	12	0
1.13 Static Loads	13	0
1.14 Dynamic Loads	14	0
1.15 Envelop Dimensions	15	0
1.16 Weight Allocation	16	0
1.17 Safety	17	0
2.0 Steady State Functional Performance	18	0
3.0 Startup Transient Functional Performance	19	0
4.0 Throttling Transient Functional Performance	20	0
5.0 Shutdown Transient Functional Performance	21	0
6.0 Cooldown Functional Performance	22	0

Date: 12-3-69

Rev: 0

Sheet: 1

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: Memorandum 7850:MO346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999710

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve, EC-90117

DATA SOURCE: NPRD-1 and Engineering Evaluation by Klacking/Shoemaker

- 1.2 Maintainability: The propellant shutoff valve shall be designed to incorporate the maintainability requirements of the engine .
(See Sheet 2 of RN-DR-0187). The following time limitations shall be met: (a) repair time - the time required to repair shall not exceed (4.0) hours. (b) active maintenance time - the maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operations.
- 1.2.1 Maintenance and repair cycles
- 1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.
- 1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.
- 1.2.2 Service and access
- 1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.
- 1.2.2.2 Capability for remote and manual replacement of valve/ actuator assembly shall be provided for both ground test engines and space operations.
- 1.2.2.3 The PSV shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.
- 1.2.2.4 Provision shall be made for purging the PSV with inert gas through the engine purge system.
- 1.2.2.5 PSV's shall be physically interchangeable without adjustment or modification of mating engine components.

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life Propellant Shutoff Valve and Actuator

The Propellant Shutoff Valve and Actuator shall be capable of satisfying the minimum useful life of the NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes (maximum of 60 cycles)
1.3.2	Non-Rated Operating Life (Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad (Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years (Including Operational Life)
1.3.4	Storage Life (Ground)	5 years

DATE: 12-3-69
 REV: 0
 SHEET: 4

DESIGN REQUIREMENT SHEET

Component: PSOV

Data Source: Engineering Judgement based on analyses of an idealized configuration, Section 7830, Warman

1.4 Nuclear Environment Flight Engine - No Shield - Unperturbed

Description	Location(In) Station R		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
						Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
PSOV	-23.0	0.0	7.2 + 5	7.2 + 6	9.0 - 5	9.8 + 8	3.5+13	5.5+10	2.0+15	8.7+10	3.1+15
PSOV			2.1 + 6		ETS-1 2.6 - 4			9.5+10			

Date: 12-3-69
REV: 0
SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: NEERVA Engine Natural Environment Report Data Item
S023-CP09019⁴-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6-1
NATURAL ENVIRONMENTS SUMMARY

Pump Discharge Check Valve and Actuator, EC-90246

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.09 \text{ lb/in}^2$ in 1 hr
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min: 488 Max: 559 (ETR Values)
Atmospheric Density - lb/ft^3	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	Min: 7.12×10^{-2} Max: 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch: 11.8 gr $\text{H}_2\text{O/Pt}^3$	Extreme: 100% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs, 15 day cycle
Solar radiation - $\text{Btu/ft}^2/\text{hr}$	442.4	N.A.	TBD
Rain	N.A.	N.A.	See Table 8
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

Phase			Vehicle Assembly and Checkout Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

Date: 12-3-69
Rev: 0
Sheet: 7

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve

DATA SOURCE: Drawing 1136390, Section 7840, Klacking/Krivanic

1.7 Dimensional Interfaces

1 - 24.0" O.D. Bolted Flange, inlet

1 - 14.8" O.D. Coupling, Outlet
I.D. - 9.00 outlet

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shut-off Valve

DATA SOURCE: Engineering Evaluation by Section 7840, Klacking/Krivanic

1.8 Mechanical Interfaces

1 - Bolted Flange - Manual

1 - Coupling - Manual

Replaceable as single unit

Date: 12-3-69
Rev: 0
Sheet: 9

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanic

1.9 Electrical Interfaces

Data no available for this issue

Date: 12-3-69
Rev: 0
Sheet: 10

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanic

1.10 Functional Interfaces

Refer to Section 2.0, Sheet 18

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: Packaging Plan, Section 7810, McClurkin

1.11 Handling & Shipping

1. Capability of being handled and shipped in any attitude.
2. Shipment by land, sea, or air.
3. Methods for preservation, packaging, and packing for the component will be developed to provide adequate protection against corrosion, contamination, and physical damage from shock and vibration. Packaging will be designed to facilitate handling, inspection, and warehousing. Special packing requirements should be defined by the designer if the shock and vibration loads presented in Data Item S-038 "Environment Vibration and Acoustics Report" are considered excessive.

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to R. W. Froelich,
dated 11-21-69

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve and Actuator, EC-90117

DATA SOURCE: XE Experience, Section 7810, McClurkin/Bailey

1.12 Checkout

Checks to be performed:

- A. Leak Test
- B. Insulation dielectric measurements
- C. Electrical circuit measurements
- D. Functional/Operating tests

Checkout Details:

A. Leak test

1. Apply closures and attach the leak pressurization unit to the upstream side of the PSOV (Valve is initially open)
2. Pressurize the PSOV with GEe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer check all flanges, seals and joints for leakage.
5. Verify that the leak rate is less than 1.0 CC per hour.
6. Close valve.
7. Release pressure on the downstream side of valve.
8. Repeat Steps 3 and 4 and verify the PSOV valve leak rate is less than 1.0 CC per hour.
9. Vent test gas to atmosphere.

B. Insulation Dielectric Measurements

1. Connections to the Electrical Test Set.
2. Measure each actuator wire, instrumentation wire, and shield to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: Test current shall not exceed 10 ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Measurements

1. Connect all electrical connectors to the electrical test.
2. Measure the circuit impedance to verify that the components or their circuits, are within a prescribed tolerance, with respect to resistance, impedance, and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically designated to be so, between any wires, shields and ground.
4. Verify position potentiometers and limit switch settings with respect to valve position.
5. Disconnect test set and replace protective covers.

D. Functional/Operating tests

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 28 VDC (current limited) to the limit switches.
4. Supply valve open command monitoring - The following parameters through the entire opening cycle:
 - a. Valve current vs. position
 - b. Voltage across the valve actuator
 - c. Limit switch operation vs. time
 - d. Comparison of all position monitoring sensors
 - e. Valve position vs. time
 - f. Break-away torque
 - g. Valve bounce at end of travel
5. Supply valve close command and monitor items a through g, Paragraph 4 above. In addition, verify that the opening and closing hysteresis characteristics are within prescribed band width tolerance.
6. Perform the test indicated in Paragraphs 4 and 5 at the high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.
7. Disconnect the test set and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the P30V and its subassemblies. Data log sheets, print-outs, X-Y Plotter, and strip chart recordings shall support the test records, as applicable.

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: Data Item S038, Section 7730

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. Longitudinal Static Acceleration: + 5.2g's -1.0g.
2. Max. Lateral static acceleration: $\pm 1.0g$

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: Data Item S038, Section 7730

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural Considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Conditions: Launch Vehicle Operations

1. Max longitudinal dynamic acceleration (3.35 HZ Freq range)* $\pm 6.75g's$
2. Max lateral dynamic acceleration (.1-15HZ freq range) = $\pm 4.5g's$

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels:

<u>20 to 200 cps</u>	<u>200 to 800 cps</u>	<u>800 to 2000 cps</u>
Linear Increase	at $1.5 g^2/Hz$	Linear Decrease
From 0.03 to		From 1.5 to
$1.5 g^2/Hz$		$0.06 g^2/Hz$
(3db/Octave)		(3db/Octave)

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve

DATA SOURCE: Drawing 1136390

1.15 Envelope Dimensions

Length - 28.0 in.

Diameter - 25.0 in.

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve and Actuator

DATA SOURCE: Data Item S047, Section 7730

1.16 Weight Allocation - 150 pounds

NOTE: This figure is an allocation only, not an estimate
based on any design

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: PSOV

DATA SOURCE: NPRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I_{sp} of not less than 500 seconds for a minimum of 1 hour at any time during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Propellant Shutoff Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

DESIGN REQUIREMENT SHEET

Table 2.0

<u>Component</u>		<u>PSOV</u>			
1.0	<u>Fluid</u>	LH ₂ (GH ₂)			
2.0	<u>Steady State Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1	Inlet Pressure, psia	30.0	30.0	25.0	30.0
2.2	Outlet Pressure, psia	29.9	29.7	24.8	29.9
2.3	Inlet Temperature, °R	40.0	40.0	42.0	40.0
2.4	Outlet Temperature, °R	40.0	40.0	42.0	40.0
2.5	Inlet Flowrate, lb/sec	44.8	89.8	93.0	26.9
2.6	Outlet Flowrate, lb/sec	44.8	89.8	93.0	26.9
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	no limit			
3.2	Valve Opening Time, sec, max	3-30 sec			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	no limit			
4.2	Valve Closing Time, sec, max	3-30 sec			
5.0	<u>Cooldown</u>				
5.1	Flow Rate MN, lb/sec	4.0 lb/sec			
5.2	Valve Response time, sec, max	3 sec opening & closing			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	8/80			
6.2	Cooldown Pulses, per trip/total	N/A			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	C			
8.0	Line size, in, O.D.	9.68			

Estimates as of 4 December 1969
Data Source: RN-PD-T-1601C

9.0	<u>Leakage</u>	
9.1	Internal, scc per sec. GH ₂	10
9.2	External	
9.2.1	Static Seal, SCC per sec per inch joint diam	0.01
9.2.2	Dynamic Seal, SCC per sec per inch joint diam	1.0
10.0	Pressure Drop (ΔP at Design Point) psi	0.1 + 0.05
11.0	Actuator Power	
11.1	Hold Position, watts	300 max
11.2	Change Position, watts	
11.2.1	Open	3000 max
11.2.1	Close	300 max
12.0	Opening and Closing Characteristics	
12.1	Cracking Pressure, psi	N/A
12.2	Closing Pressure, psi	N/A
13.0	Controlled Flow Rate	N/A

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

PSOV_{IN} to TANK

STATE POINT No. 2

FIGURE 2.0-1

PSOV_{in}

STATE POINT No 2

FIGURE 2.0-2

PSOVOUT

STATE POINT No 3

151Z NERVA FULL FLOW ENGINE NO 1736300

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

PART NAME
SPEC TREE NO
PLOTTER BY: CHECKED BY:

27:27 52 1500 1513 1543 1554
BOOTSTRAP PRESTART DUMP TO FULL POWER THROTTLING PUMP TAIL OFF

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

FIGURE 2.0-3

PSOVOUT

STATE POINT NO 3

FIGURE 2.0-4

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

PUMP DISCHARGE CHECK VALVE AND ACTUATOR (PDKV)

EC-90246

The following data are included in this issue:

		<u>Sheet</u>	<u>Revision</u>
1.0	Design Criteria		
1.1	Reliability Allocation	1	0
1.2	Maintainability	2	0
1.3	Useful Life	3	0
1.4	Nuclear Environment	4	0
1.5	Thermal Environment	5	0
1.6	Natural Environment	6	0
1.7	Dimensional Interfaces	7	0
1.8	Mechanical Interfaces	8	0
1.9	Electrical Interfaces	9	0
1.10	Functional Interfaces	10	0
1.11	Handling & Shipping	11	0
1.12	Test & Checkout	12	0
1.13	Static Loads	13	0
1.14	Dynamic Loads	14	0
1.15	Envelop Dimensions	15	0
1.16	Weight Allocation	16	0
1.17	Safety	17	0
2.0	Steady State Functional Performance	18	0
3.0	Startup Transient Functional Performance	19	0
4.0	Throttling Transient Functional Performance	20	0
5.0	Shutdown Transient Functional Performance	21	0
6.0	Cooldown Functional Performance	22	0

DATE: 12-3-69
REV: 0
SHEET: 1

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: Memorandum 7850:MO346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999980 or greater.

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve (EC 90246)

DATA SOURCE: NPRD-1 and Evaluation by Klacking/Shoemaker

1.2 Maintainability - The Pump Discharge Check Valve shall be designed to incorporate the maintainability requirements of the Engine. (See Sheet 2 of RN-DR-0187). The following time limitations shall be met: (a) Repair Time - The time required to repair shall not exceed (2.0) hours, (b) Active Maintenance Time - The maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operation.

1.2.1 Maintenance and Repair Cycles

1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.

1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.

1.2.2 Service and Access

1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.

1.2.2.2 Capability for remote and manual replacement of valve/actuator assembly shall be provided for both ground test engines and space operations. Replacement will be accomplished by replacing both PDKV's and their interconnecting lines.

1.2.2.3 Capability for manual replacement of the actuator shall be provided for both ground test engines and space operations.

1.2.2.4 The Pump Discharge Check Valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.

1.2.2.5 Provision shall be made for purging the Pump Discharge Check Valve with inert gas through the engine purge system.

1.2.2.6 Pump Discharge Check Valve shall be physically interchangeable without adjustment or modification of mating engine components.

Date: 12-3-69
Rev: 0
Sheet: 3

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life

The
shall be capable of satisfying the minimum useful life of the
NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes
(maximum of 60 cycles)
1.3.2	Non-Rated Operating Life
(Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad
(Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years
(Including Operational
Life)
1.3.4	Storage Life (Ground)	5 years

DATE: 12-3-69

REV: 0

SHEET: 4

DESIGN REQUIREMENT SHEET

Component: PDKV

Data Source: Engineering Judgement Based on Analyses of an Idealized Configuration, Dept. 7830, Warman

1.4 Nuclear Environment Flight Engine - No Shield - Unperturbed

Description	Location(In) Station R		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
						Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
PDKV	62.3	41.2	4.0 + 6	4.0 + 7	5.0 - 4	2.5 + 10	9.0+14	5.8 + 11	2.1+16	1.3 + 12	4.7 + 16
PDKV			5.4 + 6		<u>ETS-1</u> 6.7 - 4			6.2 + 11			

Date: 12-3-69

REV: 0

SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CP090194-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6-1
 NATURAL ENVIRONMENTS SUMMARY
 TURBINE DISCHARGE CHECK VALVE EC-90260

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.09 \text{ lb/in}^2$ in 1 hr
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min: 488 Max: 559 (ETR Values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	Min: 7.12×10^{-2} Max: 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2.	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch: 11.8 gr H ₂ O/Ft ³	Extreme: 100% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs, 15 day cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	TBD
Rain	N.A.	N.A.	N.A.
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

Phase			Vehicle Assembly and Checkout Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

DATE: 12-3-69
REV: 0
SHEET: 7

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve

DATA SOURCE: Dwg. 1136390 *Dept. 7840, Klacking/Krivanec

1.7 Dimensional Interfaces

"Y"
Valve { 5.5" O.D. coupling on inlet ends (2)
5.5" O.D. coupling on outlet ends (1)

DATE: 12-3-69
REV: 0
SHEET: 8

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.8 Mechanical Interfaces

"Y" Valve Coupling with Seal at inlet (2)
Coupling with Seal at outlet (1)

DATE: 12-3-69
REV: 0
SHEET: 9

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.9 Electrical Interfaces

Data not available for this issue.

DATE: 12-3-69
REV: 0
SHEET: 10

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.10 Functional Interfaces

Refer to Section 2.0 - Sheet 18.

DATE: 12-3-69
REV: 0
SHEET: 11

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: McClurkin, Dept. 7810 - Packaging Plan

1.11 Handling and Shipping

This component shipped installed on the Pump Discharge Line
(See Design Requirement Sheet).

DATE: 12-3-69

REV: 0

SHEET: 12-1

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to R. W. Froelich,
dtd 11-21-69

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DATE: 12-3-69

REV: 0

SHEET: 12-2

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve and Actuator, EC 90246

DATA SOURCE: Dept. 7810 XE Experience - McClurkin/Bailey

1.12 Checkout

Checks to be Performed

- A. Leak Test
- B. Insulation Dielectric Measurements
- C. Electrical Circuit Measurements
- D. Functional/Operating Tests

Checkout Details:

A. Leak Test

1. Apply closures and attach the leak pressurization unit to the upstream side of the PDCV (pressurize both sides of check)
2. Pressurize the PDCV with GHe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer check all flanges, seals, and joints for leakage.
5. Verify that the leak rate is less than 10^{-2} cc/sec/in of flange dia.
6. Release pressure on the upstream side of valve.
7. Repeat Steps 3 and 4 and verify the PDCV back leak rate is less than 10^{-2} cc/sec/in of seal dia.
8. Vent test gas to atmosphere.

B. Insulation Dielectric Measurements

1. Connect all check valve and actuator electrical connections to the Electrical Test Set.
2. Measure each actuator wire, instrumentation wire, and shield to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: The test current shall not exceed 10 ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Measurements

1. Connect all electrical connectors to the electrical test set.
2. Measure the circuit impedance to verify that the components, or their circuits, are within a prescribed tolerance, with respect to resistance, impedance, and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically designated to be so, between any wires, shields and valve ground.
4. Verify position potentiometers and limit switch settings with respect to valve position.
5. Disconnect the test set and replace the valve protective covers.

D. Functional/Operating Tests

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 23 VDC (current limited) to the limit switches.
4. Supply check valve open command: Monitoring - the following parameters through the entire opening cycle:
 - a. Valve current vs. position
 - b. Voltage across the valve actuator
 - c. Limit switch operation vs time
 - d. Comparison of all position monitoring sensors
 - e. Valve position vs time
 - f. Break-away torque
 - g. Valve bounce at end of travel
5. Supply valve close command and monitor items a through g, Paragraph 4 above. In addition, verify that the opening and closing hysteresis characteristics are within prescribed band width tolerance.
6. Perform the test indicated in Paragraphs 4 and 5 at the high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.
7. Disconnect the test set and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the PDCV and its subassemblies. Data log sheets, print-outs, X-Y Plotter charts, and strip chart recordings shall support the test records, as applicable.

DATE: 12-3-69
REV: 0
SHEET: 13

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: Dept. 7730, Data Item SO38

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal static acceleration: ± 5.2 g's, -1.0 g
2. Max. lateral static acceleration: ± 1.0 g

DATE: 12-3-69
REV: 0
SHEET: 14

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: Dept. 7730, Data Item SO38

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal dynamic acceleration (3-34 Hz Freq. Range) =
± 6.75 g's
2. Max. lateral dynamic acceleration (.1-15 Hz Freq. Range) =
± 4.5 g's.

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels.

20 to 200 cps

Linear Increase

From 0.03 to

1.5 g²/Hz

(3db/Octave)

200 to 800 cps

at 1.5 g²/Hz

800 to 2000 cps

Linear Decrease

From 1.5 to

0.06 g²/Hz

3db/Octave)

DATE: 12-3-69
REV: 0
SHEET: 15

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve

DATA SOURCE: Dwg. 1136390

1.15 Envelope Dimensions

Length = 15.0"

Width = 15.0"

Height = 15.0"

DATE: 12-3-69
REV: 0
SHEET: 16

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve and Actuator

DATA SOURCE: Dept. 7730, Data Item S047

1.16 Weight Allocation - 60 pounds for inline configuration
-125 pounds for dual configuration

NOTE: This figure is an allocation only, not an estimate based
on any design.

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: PDKV

DATA SOURCE: NPRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I of not less than 500 seconds for a minimum of 1 hour at any time^{sp} during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Pump Discharge Check Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>		<u>PDKV</u>			
1.0	<u>Fluid</u>	LH ₂ (GH ₂)			
2.0	<u>Steady State Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1	Inlet Pressure, psia	1460.0	1867.0	2232.0	745.0
2.2	Outlet Pressure, psia	1447.0	1810.0	2163.0	736.0
2.3	Inlet Temperature, °R	61.0	67.3	67.5	51.7
2.4	Outlet Temperature, °R	61.1	67.3	67.5	51.7
2.5	Inlet Flowrate, lb/sec	44.6	89.3	93.0	26.7
2.6	Outlet Flowrate, lb/sec	44.6	89.3	93.0	26.7
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	No limit			
3.2	Valve Opening Time, sec, max	.100 sec			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	No limit			
4.2	Valve Closing Time, sec, max	.050-.100 sec			
5.0	<u>Cooldown</u>				
5.1	Flow Rate Min, lb/sec	4.0			
5.2	Valve Response time, sec, max	N/A			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	8/80			
6.2	Cooldown Pulses, per trip/total	N/A			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	L			
8.0	Line size, in, O.D.	3.92			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

DESIGN REQUIREMENT SHEET

9.0	<u>Leakage</u>	(Forward Flow) scc per sec.	1.0 (with inlet press.30 psia outle
9.1	Internal	(Reverse Flow), scc per sec.	press 15 psia)
9.2	External		5.0 (with normal engine operating
	9.2.1	Static Seal, SCC per sec	conditions)
		per inch joint diam	0.01
	9.2.2	Dynamic Seal, SCC per sec	10.0
		per inch joint diam	
10.0	Pressure Drop (ΔP at Design Point) psi		13.0 + 1.0
11.0	Actuator Power		
	11.1	Hold Position, watts	N/A
	11.2	Change Position, watts	
		11.2.1 Open	100
		11.2.1 Close	375
12.0	Opening and Closing Characteristics		
	12.1	Cracking Pressure, psid	2 (+2,-0)
	12.2	Closing Pressure, psid	0 (+4,-0)
13.0	Controlled Flow Rate		N/A

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

PUMP DISCH. LINE to PUMP DISCH. CK. VALVE

STATE POINT NO. 6

151K NEDVA FULL FLOW ENGINE NO. 136390

MISSION A-L-M, 1ST BURN 1457 SEC SS, STOP=52, SHDN=45 SEC, CST=7.6 HR

PART NAME P-1-KV-1N

SPEC TREE NO.

PLOTTED BY: CHECKED BY:

23 27 52 1503 1513 1543 1554
 BOOTSTRAP 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 2.0-1

STATE POINT No 6

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

FIGURE 2.0-2

Pump Disch. Cr. V_{OUT} to Pump Disch. Line

STATE POINT No. 7

FIGURE 2.0-3

PDKVOUT

STATE POINT NO 7

15 K NEPVA FULL FLOW ENGINE NO 1136390

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

LEGEND

FLOW RATE
 PRESSURE
 TEMPERATURE
 TPA SPEED
 PUMP EFFICIENCY
 TURBINE EFFICIENCY
 VALVE POSITION
 THRUST
 IS

PART NAME
 SPEC TREE NO
 PLOTTED BY CHECKED BY

END OF PUMP
TAILOFF

1734.6

C O O L D O W N

END OF COOLDOWN

FIGURE 2.0-4

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

BYPASS CONTROL VALVE AND ACTUATOR (BCV)

EC-90122

The following data are included in this issue:

		<u>Sheet</u>	<u>Revision</u>
1.0	Design Criteria		
1.1	Reliability Allocation	1	0
1.2	Maintainability	2	0
1.3	Useful Life	3	0
1.4	Nuclear Environment	4	0
1.5	Thermal Environment	5	0
1.6	Natural Environment	6	0
1.7	Dimensional Interfaces	7	0
1.8	Mechanical Interfaces	8	0
1.9	Electrical Interfaces	9	0
1.10	Functional Interfaces	10	0
1.11	Handling & Shipping	11	0
1.12	Test & Checkout	12	0
1.13	Static Loads	13	0
1.14	Dynamic Loads	14	0
1.15	Envelop Dimensions	15	0
1.16	Weight Allocation	16	0
1.17	Safety	17	0
2.0	Steady State Functional Performance	18	0
3.0	Startup Transient Functional Performance	19	0
4.0	Throttling Transient Functional Performance	20	0
5.0	Shutdown Transient Functional Performance	21	0
6.0	Cooldown Functional Performance	22	0

Date: 12-3-69
Rev: 0
Sheet: 1

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: Memorandum 7850:MO346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999732 or greater.

DATE: 12-3-69
REV: 0
SHEET: 2

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve (EC 90122)

DATA SOURCE: NPRD-1 and Evaluation by Klacking/Shoemaker

1.2 Maintainability - The Bypass Control Valve shall be designed to incorporate the maintainability requirements of the Engine. (See Sheet 2 of PW-DR-0187). The following time limitations shall be met: (a) Repair time - the time required to repair shall not exceed (3.0) hours, (b) Active Maintenance Time - The maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operations.

1.2.1 Maintenance and Repair Cycles

1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.

1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.

1.2.2 Service and Access

1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.

1.2.2.2 Capability for remote and manual replacement of valve/actuator assembly shall be provided for ground test engines and space operations. Replacement will be accomplished by replacing a module containing (2) BCV and (2) BEV.

1.2.2.3 Capability for manual replacement of the actuator shall be provided for both Ground Test Engines and space operations.

1.2.2.4 The Bypass Control Valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.

1.2.2.5 Provision shall be made for purging the Bypass Control Valve with inert gas through the engine purge system.

1.2.2.6 Bypass Control Valve shall be physically interchangeable without adjustment or modification of mating engine components.

DATE: 12-3-69
REV: 0
SHEET: 3

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1 and Engineering Estimate
Froelich/Paavola

1.3 Useful Life

The Bypass Control Valve shall be capable of satisfying the minimum useful life of the NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes
(sixty cycles maximum)
1.3.2	Non-rated Operating Life
(transients and in-flight checkout)	72 days
1.3.3	Non-Operating Life	
	1.3.3.1 Engine Assembly to
Launch Pad
(Less Storage)	6 months
	1.3.3.2 Launch Pad
Environment	6 months
	1.3.3.3 Space Storage
Conditions	3 Years
1.3.4	Storage Life (Ground)	5 Years

SHEET: 4

Component: BCV

1.4 Nuclear Environment Flight Engine - No Shield - Unperturbed

Description	Location(In)		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
	Station	R				Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
BBV & BCV #1	74.1	30.5	2.3 + 6	2.3 + 7	2.9 - 4	5.0 + 9	1.8+14	2.7 + 11	9.7+15	3.2 + 11	1.2 + 16
BBV & BCV #2	74.1	39.0	4.8 + 6	4.8 + 7	6.0 - 4	3.0 + 10	1.1+15	7.0 + 11	2.5+16	1.6 + 12	5.9 + 16
ETS-1											
BBV & BCV #1			3.7 + 6		4.6 - 4			3.1 + 11			
BBV & BCV #2			6.2 + 6		5.7 - 4			7.4 + 11			

Date: 12-3-69
REV: 0
SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CP090194-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6-1
 NATURAL ENVIRONMENTS SUMMARY
 BYPASS CONTROL VALVE AND ACTUATOR EC-90122

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.09 \text{ lb/in}^2$ in 1 hr
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min: 488 Max: 559 (ETR Values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	Min: 7.12×10^{-2} Max: 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch: 11.8 gr H ₂ O/Ft ³	Extreme: 100% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs, 15 day cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	TBD
Rain	N.A.	N.A.	N.A.
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

Phase			Vehicle Assembly and Checkout Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

DATE: 12-3-69
REV: 0
SHEET: 7

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: Dwg. 1136390, Dept. 7840, Klacking/Krivanec

1.7 Dimensional Interfaces

Line I.D. = 3.902[#](inlet and outlet)

Flange = None

DATE: 12-3-69
REV: 0
SHEET: 8

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.8 Mechanical Interfaces
Welded (inlet and outlet)
Replaceable as line-valve module.

DATE: 12-3-69
REV: 0
SHEET: 9

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve

DATA SOURCE: Klacking/Krivanec, Dept. 7840

1.9 Electrical Interfaces

Data not available for this issue.

DATE: 12-3-69
REV: 0
SHEET: 10

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve

DATA SOURCE: Klacking/Krivanec, Dept. 7840

1.10 Functional Interface

Refer to Section 2.0, Sheet 18.

DATE: 12-3-69
REV: 0
SHEET: 11

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: McClurkin, Dept. 7810 - Packaging Plan - Maintainability Plan

1.11 Handling and Shipping

1. This component is shipped installed in the Thrust Structure or as a valve and piping module.
2. Attach points for lifting the component should be provided for handling during pre-assembly and assembly.

DATE: 12-3-69
REV: 0
SHEET: 12-1

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to R. W. Froelich,
dtd 11-21-69

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve and Actuator, EC 90122

DATA SOURCE: Dept. 7810 - XE Experience - McClurkin/Bailey

1.12 Checkout

Checks to be Performed

- A. Leak test
- B. Insulation dielectric measurements
- C. Electrical circuit measurements
- D. Functional/Operating tests

Checkout Details

A. Leak Test

1. Apply closures and attach the leak pressurization unit to the upstream side of the BCV (valve is open).
2. Pressurize the BCV with GHe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer check all flanges, seals, and joints for leakage.
5. Verify that the leak rate is less than 10^{-2} cc/sec/in. of flange diameter.
6. Close Valve.
7. Release pressure on the downstream side of valve.
8. Repeat Steps 3 and 4 and verify the BCV valve seat leak rate is less than 10^{-2} cc/sec/in of seal diameter.
9. Vent test gas to atmosphere and disconnect the leak test set.

B. Insulation Dielectric Measurements

1. Connect all valve electrical connections to the electrical test set.
2. Measure each actuator wire, instrumentation wire, and shield to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: Test current shall not exceed 10 ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Measurements

1. Connect all electrical connectors to the electrical test set.

2. Measure the circuit impedance to verify that the components, or their circuits, are within a prescribed tolerance, with respect to resistance, impedance and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically designated to be so, between any two wires, shields, and valve ground.
4. Verify position potentiometer and limit switch settings with respect to valve position.
5. Disconnect test set and replace protective covers.

D. Functional/Operating Tests

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 28 VDC (current limited) to the limit switches.
4. Supply valve position commands monitoring the following parameters through the entire operating cycle:
 - a. Valve actuator current vs. position and time.
 - b. Voltage across the valve actuator
 - c. Limit switch operation vs. time
 - d. Comparison of all position monitoring sensors
 - e. Valve position and command signal vs time (response)
 - f. Break-away torque vs. current.
 - g. Valve overshoot at command position.
5. Supply valve position sine wave and square wave position commands and monitor Items a through g, Paragraph 4 above. Supply the sine wave commands and the square wave commands at the following frequencies: (TBD)
6. Perform the tests indicated in Paragraph 4 and 5 at the high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.
7. Disconnect the test set and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the BCV and its subassemblies. Data log sheets, print outs, X-Y plotter charts, and strip chart recordings shall support the test records, as applicable.

DATE: 12-3-69
REV: 0
SHEET: 13

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: Dept. 7730, Data Item S038

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal static acceleration: + 5.2 g's. -1.0 g
2. Max. lateral static acceleration: ± 1.0 g

DATE: 12-3-69
REV: 0
SHEET: 14

DESIGN REQUIREMENT SHEET

COMPONENT: BCV

DATA SOURCE: Dept. 7730, Data Item S038

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these component. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition - Launch Vehicle Operations

1. Max. longitudinal dynamic acceleration
(3-35 Hz Freq. Range) = ± 6.75 g's
2. Max. lateral dynamic acceleration
(.1-15 Hz Freq. Range) = ± 4.5 g's.

Vibration

The component shall withstand random vibration along each **of three** mutually perpendicular axes for 30 minutes in each axis at the following levels:

20 to 200 cps

Linear Increase

From 0.03 to

$1.5 \text{ g}^2/\text{Hz}$

(3db/Octave)

200 to 800 cps

at $1.5 \text{ g}^2/\text{Hz}$

800 to 2000 cps

Linear Decrease

From 1.5 to

$0.06 \text{ g}^2/\text{Hz}$

(3db/Octave)

DATE: 12-3-69
REV: 0
SHEET: 15

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve

DATA SOURCE: Dwg. 1136390

1.15 Envelope Dimensions

Length = 21.0"
Width = 22.0"
Height = 13.5"

DATE: 12-3-69
REV: 0
SHEET: 16

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve and Actuator

DATA SOURCE: Dept. 7730, Data Item S047

1.16 Weight Allocation - 90 pounds

Based on XE 4" control valve.

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve

DATA SOURCE: NPRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I of not less than 500 seconds for a minimum of 1 hour at any time^{sp} during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Control Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>		<u>BCV</u>			
1.0	<u>Fluid</u>	<u>CH₂</u>			
2.0	<u>Steady State Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1	Inlet Pressure, psia	1239.0	1551.0	2026.0	620.0
2.2	Outlet Pressure, psia	688.0	687.5	722.0	463.1
2.3	Inlet Temperature, °R	262.0	269.0	280.0	273.9
2.4	Outlet Temperature, °R	262.0	269.0	280.0	273.9
2.5	Inlet Flowrate, lb/sec	13.5	13.0	20.0	22.1
2.6	Outlet Flowrate, lb/sec	13.5	13.0	20.0	22.1
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	No limit			
3.2	Valve Opening Time, sec, max	2-5 full actuation, analog			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	No limit			
4.2	Valve Closing Time, sec, max	2-5			
5.0	<u>Cooldown</u>				
5.1	Flow Rate max, lb/sec	4.0			
5.2	Valve Response time, sec, max	N/A			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	8/80			
6.2	Cooldown Pulses, per trip/total	(kept open)			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	C			
8.0	Line size, in, O.D.	4.0			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

9.0	<u>Leakage</u>	
9.1	Internal	<u>2000 SCFM</u>
9.2	External	
9.2.1	Static Seal, SCC per sec per inch joint diam	<u>0.01</u>
9.2.2	Dynamic Seal, SCC per sec per inch joint diam	<u>20.0</u>
10.0	Pressure Drop (ΔP at Design Point) psi	<u>50.0 $\pm$ 5.0</u>
11.0	Actuator Power	
11.1	Hold Position, watts	<u>300</u>
11.2	Change Position, watts	
11.2.1	Open	<u>300</u>
11.2.1	Close	<u>300</u>
12.0	Opening and Closing Characteristics	
12.1	Cracking Pressure, psid	<u>N/A</u>
12.2	Closing Pressure, psid	<u>N/A</u>
13.0	Controlled Flow Rate	<u>N/A</u>

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

TURBINE REPAIRS LUNG to B. B. V. M.

STATE POINT No 30

FIGURE 2.0-1

TURBINE BYPASS LINE to B.C.V.M.

STATE POINT No 28 27

FIGURE 2.0-2

BCV_{IN}

STATE POINT NO 28-27

FIGURE 2.0-3

B C V OUT to TURB. P. PASS LINE

STATE POINT No 29

FIGURE 2.0-4

BCVOUT

STATE POINT No 29

FIGURE 2.0-5

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

BYPASS BLOCK VALVE AND ACTUATOR (BBV)

EC-90257

The following data are included in this issue:

	<u>Sheet</u>	<u>Revision</u>
1.0 Design Criteria		
1.1 Reliability Allocation	1	0
1.2 Maintainability	2	0
1.3 Useful Life	3	0
1.4 Nuclear Environment	4	0
1.5 Thermal Environment	5	0
1.6 Natural Environment	6	0
1.7 Dimensional Interfaces	7	0
1.8 Mechanical Interfaces	8	0
1.9 Electrical Interfaces	9	0
1.10 Functional Interfaces	10	0
1.11 Handling & Shipping	11	0
1.12 Test & Checkout	12	0
1.13 Static Loads	13	0
1.14 Dynamic Loads	14	0
1.15 Envelop Dimensions	15	0
1.16 Weight Allocation	16	0
1.17 Safety	17	0
2.0 Steady State Functional Performance	18	0
3.0 Startup Transient Functional Performance	19	0
4.0 Throttling Transient Functional Performance	20	0
5.0 Shutdown Transient Functional Performance	21	0
6.0 Cooldown Functional Performance	22	0

Date: 12-3-69
Rev: 0
Sheet: 1

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 90257

DATA SOURCE: Memorandum 7850:MO346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999642 or greater.

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 90257

DATA SOURCE: NPRD-1 and evaluation by Klacking/Shoemaker

1.2 Maintainability

The bypass block valve shall be designed to incorporate the maintainability requirements of the engine . (See Sheet 2 of RN-DR-0187).

The following time limitations shall be met: (a) Repair Time - the time required to repair shall not exceed (3.0) hours; (b) Active Maintenance Time - the maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operations.

1.2.1 Maintenance & Repair Cycles

1.2.1.1 Periodic Maintenance

Other than an inert gas purge, shall not be required during storage.

1.2.1.2 Periodic Maintenance or Repair

Shall not be used to attain specified reliability or operating life requirements.

1.2.2 Service and Access

1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.

1.2.2.2 Capability for remote and manual replacement of valve/actuator assembly shall be provided for both ground test engines and space operations. Replacement will be accomplished by replacing a module containing (2) BBV, (2) BCV, and their interconnecting lines.

1.2.2.3 Capability for manual replacement of the actuator shall be provided for both ground test engines and space operations.

1.2.2.4 The bypass block valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.

1.2.2.5 Provision shall be made for purging the bypass block valve with inert gas through the engine purge system.

1.2.2.6 Bypass block valve shall be physically interchangeable without adjustment or modification of mating engine components.

Date: 12-3-69
Rev: 0
Sheet: 3

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 90257

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life

The Bypass Block Valve
shall be capable of satisfying the minimum useful life of the
NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes (maximum of 60 cycles)
1.3.2	Non-Rated Operating Life (Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad (Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years (Including Operational Life)
1.3.4	Storage Life (Ground)	5 years

DATE: 12-3-69
 REV: 0
 SHEET: 4

DESIGN REQUIREMENT SHEET

Component: Bypass Block Valve - EC 90257

Data Source: Engineering judgement based on analysis of an idealized configuration, Dept 7830 - E.A. Warman

1.4 Nuclear Environment

Description	Location(In) Station R		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
						Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
BBV & BCV #1	74.1	30.5	2.3+6	2.3+7	2.9-4	5.0+9	1.8+14	2.7+11	7.7+15	3.2+11	1.2+16
BBV & BCV #2	74.1	33.0	4.8+6	4.8+7	6.0-4	3.0+10	1.1+15	7.0+11	2.5+11	1.6+12	5.9+16
<u>ETS-1</u>											
BBV & BCV #1			3.7+6		4.6-4			3.1+11			
BBV & BCV #2			6.2+6		7.7-4			7.4+11			

Date: 12-3-69
REV: 0
SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 90257

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 90257

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CP090194-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6-1
NATURAL ENVIRONMENTS SUMMARY
Bypass Block Valve & Actuator EC-90257

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.00 \text{ lb/in}^2$ in 1 hr
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min: 488 Max: 559 (FTR Values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	Min: 7.12×10^{-2} Max: 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch: 11.8 gr H ₂ O/ft ³	Extreme: 100% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs, 15 day cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	TBD
Rain	N.A.	N.A.	N.A.
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

TABLE-1.6-1

2 of 2

Phase			Vehicle Assembly and Checkout Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

DATE: 12-3-69
REV: 0
SHEET: 7

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve

DATA SOURCE: Dwg. 1136390 - Dept 7840 - Klacking/Krivanec

1.7 Dimensional Interfaces

Line I.D. = 3.902"(Inlet & Outlet)

Flange = None

DATE: 12-3-69
REV: 0
SHEET: 8

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC90257

DATA SOURCE: Engineering Evaluation - Dept 7840 - Klacking/Krivanec

1.8 Mechanical Interfaces

Welded (Inlet and Outlet)

Replaceable as line-valve module

DATE: 12-3-69
REV: 0
SHEET: 9

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC90257

DATA SOURCE: Engineering Evaluation - Dept 7840 - Klacking/Krivanec

1.9 Electrical Interfaces

Data not available for this issue.

DATE: 12-3-69
REV: 0
SHEET: 10

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC90257

DATA SOURCE: Engineering Evaluation - Dept 7840 - Klacking/Krivanec

1.10 Functional Interfaces

Refer to Section 2.0, Sheet 18.

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 90257

DATA SOURCE: McClurking - Dept 7810 - Packaging Plan

1.11 Handling and Shipping

- (1) This component is shipped installed in the thrust structure module or as a valve and piping module.
- (2) Attach points for lifting the component should be provided for handling during pre-assembly and assembly.
- (3) Methods for preservation, packaging, and packing for the component or module will be developed to provide adequate protection against corrosion, contamination, and physical damage from shock and vibration. Packaging will be design to facilitate handling, inspection, and warehousing. Special packing requirements should be defined by the designer if the shock and vibration loads presented in Data Item S-038 "Environment Vibration and Acoustics Report" are considered excessive.

DATE: 12-3-69

REV: 0

SHEET: 12-1

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 90257

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to
R. W. Froelich, dtd 11-21-69

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Vlock Valve and Actuator, EC-90257

DATA SOURCE: Dept 7810 - XE Experience - McClurkin/Bailey

1.12 Checkout

Checks to be performed:

- A. Leak test
- B. Insulation Dielectric Measurements
- C. Electrical Circuit Measurements
- D. Functional/Operating Tests

Checkout Details:

A. Leak Test

1. Apply closures and attach the leak pressurization unit to the upstream side of the BBV (valve is open).
2. Pressurize the BBV with GHe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer check all flanges, seals, and joints for leakage.
5. Verify that the leak rate is less than (10^2 CC/sec/in. of flange diameter).
6. Close Valve
7. Release pressure on the downstream side of the BBV.
8. Repeat Steps 3 and 4 and verify the BBV valve seat leak rate is less than (10^2 CC/Sec/in. of seal diameter.)
9. Vent test gas to atmosphere.

B. Insulation Dielecteic Measurements

1. Connect all valve electrical connections to the electrical test set.
2. Measure each actuator wire, instrumentation wire, and shield to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: Test current shall not exceed 10ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Measurements

1. Connect all electrical connectros to the electrical test set.
2. Measure the circuit impedance to verify that the compoents, or their circuits, are within a prescribed tolerance, with respect to resistance, impedance and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically designated to be so, between any two wires, shields, and valve ground.
4. Verify position potentiometer and limit switch settings with respect to valve position.
5. Disconnect test set and replace protective covers.

D. Functional/Operating Tests

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 28 VDC (current limited) to the limit switches.
4. Supply valve open command monitoring the following parameters through the entire opening cycle:
 - a. Valve current vs. position
 - b. Voltage across the valve actuator
 - c. Limit switch operations vs. time
 - d. Comparison of all position monitoring sensors
 - e. Valve position vs. time
 - f. Break-away torque
 - g. Valve bounce at end of travel
5. Supply valve close command and monitor Items a through g, Paragraph 4 above. In addition, verify that the opening and closing hysteresis characteristics are within a prescribed band width tolerance.
6. Perform the tests indicated in Paragraph 4 and 5 at high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.
7. Remove power, disconnect the test set and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the BBV and its subassemblies, data log sheets, print outs, X-Y plotter records, and strip chart recordings shall support the test records, as applicable.

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve

DATA SOURCE: Dept 7730 - Data Item 5038

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition - Launch Vehicle Operations

1. Max. Longitudinal Static Acceleration: +5.2g's -1.0g.
2. Max. Lateral Static Acceleration: $\pm 1.0g$.

DESIGN REQUIREMENT SHEET

COMPONENT: By Pass Block Valve

DATA SOURCE: Data Item S038, Section 7730

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural Considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Conditions: Launch Vehicle Operations

1. Max longitudinal dynamic acceleration (3.35 HZ Freq range) = $\pm 6.75g's$
2. Max lateral dynamic acceleration (.1-15HZ freq range) = $\pm 4.5g's$

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels:

<u>20 to 200 cps</u>	<u>200 to 800 cps</u>	<u>800 to 2000 cps</u>
Linear Increase	at $1.5 g^2/Hz$	Linear Decrease
From 0.03 to		From 1.5 to
$1.5 g^2/Hz$		$0.06 g^2/Hz$
(3db/Octave)		(3db/Octave)

DATE: 12-3-69
REV: 0
SHEET: 15

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC 92057

DATA SOURCE: Dwg. 1136390

1.15 Envelope Dimensions

Length = 11.0 "

Width = 10.0 "

Height = 13.5 "

DATE: 12-3-69
REV: 0
SHEET: 16

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve and Actuator

DATA SOURCE: Dept 7730 - Data Item S047

1.16 Weight Allocation - 70 pounds

Based on XE 4" Block Valve

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve - EC90257

DATA SOURCE: NFRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I_{sp} of not less than 500 seconds for a minimum of 1 hour at any time during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Bypass Block Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>		<u>BBV</u>			
1.0	<u>Fluid</u>	GH ₂			
2.0	<u>Steady State Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1	Inlet Pressure, psia	687.0	687.0	721.0	462.0
2.2	Outlet Pressure, psia	678.7	679.7	714.7	457.0
2.3	Inlet Temperature, °R	262.0	269.0	280	273.9
2.4	Outlet Temperature, °R	262.0	269.0	280	273.9
2.5	Inlet Flowrate, lb/sec	13.5	13.0	20.0	22.1
2.6	Outlet Flowrate, lb/sec	13.5	13.0	20.0	22.1
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	No limit			
3.2	Valve Opening Time, sec, max	1-3			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	No limit			
4.2	Valve Closing Time, sec, max	1-3			
5.0	<u>Cooldown</u>				
5.1	Flow Rate MN, lb/sec	4.0			
5.2	Valve Response time, sec, max	NA			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	8/80			
6.2	Cooldown Pulses, per trip/total	kept open			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	L			
8.0	Line size, in, O.D.	4.0			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

DESIGN REQUIREMENT SHEET

9.0	<u>Leakage</u>	
9.1	Internal	2000 SCFM
9.2	External	
9.2.1	Static Seal, SCC per sec per inch joint diam	0.01
9.2.2	Dynamic Seal, SCC per sec per inch joint diam	10.0
10.0	Pressure Drop (ΔP at Design Point) psi	8.3 $\pm$ 1
11.0	Actuator Power	
11.1	Hold Position, watts	300
11.2	Change Position, watts	
11.2.1	Open	1500
11.2.1	Close	1500
12.0	Opening and Closing Characteristics	
12.1	Cracking Pressure, psid	N/A
12.2	Closing Pressure, psid	N/A
13.0	Controlled Flow Rate	N/A

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

BBVIN

STATE POINT NO 30

75K NERVA FULL FLOW ENGINE NO 1126390

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

FIGURE 2.0-2

BBV_{OUT} to TURB. BYPASS LINE

STATE POINT NO. 31-32

FIGURE 2.0-3

BBV_{OUT}

STATE, POINT NO 31-32

FIGURE 2.0-4

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

* TURBINE BLOCK VALVE AND ACTUATOR (TBV)

EC-90121

The following data are included in this issue:

		<u>Sheet</u>	<u>Revision</u>
1.0	Design Criteria		
1.1	Reliability Allocation	1	0
1.2	Maintainability	2	0
1.3	Useful Life	3	0
1.4	Nuclear Environment	4	0
1.5	Thermal Environment	5	0
1.6	Natural Environment	6	0
1.7	Dimensional Interfaces	7	0
1.8	Mechanical Interfaces	8	0
1.9	Electrical Interfaces	9	0
1.10	Functional Interfaces	10	0
1.11	Handling & Shipping	11	0
1.12	Test & Checkout	12	0
1.13	Static Loads	13	0
1.14	Dynamic Loads	14	0
1.15	Envelop Dimensions	15	0
1.16	Weight Allocation	16	0
1.17	Safety	17	0
2.0	Steady State Functional Performance	18	0
3.0	Startup Transient Functional Performance	19	0
4.0	Throttling Transient Functional Performance	20	0
5.0	Shutdown Transient Functional Performance	21	0
6.0	Cooldown Functional Performance	22	0

DATE: 12-3-69
REV: 0
SHEET: 1

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: Memorandum 7850:346, Mihanovich to Varga, dated
25 November 1969

1.1 Reliability Allocation

The probability that this component shall successfully fulfill
its operating requirements shall be $.9996^{44}$ or greater.

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve, EC-90121

DATA SOURCE: NPRD-1 and Evaluation by Klacking/Shoemaker

- 1.2 Maintainability: The turbine block valve shall be designed to incorporate the maintainability requirements of the engine .
(See Sheet 2 of RN-DB-0187). The following time limitations shall be met: (a) repair time - the time required to repair shall not exceed (2.0) hours. (b) active maintenance time - the maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly.
- 1.2.1 Maintenance and repair cycles and operations .
- 1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.
- 1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.
- 1.2.2 Service and access
- 1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.
- 1.2.2.2 Capability for remote and manual replacement of valve/ actuator assembly shall be provided for both ground test engines and space operations. Replacement will be accomplished by replacing both TBV's and their inter-connecting lines.
- 1.2.2.3 Capability for manual replacement of the actuator shall be provided for both ground test engines and space operations.
- 1.2.2.4 The turbine block valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.
- 1.2.2.5 Provision shall be made for purging the turbine block valve inert gas through the engine purge system.
- 1.2.2.6 Turbine Block Valve shall be physically inter-changeable without adjustment or modification of mating engine components.

Date: 12-3-69
Rev: 0
Sheet: 3

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life

The turbine block valve shall be capable of satisfying the minimum useful life of the NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes (maximum of 60 cycles)
1.3.2	Non-Rated Operating Life (Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad (Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years (Including Operational Life)
1.3.4	Storage Life (Ground)	5 years

SHEET : 4

Component: TBV

1.4 Nuclear Environment

Flight Engine - No Shield - Unperturbed

Description	Location(In)		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
	Station	R				Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
TBV #1	56.5	37.0	3.0 + 6	3.0 + 7	3.8 - 4	1.7+10	6.1+14	4.5+11	1.6+16	8.4+11	3.0+16
TBV #2	56.5	44.0	4.0 + 6	4.0 + 7	4.9 - 4	2.8+10	1.0+15	6.0+11	2.2+16	1.5+12	5.4+16
TBV #1 #2			4.4 + 6 5.4 + 6		ETS - 1 5.5 - 4 6.6 - 4			4.9 + 11 6.4 + 11			

Date: 12-3-69
REV: 0
SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CP090194-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6-1
NATURAL ENVIRONMENTS SUMMARY

Turbine Block Valve and Actuator EC-90121

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.09 \text{ lb/in}^2$ in 1 hr
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min: 488 Max: 559 (EIR Values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	Min: 7.12×10^{-2} Max: 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch: $11.8 \text{ gr H}_2\text{O/ft}^3$	Extreme: 100% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs, 15 day cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	TBD
Rain	N.A.	N.A.	See Table 8
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

Phase			Vehicle Assembly and Checkout Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve

DATA SOURCE: Drawing 1136390, Section 7840, Klacking/Krivanec

1.7 Dimensional Interfaces

Line I.D. = 6.84" (inlet and outlet)

Flange = 7.78" O.D. (inlet only)

Coupling Dia. = 11.2" (inlet only)

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanec

1.8 Mechanical Interfaces

Inlet - coupling (manual)

Outlet- Welded

Replaceable as line-valve module

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanec

1.9 Electrical Interfaces

Data not available for this issue

Date: 12-3-69
Rev: 0
Sheet: 10

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanec

1.10 Functional Interfaces

Refer to Section 2.0, Sheet 18

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: Packaging Plan, McClurkin, Section 7810

1.11 Handling & Shipping

1. This component is shipped installed in the Thrust Structure Module.
2. Attach points for lifting the component should be provided for handling during pre-assembly and assembly.

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to R. W. Froelich,
dated 11-21-69.

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve and Actuator, EC-90121

DATA SOURCE: XE Experience, Section 7810, McClurkin/Bailey

1.12 Checkout

Checks to be Performed

- A. Leak Test
- B. Insulation Dielectric Measurements
- C. Electrical Circuit Measurements
- D. Functional/Operating Tests

Checkout Details:

A. Leak Test

1. Apply closures and attach the leak pressurization unit to the upstream side of the TBV (valve is open).
2. Pressurize the TBV with GHe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer check all flanges, seals, and joints for leakage.
5. Verify that the leak rate is less than 10^{-2} cc/sec/in. of flange diameter.
6. Close valve.
7. Release pressure on the downstream side of valve.
8. Repeat Steps 3 and 4 and verify the TBV valve leak rate is less than 10^{-2} cc/sec/in. of seal diameter.
9. Vent test gas to atmosphere.

B. Insulation Dielectric Measurements

1. Connect all valve electrical connections to the electrical test set.
2. Measure each actuator wire, instrumentation wire, and shield to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: Test current shall not exceed 10 ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Measurements

1. Connect all electrical connectors to the electrical test set.
2. Measure the circuit impedance to verify that the components, or their circuits, are within a prescribed tolerance, with respect to resistance, impedance, and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically designated to be so, between any two wires, shields, and valve ground.
4. Verify position potentiometer and limit switch settings with respect to valve position.
5. Disconnect test set and replace protective covers.

D. Functional/Operating Tests

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 28 VDC (current limited) to the limit switches.
4. Supply valve open command monitoring the following parameters through the entire opening cycle:
 - a. Valve current vs. position
 - b. Voltage across the valve actuator
 - c. Limit switch operation vs. time.
 - d. Comparison of all position monitoring sensors
 - e. Valve position vs. time.
 - f. Break-away torque
 - g. Valve bounce at end of travel
5. Supply valve close command and monitor items a through g, Paragraph 4 above. In addition, verify that the opening and closing hysteresis characteristics are within a prescribed band width tolerance.
6. Perform the tests indicated in Paragraphs 4 and 5 at high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.

7. Remove power, disconnect the test set, and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the TBV and its subassemblies. Data log sheets, print outs, X-Y plotter records, and strip chart recordings shall support the test records, as applicable.

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: Data Item S038, Section 7730

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural Aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal static acceleration: + 5.2g's, -1.0g
2. Max. lateral static acceleration: ± 1.0g

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: Data Item S038, Section 7730

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. Longitudinal Dynamic Acceleration (3-35HZ freq. range) = $\pm 6.75g$
2. Max. Lateral Dynamic Acceleration (.1-15HZ freq. range) = $\pm 4.5 g's$.

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels:

<u>20 to 200 cps</u>	<u>200 to 800 cps</u>	<u>800 to 2000 cps</u>
Linear Increase	at $1.5 g^2/Hz$	Linear decrease
From 0.03 to $1.5 g^2/Hz$ (3db/Octave)		From 1.5 to $0.06 g^2/Hz$ (3db/Octave)

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve

DATA SOURCE: Drawing 1136390

1.15 Envelope Dimensions

Length = 12.0 "

Width = 12.0 "

Height = 10.0 "

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve and Actuator

DATA SOURCE: Data Item, S047, Section 7730

1.16 Weight Allocation - 150 pounds

NOTE: This figure is an allocation only, not an estimate
based on any design

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: TBV

DATA SOURCE: NFRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I_{sp} of not less than 500 seconds for a minimum of 1 hour at any time during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Block Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>	<u>TBV</u>			
1.0 <u>Fluid</u>	GH ₂			
2.0 <u>Steady State Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1 Inlet Pressure, psia	1235	1538.0	2025.0	620.0
2.2 Outlet Pressure, psia	1232	1528.0	2015.0	618.5
2.3 Inlet Temperature, °R	262	269.0	320.0	273.9
2.4 Outlet Temperature, °R	262	269.0	315.0	273.9
2.5 Inlet Flowrate, lb/sec	37.6	75.8	88.0	15.6
2.6 Outlet Flowrate, lb/sec	37.6	75.8	88.0	15.6
3.0 <u>Startup Conditions</u>				
3.1 Valve Opening Time, sec, min		no limit		
3.2 Valve Opening Time, sec, max		5 sec to open **		
4.0 <u>Shutdown</u>				
4.1 Valve Closing Time, sec, min		no limit		
4.2 Valve Closing Time, sec, max		.050 sec to close from any position (during emergency shutdown)		
5.0 <u>Cooldown</u>				
5.1 Flow Rate MN, lb/sec		.40		
5.2 Valve Response time, sec, max		N/A		
6.0 <u>Number of Operations</u>				
6.1 Main Burns, per trip/total		8/80		
6.2 Cooldown Pulses, per trip/total		none (closed during cooldown)		
7.0 <u>Position Limit Indicator</u> continuous(c) or limit switch(L)		L		
8.0 <u>Line size, in, O.D.</u>		7.0		

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

**An intermediate position is a requirement for startup.

9.0	<u>Leakage</u>	
9.1	Internal	300 SCFM with min. outlet press. of 10 psia
9.2	External	
9.2.1	Static Seal, SCC per sec per inch joint diam	0.01
9.2.2	Dynamic Seal, SCC per sec per inch joint diam	10.0
10.0	Pressure Drop (ΔP at Design Point) psi	3.0 $\pm$ 0.8
11.0	Actuator Power	
11.1	Hold Position, watts	100
11.2	Change Position, watts	
11.2.1	Open	400
11.2.1	Close	400
12.0	Opening and Closing Characteristics	
12.1	Cracking Pressure, psid	N/A
12.2	Closing Pressure, psid	N/A
13.0	Controlled Flow Rate	N/A

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

TB VIN

STATE POINT No 33

FIGURE 2.0-2

FIGURE 2.0-3

TBV_{OUT}

STATE POINT No 34

TSV NERVA FULL FLOW ENGINE No 1136290

MISSION A-E-M, 1 ST BUEN 1451 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

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

END OF COOLDOWN

FLOW RATE - LB/SEC

60 2400 600
50 2000 500
40 1600 400
30 1200 300
20 800 200
10 400 100
0 0 0

TIME - SECONDS
1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 1950.1
12-5-62

FIGURE 2.0-4

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

COOLANT SUPPLY CONTROL VALVE AND ACTUATOR (CSCV)

EC-90258

The following data are included in this issue:

	<u>Sheet</u>	<u>Revision</u>
1.0 Design Criteria		
1.1 Reliability Allocation	1	0
1.2 Maintainability	2	0
1.3 Useful Life	3	0
1.4 Nuclear Environment	4	0
1.5 Thermal Environment	5	0
1.6 Natural Environment	6	0
1.7 Dimensional Interfaces	7	0
1.8 Mechanical Interfaces	8	0
1.9 Electrical Interfaces	9	0
1.10 Functional Interfaces	10	0
1.11 Handling & Shipping	11	0
1.12 Test & Checkout	12	0
1.13 Static Loads	13	0
1.14 Dynamic Loads	14	0
1.15 Envelop Dimensions	15	0
1.16 Weight Allocation	16	0
1.17 Safety	17	0
2.0 Steady State Functional Performance	18	0
3.0 Startup Transient Functional Performance	19	0
4.0 Throttling Transient Functional Performance	20	0
5.0 Shutdown Transient Functional Performance	21	0
6.0 Cooldown Functional Performance	22	0

Date: 12-3-69

Rev: 0

Sheet: 1

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: Memorandum 7850:MO346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999891 or greater.

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve

DATA SOURCE: NPRD-1 and Evaluation by Klacking/Shoemaker

- 1.2 Maintainability: The coolant supply control valve shall be designed to incorporate the maintainability requirements of the engine. (See Sheet 2 of RN-DR-0187). The following time limitations shall be met: (a) repair time - the time required to repair shall not exceed (2.0) hours. (b) active maintenance time - the maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operations.
- 1.2.1 Maintenance and repair cycles
 - 1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.
 - 1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.
 - 1.2.2 Service and access
 - 1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.
 - 1.2.2.2 Capability for remote and manual replacement of valve/ actuator assembly shall be provided for both ground test engines and space operations. Replacement will be accomplished by replacing a module containing the (2) CSCV, CSKV and their interconnecting lines.
 - 1.2.2.3 Capability for manual replacement of the actuator shall be provided for both ground test engines and space operations.
 - 1.2.2.4 The coolant supply control valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.
 - 1.2.2.5 Provision shall be made for purging the coolant supply control valve with inert gas through the engine purge system.
 - 1.2.2.6 Coolant supply control valve shall be physically interchangeable without adjustment or modification of mating engine components.

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life

The
shall be capable of satisfying the minimum useful life of the
NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes (maximum of 60 cycles)
1.3.2	Non-Rated Operating Life (Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad (Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years (Including Operational Life)
1.3.4	Storage Life (Ground)	5 years

DATE: 12-3-69

REV: 0

SHEET: 4

DESIGN REQUIREMENT SHEET

Component: CSCV

Data Source: Engineering judgement based on analysis of an idealized configuration, Section, Warman

1.4 Nuclear Environment Flight Engine - No Shield - Unperturbed

Description	Location(In) Station R		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
						Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
CSCV	-6.5	8.0	8.7 + 5	8.7 + 6	1.1 - 4	1.2 + 9	4.3+13	6.5+10	2.3+15	1.0+11	3.6+15
CSCV					ETS-1						
					2.8 - 4						
			2.3 + 6					1.1 + 11			

Date: 12-3-69
REV: 0
SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CP090194-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6-1
NATURAL ENVIRONMENTS SUMMARY

Coolant Supply Control Valve and Actuator, EC-90258

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.09 \text{ lb/in}^2$ in 1 hr
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min: 488 Max: 559 (ETR Values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	Min: 7.12×10^{-2} Max: 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch: $11.8 \text{ gr H}_2\text{O/ft}^3$	Extreme: 100% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs, 15 day cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	TBD
Rain	N.A.	N.A.	N.A.
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

COOLANT SUPPLY CONTROL VALVE AND ACTUATOR

2 of 2

Phase			
Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve

DATA SOURCE: Drawing 1136390, Section 7840, Klacking/Krivanic

1.7 Dimensional Interfaces

4.5" O.D. coupling on inlet end

2.902" I.D. at outlet end

3.00" O.D. at outlet end

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanec

1.8 Mechanical Interfaces

Coupling with seal (manual) at inlet welded to line at outlet.

Date: 12-3-69
Rev: 0
Sheet: 9

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanec

1.9 Electrical Interfaces

Data not available for this issue

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve

Data Source: Engineering Evaluation, Section 7840, Klacking/Krivanec

1.10 Functional Interfaces

Refer to Section 2.0, Sheet 18

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: Packaging Plan Maintainability Plan, Section 7810, McClurkin

1.11 Handling & Shipping

1. Capability of being handled and shipped in any attitude after proper packaging.
2. Shipment by land, sea, or air.
3. Methods for preservation, packaging, and packing for the component will be developed to provide adequate protection against corrosion, contamination, and physical damage from shock and vibration. Packaging will be designed to facilitate handling, inspection, and warehousing. Special packing requirements should be defined by the designer if the shock and vibration loads presented in Data Item S-038 "Environment Vibration and Acoustics Report" are considered excessive.
4. SSCL (Sta 0.00 to -23.00), CSCV, CSKV shipped as a module.

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to R. W. Froelich,
dated 11-21-69.

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve and Actuator, EC 90258

DATA SOURCE: XE Experience, Section 7810, McClurkin/Bailey

1.12 Checkout

Checks to be performed:

- A. Leak test
- B. Insulation dielectric measurements
- C. Electrical circuit measurements
- D. Functional/Operating tests

Checkout Details:

A. Leak Test

1. Apply closures and attach the leak pressurization unit to the upstream side of the CSCV (valve is open).
2. Pressurize the CSCV with GHe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer check all flanges, seals, and joints for leakage.
5. Verify that the leak rate is less than 10^{-2} cc/sec/in. of flange diameter.
6. Close valve
7. Release pressure on the downstream side of valve.
8. Repeat Steps 3 and 4 and verify the CSCV valve seat leak rate is less than 10^{-2} cc/sec/in. of seal diameter.
9. Vent test gas to atmosphere and disconnect the leak test set.

B. Insulation Dielectric Measurements

1. Connect all valve electrical connections to the electrical test set.
2. Measure each actuator wire, instrumentation wire, and shield to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: Test current shall not exceed 10 ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Measurements

1. Connect all electrical connectors to the electrical test set.
2. Measure the circuit impedance to verify that the components, or their circuits, are within a prescribed tolerance, with respect to resistance, impedance and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically designated to be so, between any two wires, shields, and valve ground.
4. Verify position potentiometer and limit switch settings with respect to valve position.
5. Disconnect test set and replace protective covers.

D. Functional/Operating Test

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 28 VDC (current limited) to the limit switches.
4. Supply valve position commands monitoring the following parameters through the entire operating cycle:
 - a. Valve actuator current vs. position and time
 - b. Voltage across the valve actuator
 - c. Limit switch operation vs. time
 - d. Comparison of all position monitoring sensors
 - e. Valve position and command signal vs time (response)
 - f. Break-away torque vs. current
 - g. Valve overshoot at command position
5. Supply valve position sine wave and square wave position commands and monitor items a through g, Paragraph 4 above. Supply the sine wave commands and the square wave commands at the following frequencies: (TBD)
6. Perform the tests indicated in Paragraphs 4 and 5 at high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.
7. Disconnect the test set and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the CSCV and its subassemblies. Data log sheets, print outs, X-Y plotter charts, and strip chart recordings shall support the test records, as applicable.

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: Data Item S038, Section 7730

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. Longitudinal static acceleration: + 5.2g's, -1.0g
2. Max. lateral static acceleration: ± 1.0g

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: Data Item S038, Section 7730

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal dynamic acceleration (3-35HZ freq. range) = $\pm 6.75g's$
2. Max. lateral dynamic acceleration (.1-15HZ freq. range) = $\pm 4.5 g's$

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels:

20 to 200 cps

Linear Increase

From 0.03 to

$1.5 g^2/Hz$

(3db/Octave)

200 to 800 cps

at $1.5 g^2/Hz$

800 to 2000 cps

Linear Decrease

From 1.5 to

$0.06 g^2/Hz$

(3db/Octave)

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve

DATA SOURCE: Drawing 1136390

1.15 Envelop Dimensions

Length - 7.5"

Width - 8.5"

Height- 10.5"

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve and Actuator

DATA SOURCE: Data Item S047, Section 7730

1.16 Weight Allocation - 50 pounds

NOTE: This figure is an allocation only, not an
estimate based on any design.

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: CSCV

DATA SOURCE: NPRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I of not less than 500 seconds for a minimum of 1 hour at any time^{sp} during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Control Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>		<u>CSCV</u>			
1.0	<u>Fluid</u>	LH ₂ (CH ₂)			
2.0	(Cooldown) <u>Conditions</u>	(2 pump) Normal <u>Performance</u>	(1 pump) Malfunction <u>Performance</u>	<u>Extreme Condition</u>	<u>Throttled Condition</u>
2.1	Inlet Pressure, psia	30.0 (30.0)	(30.0)	(30.0)	(30.0)
2.2	Outlet Pressure, psia	29.5 (1324.2)	(1628.0)	(2103.0)	(678.0)
2.3	Inlet Temperature, °R	40.0 (40.0)	(40.0)	(42.0)	(40.0)
2.4	Outlet Temperature, °R	40.0 (45.0)	(45.0)	(220.0)	(51.7)
2.5	Inlet Flowrate, lb/sec	4.0 (0.0)	(0.0)	(0.0)	(0.0)
2.6	Outlet Flowrate, lb/sec	4.0 (0.0)	(0.0)	(0.0)	(0.0)
	Cooldown Pulse				
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	<u>No Limit</u>			
3.2	Valve Opening Time, sec, max	<u>1-3 sec</u>			
4.0	Cooldown Pulse <u>Shutdown Conditions</u>				
4.1	Valve Closing Time, sec, min	<u>No Limit</u>			
4.2	Valve Closing Time, sec, max	<u>1-3 sec</u>			
5.0	<u>Cooldown</u>				
5.1	Flow Rate Max, lb/sec	<u>4.0</u>			
5.2	Valve Response time, sec, max	<u>NA</u>			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	<u>None</u>			
6.2	Cooldown Pulses, per trip/total	<u>345/3450</u>			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	<u>L</u>			
8.0	Line size, in, O.D.	<u>3.0</u>			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

Notes:

This valve is closed during steady state engine burn operations.

2. Values of parameters in brackets are for valve conditions during engine steady state burn mode. Outlet pressure and temperature are based on assumption of some leakage through the CSKV.

DESIGN REQUIREMENT SHEET

9.0	<u>Leakage</u>	Inlet to outlet - 42 SCC per sec GH ₂ with 30 psia inlet press	
9.1	Internal	Outlet to inlet - 5 SCFM GH ₂ with 2200 psia outlet press.	
9.2	External		
	9.2.1	Static Seal, SCC per sec per inch joint diam	0.01
	9.2.2	Dynamic Seal, SCC per sec per inch joint diam	10.0
10.0	Pressure Drop (ΔP at Design Point) psi		0.6 $\pm$ 0.2
11.0	Actuator Power		
	11.1	Hold Position, watts	100
	11.2	Change Position, watts	
	11.2.1	Open	600
	11.2.1	Close	300
12.0	Opening and Closing Characteristics		
	12.1	Cracking Pressure, psid	N/A
	12.2	Closing Pressure, psid	N/A
13.0	Controlled Flow Rate	Rate of Change	0.1 pps per minute min.

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

Tr. to CSCV_{IN}

STATE POINT No 50

FIGURE 2.0-1

CSCVIN

STATE POINT No 50

FIGURE 2.0-2

CSCV_{OUT}

STATE POINT NO 51

FIGURE 2.0-3

CSCV_{OUT}

STATE POINT No 51

FIGURE 2.0-4

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

•COOLANT SUPPLY CHECK VALVE (CSKV)

EC-90259

The following data are included in this issue:

		<u>Sheet</u>	<u>Revision</u>
1.0	Design Criteria		
1.1	Reliability Allocation	1	0
1.2	Maintainability	2	0
1.3	Useful Life	3	0
1.4	Nuclear Environment	4	0
1.5	Thermal Environment	5	0
1.6	Natural Environment	6	0
1.7	Dimensional Interfaces	7	0
1.8	Mechanical Interfaces	8	0
1.9	Electrical Interfaces	9	0
1.10	Functional Interfaces	10	0
1.11	Handling & Shipping	11	0
1.12	Test & Checkout	12	0
1.13	Static Loads	13	0
1.14	Dynamic Loads	14	0
1.15	Envelop Dimensions	15	0
1.16	Weight Allocation	16	0
1.17	Safety	17	0
2.0	Steady State Functional Performance	18	0
3.0	Startup Transient Functional Performance	19	0
4.0	Throttling Transient Functional Performance	20	0
5.0	Shutdown Transient Functional Performance	21	0
6.0	Cooldown Functional Performance	22	0

Date: 12-3-69
Rev: 0
Sheet: 1

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: Memorandum 7850:M0346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999980 or greater.

DATE: 12-3-69
REV: 0
SHEET: 2

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve, EC 90259

DATA SOURCE: NPRD-1 and Evaluation by Klacking/Shoemaker

- 1.2 Maintainability - The Coolant Supply Check Valve shall be designed to incorporate the maintainability requirements of the Engine. (See Sheet 2 of RN-DR-0187). The following time limitations shall be met; (a) Repair Time - The time required to repair shall not exceed (2.0) hours, (b) Active Maintenance Time - The maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operation.
- 1.2.1 Maintenance and Repair Cycles
- 1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.
- 1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.
- 1.2.2 Service and Access
- 1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.
- 1.2.2.2 Capability for remote and manual replacement of valve assembly shall be provided for both ground test engines and space operations. Replacement will be accomplished by replacing a module containing the CSKV, (2) CSCV, and their Interconnecting Lines.
- 1.2.2.3 The Coolant Supply Check Valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.
- 1.2.2.4 Provision shall be made for purging the coolant supply check valve with inert gas through the engine purge system.
- 1.2.2.5 Coolant Supply Check Valves shall be physically interchangeable without adjustment or modification of mating engine components.
- 1.2.2.6 Capability for manual replacement of the actuator shall be provided for ground test engines and space operations.

Date: 12-3-69
Rev: 0
Sheet: 3

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life

The
shall be capable of satisfying the minimum useful life of the
NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes (maximum of 60 cycles)
1.3.2	Non-Rated Operating Life (Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad (Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years (Including Operational Life)
1.3.4	Storage Life (Ground)	5 years

DATE: 12-3-69
 REV: 0
 SHEET: 4

DESIGN REQUIREMENT SHEET

Component: CSKV

Data Source: Engineering Judgement Based on Analysis of an Idealized Configuration, Dept. 7830, Warman

1.4 Nuclear Environment Flight Engine - No Shield - Unperturbed

Description	Location(In) Station R		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
						Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
CSKV	2.3	36.0	8.9 + 5	8.9 + 6	1.1 - 4	4.6 + 9	1.7+14	5.9 + 10	2.1+15	2.1 + 11	7.6 + 15
CSKV			2.3 + 6		<u>ETS-1</u> 2.8 - 4			9.9 + 10			

Date: 12-3-69
REV: 0
SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CPO90194-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6-1
NATURAL ENVIRONMENTS SUMMARY
COOLANT SUPPLY CHECK VALVE

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.09 \text{ lb/in}^2$ in 1 hr
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min: 188 Max: 559 (ETR Values)
Atmospheric Density - lb/ft^3	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	Min: 7.12×10^{-2} Max: 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch: 11.8 gr $\text{H}_2\text{O/ft}^3$	Extreme: 100% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs, 15 day cycle
Solar radiation - $\text{Btu/ft}^2/\text{hr}$	442.4	N.A.	TBD
Rain	N.A.	N.A.	N.A.
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

COOLANT SUPPLY CHECK VALVE

2 of 2

Phase			Vehicle Assembly and Checkout Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

DATE: 12-3-69
REV: 0
SHEET: 7

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve

DATA SOURCE: Dwg. 1136390, Dept. 7840, Klacking/Krivanec

1.7 Dimensional Interfaces

I.D. at both ends - 2.902"

O.D. at both ends - 3.00"

DATE: 12-3-69
REV: 0
SHEET: 8

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.8 Mechanical Interfaces

Welded to line (both ends)

DATE: 12-3-69
REV: 0
SHEET: 9

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.9 Electrical Interfaces

Data not available for this issue.

DATE: 12-3-69
REV: 0
SHEET: 10

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.10 Functional Interfaces

Refer to Section 2.0, Sheet 18

DATE: 12-3-69
REV: 0
SHEET: 11

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: McClurkin, Dept. 7810, Packaging Plan - Maintainability Plan

1.11 Handling and Shipping

- (1) Capability of being handled and shipped in any attitude after proper packaging.
- (2) Shipment by land, sea or air.
- (3) Methods for preservation, packaging, and packing for the component will be developed to provide adequate protection against corrosion, contamination, and physical damage from shock and vibration. Packaging will be designed to facilitate handling, inspection, and warehousing. Special packing requirements should be defined by the designer if the shock and vibration loads presented in Data ITEM S-038 "Environment Vibration and Acoustics Report" are considered excessive.
- (4) SSCL (Sta. 0.00 to - 23.00), CSCV, CSKV shipped as a module.

DATE: 12-3-69
REV: 0
SHEET: 12

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to R. W. Froelich,
dtd 11-21-69

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DATE: 12-3-69
REV: 0
SHEET: 13

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: Dept. 7730, Data Item S038

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal static acceleration: ± 5.2 g's, -1.0 g
2. Max. lateral static acceleration: ± 1.0 g

DATE: 12-3-69
REV: 0
SHEET: 14

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: Dept. 7730, Data Item S038

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal dynamic acceleration (3-35 Hz Freq. Range) =
 ± 6.75 g's.
2. Max. lateral dynamic acceleration (.1-15 Hz Freq. Range) =
 ± 4.5 g's.

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels:

<u>20 to 200 cps</u>	<u>300 to 800 cps</u>	<u>800 to 2000 cps</u>
Linear Increase	at $1.5 \text{ g}^2/\text{Hz}$	Linear Decrease
From 0.03 to		From 1.5 to
$1.5 \text{ g}^2/\text{Hz}$		$0.06 \text{ g}^2/\text{Hz}$
(3db/Octave)		(3db/Octave)

DATE: 12-3-69
REV: 0
SHEET: 15

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve

DATA SOURCE: Dwg. 1136390

1.15 Envelope Dimensions

Length = 7.0"

Width = 6.0"

Height = 10.5"

DATE: 12-3-69
REV: 0
SHEET: 16

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve and Actuator

DATA SOURCE: Dept. 7730, Data Item S047

1.16 Weight Allocation - 25 pounds

NOTE: This figure is an allocation only, not an estimate based
on any design.

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: CSKV

DATA SOURCE: NPRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I_{sp} of not less than 500 seconds for a minimum of 1 hour at any time during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Coolant Supply Check Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>		<u>CSKV</u>			
1.0	<u>Fluid</u>	LH ₂ (CH ₂)			
2.0	<u>Cooldown Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1	Inlet Pressure, psia	29.5 (30.0)	(30.0)	(30.0)	(30.0)
2.2	Outlet Pressure, psia	29.3 (1324.2)	(1628.0)	(2103.0)	(678.0)
2.3	Inlet Temperature, °R	40.0 (50.0)	(45.0)	(67.5)	(50.0)
2.4	Outlet Temperature, °R	40.0 (61.1)	(67.3)	(220.0)	(51.7)
2.5	Inlet Flowrate, lb/sec	4.0 (0.0)	(0.0)	(0.0)	(0.0)
2.6	Outlet Flowrate, lb/sec	4.0 (0.0)	(0.0)	(0.0)	(0.0)
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	no limit			
3.2	Valve Opening Time, sec, max	0.5 sec			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	no limit			
4.2	Valve Closing Time, sec, max	0.5 sec			
5.0	<u>Cooldown</u>				
5.1	Flow Rate , lb/sec	4.0			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	none			
6.2	Cooldown Pulses, per trip/total	345/3450			
7.0	Position Limit Indicator continuous(c) or limit switch(l)	L			
8.0	Line size, in, O.D.	30			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

Note:

This valve is closed during steady state engine operations.

2. Values of parameters in brackets are for valve conditions during engine steady state mode.

9.0	<u>Leakage</u>	
9.1	Internal (Forward Flow)	50 SCC He with inlet press. 30 psia
9.2	External (Reverse Flow)	5 SCC He with outlet press. as in 2.0
	9.2.1 Static Seal, SCC per sec per inch joint diam	<u>0.01</u>
	9.2.2 Dynamic Seal, SCC per sec per inch joint diam	<u>10.0</u>
10.0	Pressure Drop (ΔP at Design Point) psi	<u>0.3 ± 0.1</u>
11.0	Actuator Power	
	11.1 Hold Position, watts	<u>N/A</u>
	11.2 Change Position, watts	
	11.2.1 Open	<u>100</u>
	11.2.1 Close	<u>375</u>
12.0	Opening and Closing Characteristics	
	12.1 Cracking Pressure, psid	<u>$2(+2, -0)$</u>
	12.2 Closing Pressure, psid	<u>$0(+4, -0)$</u>
13.0	Controlled Flow Rate	<u>N/A</u>

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

CSKV_{III}

STATE POINT No 52

FIGURE 2.0-1

$CSK V_{IN}$ STATE POINT No 52

754 NERVA FULL FLOW ENGINE No 1136390

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

FIGURE 2.0-2

CSK.V_{OUT}

STATE POINT NO. 53

FIGURE 2.0-3

CSKV_{OUT}

STATE POINT No 53

FIGURE 2.0-4

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

TURBINE DISCHARGE CHECK VALVE (TDKV)

EC-90260

The following data are included in this issue:

	<u>Sheet</u>	<u>Revision</u>
1.0 Design Criteria		
1.1 Reliability Allocation	1	0
1.2 Maintainability	2	0
1.3 Useful Life	3	0
1.4 Nuclear Environment	4	0
1.5 Thermal Environment	5	0
1.6 Natural Environment	6	0
1.7 Dimensional Interfaces	7	0
1.8 Mechanical Interfaces	8	0
1.9 Electrical Interfaces	9	0
1.10 Functional Interfaces	10	0
1.11 Handling & Shipping	11	0
1.12 Test & Checkout	12	0
1.13 Static Loads	13	0
1.14 Dynamic Loads	14	0
1.15 Envelop Dimensions	15	0
1.16 Weight Allocation	16	0
1.17 Safety	17	0
2.0 Steady State Functional Performance	18	0
3.0 Startup Transient Functional Performance	19	0
4.0 Throttling Transient Functional Performance	20	0
5.0 Shutdown Transient Functional Performance	21	0
6.0 Cooldown Functional Performance	22	0

Date: 12-3-69
Rev: 0
Sheet: 1

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: Memorandum 7850:MO346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999480 or greater.

Date: 12-3-69
Rev: 0
Sheet: 2

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve, EC 90260

DATA SOURCE: NPRD-1 and evaluation by Klacking/Shoemaker

1.2 Maintainability

The Turbine Discharge Check Valve shall be designed to incorporate the maintainability requirements of the engine. (See Sheet 2 of RN-DR-0187.) The following time limitations shall be met: (a) repair time--the time required to repair shall not exceed (1.5) hours, (b) active maintenance time--the maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operations.

1.2.1 Maintenance and Repair Cycles

1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.

1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.

1.2.2 Service and Access

1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.

1.2.2.2 Capability for remote and manual replacement of valve assembly shall be provided for both ground test engines and space operations. Replacement will be accomplished by replacing both TDKV's and their interconnecting lines.

1.2.2.3 The Turbine Discharge Check Valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.

1.2.2.4 Provision shall be made for purging the Turbine Discharge Check Valve with inert gas through the engine purge system.

1.2.2.5 Turbine Discharge Check Valve shall be physically interchangeable without adjustment or modification of mating engine components.

Date: 12-3-69
Rev: 0
Sheet: 3

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life

The Turbine Discharge Check Valve shall be capable of satisfying the minimum useful life of the NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes (maximum of 60 cycles)
1.3.2	Non-Rated Operating Life (Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad (Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years (Including Operational Life)
1.3.4	Storage Life (Ground)	5 years

SHEET: 4

Component: TDKV

1.4 Nuclear Environment --Flight Engine--No Shield--Unperturbed

Description	Location(In)		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
	Station	R				Flux n/cm ² -sec	Nvt n/cm ²	Flux n/cm ² -sec	Nvt n/cm ²	Flux n/cm ² -sec	Nvt n/cm ²
TDL Bell #2	69.1	33.8	2.3 + 6	2.3 + 7	2.9 - 4	6.4 + 9	2.3 + 14	3.0 + 11	1.1 + 16	5.2 + 11	1.9 + 16
TDL Bell #2			3.7 + 6		<u>ETS-1</u> 4.6 - 4			3.4 + 11			

Date: 12-3-69
REV: 0
SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CP090194-F1 - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1
NATURAL ENVIRONMENTS SUMMARY
Turbine Discharge Check Valve

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Launch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	Min 14.4, max 15.0 $\Delta P = 0.04 \text{ lb/in}^2 \text{ in 24 hr.}$ $\Delta P_{\text{max}} = -0.09 \text{ lb/in}^2 \text{ in 1 hr}$
Atmospheric temperature (Kinetic) °R	2700°R at 262 N.M.	See Figure 3 for nominal profile	Min 480 Max 559 (IF Values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profile established by Figures 1 and 2	Min 7.2 x 10 ⁻² Max 8.27 x 10 ⁻²
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch 11.8 x 10 ⁻³	the 100% at 73°F for 6 hrs, 75% at 82°F for 18 hrs, 15% by cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	TBD
Rain	N.A.	N.A.	N.A.
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	See Table 10	See Table 10	N.A.

Phase			Vehicle Assembly and Checkouts, Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	N.A.
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

Date: 12-3-69
Rev: 0
Sheet: 7

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve

DATA SOURCE: Dwg. 1136390, Dept. 7840, Klacking/Krivanec

1.7 Dimensional Interfaces

"Y" Valve $\left\{ \begin{array}{l} 8.0'' \text{O.D. at both inlet legs.} \\ 9.5'' \text{O.D. at outlet leg.} \end{array} \right.$

Date: 11-6-69
Rev: 0
Sheet: 8

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.8 Mechanical Interfaces

"Y" Valve { Coupling at outlet.
Welded to lines at both inlet legs.

Date: 12-3-69
Rev: 0
Sheet: 9

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.9 Electrical Interfaces

Data not available for this issue.

Date: 12-3-69
Rev: 0
Sheet: 10

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve

DATA SOURCE: Engineering Evaluation, Dept. 7840, Klacking/Krivanec

1.10 Functional Interfaces

Refer to Section 2.0, Sheet 18

Date: 12-3-69
Rev: 0
Sheet: 11

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: McClurkin, Dept. 7810, Packaging Plan

1.11 Handling and Shipping

- (1) This component is shipped installed in the Thrust Structure Module.
- (2) No peculiar handling requirements are anticipated prior to or during factory assembly.

Date: 12-3-69
Rev: 0
Sheet: 12-1

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to
R. W. Froelich, dated 11-21-69

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine requirements due to secondary radiation.

For ground test requirements, see Nuclear Environment Section.

Date: 11-26-69
Rev: 0
Sheet: 12-2

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Coolant Valve, EC 90192

DATA SOURCE: J. L. McClurkin, Dept. 7810

1.12 Checkout

Checks to be performed:

- A. Leak test
- B. Insulation dielectric measurements
- C. Electrical circuit measurements
- D. Function/operating tests

Checkout details:

A. Leak Test

1. Apply closures and attach the leak pressurization unit to the upstream side of the SSCV (valve is open).
2. Pressurize the SSCV with GHe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer, check all flanges, seals, and joints for leakage.
5. Verify that the leak rate is less than 10^{-2} cc/sec/in. of flange diameter.
6. Close valve.
7. Release pressure on the downstream side of valve.
8. Repeat Steps 3 and 4 and verify the SSCV valve seat leak rate is less than 10^{-2} cc/sec/in. of seal diameter.
9. Vent test gas to atmosphere and disconnect the leak test set.

B. Insulation Dielectric Measurements

1. Connect all valve electrical connections to the electrical test set.

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Rev: 0
Sheet: 12-3

2. Measure each actuator wire, instrumentation wire, and shields to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: Test current shall not exceed 10 ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Measurements

1. Connect all valve electrical connectors to the electrical test set.
2. Measure the circuit impedance to verify that the components, or their circuits, are within a prescribed tolerance, with respect to resistance, impedance and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically designated to be so, between any two wires, shields, and valve ground.
4. Verify position potentiometer and limit switch settings with respect to valve position.
5. Disconnect test set and replace protective covers.

D. Functional/Operating Tests

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 28 VDC (current limited) to the limit switches.
4. Supply valve position commands monitoring the following parameters through the entire operating cycle:
 - a. Valve actuator current vs. position and time.
 - b. Voltage across the valve actuator.
 - c. Limit switch operation vs. time.
 - d. Comparison of all position monitoring sensors.
 - e. Valve position and command signal vs. time (response).

Date: 11-26-69
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Sheet: 12-4

- f. Break-away torque vs. current.
 - g. Valveovershoot at command position.
- 5. Supply valve position sine wave and square wave position commands and monitor Items a through g, Paragraph 4 above. Supply the sine wave commands and the square wave commands at the following frequencies: (TBD)
 - 6. Perform the tests indicated in Paragraphs 4 and 5 at the high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.
 - 7. Disconnect the test set and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the SSCV and its subassemblies. Data log sheets, print-outs, X-Y plotter charts, and strip chart recordings shall support the test records, as applicable.

DATE: 12-3-69
REV: 0
SHEET: 13

DESIGN REQUIREMENTS SHEET

COMPONENT: TNKV

DATA SOURCE: Dept. 7730, Data Item S038

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal static acceleration: + 5.2 g's, -1.0 g
2. Max. lateral static acceleration: ± 1.0 g.

DATE: 12-3-69
REV: 0
SHEET: 14

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: Dept. 7730 - Data Item S038

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal dynamic acceleration (3-35 Hz Freq. Range) =
± 6.75 g's.
2. Max. lateral dynamic acceleration (.1-15 Hz Freq. Range) =
± 4.5 g's.

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels.

20 to 200 cps

Linear Increase

From 0.03 to

1.5 g^2 /Hz

(3db/Octave)

200 to 800 cps

at 1.5 g^2 /Hz

800 to 2000 cps

Linear Decrease

From 1.5 to

0.06 g^2 /Hz

(3db/Octave)

DATE: 12-3-69
REV: 0
SHEET: 15

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve

DATA SOURCE: Dwg. 1136390

1.15 Envelope Dimensions

Length = 12.0"

Width = 24.0"

Height = 19.5"

DATE: 12-3-69
REV: 0
SHEET: 16

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve

DATA SOURCE: Dept. 7730, Data Item S047

1.16 Weight Allocation - 80 pounds

NOTE: This figure is an allocation only, not an estimate based
on any design.

Date: 12-3-69
Rev: 0
Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: TDKV

DATA SOURCE: NFRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I of not less than 500 seconds for a minimum of 1 hour at any time^{sp} during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Turbine Discharge Check Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>		<u>TDKV</u>			
1.0	<u>Fluid</u>	GH ₂			
2.0	<u>Steady State Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1	Inlet Pressure, psia	690.0	725.0	738.0	421.8
2.2	Outlet Pressure, psia	685.0	707.0	720.0	418.7
2.3	Inlet Temperature, °R	230.0	228.0	315.0	249.9
2.4	Outlet Temperature, °R	230.0	228.0	315.0	249.9
2.5	Inlet Flowrate, lb/sec	37.9	76.3	88.0	15.7
2.6	Outlet Flowrate, lb/sec	37.9	76.3	88.0	15.7
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	No Limit			
3.2	Valve Opening Time, sec, max	3000 psid/sec			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	No limit			
4.2	Valve Closing Time, sec, max	3000 psid/sec			
5.0	<u>Cooldown</u>				
5.1	Flow Rate MN, lb/sec	none			
5.2	Valve Response time, sec, max	N/A			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	8/80			
6.2	Cooldown Pulses, per trip/total	none			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	none			
8.0	Line size, in, O.D.	7.902			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

9.0	<u>Leakage</u>	
9.1	Internal (Reverse Flow)	<u>SSCFM with conditions of 2.0</u>
9.2	External	
9.2.1	Static Seal, SCC per sec per inch joint diam	<u>0.01</u>
9.2.2	Dynamic Seal, SCC per sec per inch joint diam	<u>10.0</u>
10.0	Pressure Drop (ΔP at Design Point) psi	<u>5.0 + 0.5</u>
11.0	Actuator Power	
11.1	Hold Position, watts	<u>N/A</u>
11.2	Change Position, watts	
11.2.1	Open	<u>N/A</u>
11.2.1	Close	<u>N/A</u>
12.0	Opening and Closing Characteristics	
12.1	Cracking Pressure, psid	<u>2(+2, -0)</u>
12.2	Closing Pressure, psid	<u>0(+4, -0)</u>
13.0	Controlled Flow Rate	<u>N/A</u>

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

TURBINE DECH. LINE to T D K V₁₁₁

STATE POINT NO 37

15K NERVA FULL FLOW ENGINE NO 1136300

MISSION A-L-M, 1ST BURN 1457 SEC SS, STUP=52, SHDN=45 SEC, CST=7.6 HR

PART NAME
SPEC TREE NO
PLOTTED BY
CHECKED BY

20 27 32 1500 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 T₁₂

FIGURE 2.0-1

TDKVIN

STATE POINT No 37

FIGURE 2.0-2

TDRV_{OUT}

STATE POINT NO. 38

FIGURE 2.0-3

TORV_{OUT}

STATE POINT No 38

FIGURE 2.0-4

DESIGN REQUIREMENTS SHEETS

Appended hereto are design criteria and functional performance requirements for the

STRUCTURAL SUPPORT BLOCK VALVE AND ACTUATOR (SSBV) EC-90261

The following data are included in this issue:

		<u>Sheet</u>	<u>Revision</u>
1.0	Design Criteria		
1.1	Reliability Allocation	1	0
1.2	Maintainability	2	0
1.3	Useful Life	3	0
1.4	Nuclear Environment	4	0
1.5	Thermal Environment	5	0
1.6	Natural Environment	6	0
1.7	Dimensional Interfaces	7	0
1.8	Mechanical Interfaces	8	0
1.9	Electrical Interfaces	9	0
1.10	Functional Interfaces	10	0
1.11	Handling & Shipping	11	0
1.12	Test & Checkout	12	0
1.13	Static Loads	13	0
1.14	Dynamic Loads	14	0
1.15	Envelop Dimensions	15	0
1.16	Weight Allocation	16	0
1.17	Safety	17	0
2.0	Steady State Functional Performance	18	0
3.0	Startup Transient Functional Performance	19	0
4.0	Throttling Transient Functional Performance	20	0
5.0	Shutdown Transient Functional Performance	21	0
6.0	Cooldown Functional Performance	22	0

Date: 12-3-69

Rev: 0

Sheet: 1

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: Memorandum 7850:MO346, Mihanovich to Varga

1.1 Reliability Allocation

The probability that this component shall successfully fulfill its operating requirements shall be .999760 or greater.

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve

DATA SOURCE: NPRD-1 and evaluation by Klacking/Shoemaker, EC-90261

1.2 Maintainability: The structural support block valve shall be designed to incorporate the maintainability requirements of the engine. (See Sheet 2 of TN-DR-0187). The following time limitations shall be met: (a) repair time - the time required to repair shall not exceed (3.5) hours. (b) Active maintenance time - the maximum time required for preventive and corrective maintenance shall not exceed (.1) man hours per hour during engine assembly and operations.

1.2.1 Maintenance and repair cycles

1.2.1.1 Periodic maintenance, other than an inert gas purge, shall not be required during storage.

1.2.1.2 Periodic maintenance or repair shall not be used to attain specified reliability or operating life requirements.

1.2.2 Service and access

1.2.2.1 Capability for remote malfunction detection and fault isolation will be provided.

1.2.2.2 Capability for remote and manual replacement of valve/ actuator assembly shall be provided for both ground test engines and space operations. Replacement will be accomplished by replacing a module containing the (4) SSBV, (2) SSCV, and their inter-connecting lines.

1.2.2.3 Capability for manual replacement of the actuator shall be provided for both ground test engines and space operations.

1.2.2.4 The structural support block valve shall be designed so manual maintenance and repair, including parts replacement can be accomplished with standard hand tools.

1.2.2.5 Provision shall be made for purging the structural support block valve with inert gas through the engine purge system.

1.2.2.6 Structural support block valve shall be physically interchangeable without adjustment or modification of mating engine components.

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: NPRD-1 Revision 6 (Draft)
Dept. 7810 Interpretation of NPRD-1
and Engineering Estimate - Froelich/Paavola

1.3 Useful Life

The Structural Support Block Valve
shall be capable of satisfying the minimum useful life of the
NERVA Engine, allocated as follows:

1.3.1	Rated Operating Life	600 minutes (maximum of 60 cycles)
1.3.2	Non-Rated Operating Life (Transients and In-Flight Checkout)	72 days
1.3.3	Non-Operating Life	
1.3.3.1	Engine Assembly to Launch Pad (Less Storage)	6 months
1.3.3.2	Launch Pad Environment	6 months
1.3.3.3	Space Storage Conditions	3 years (Including Operational Life)
1.3.4	Storage Life (Ground)	5 years

DATE: 12-3-69
REV: 0
SHEET: 4

DESIGN REQUIREMENT SHEET

Component: SSBV

Data Source: Engineering judgement based on analysis of an idealized configuration, Section 7830, Warman

1.4 Nuclear Environment Flight Engine - No Shield - unperturbed

Description	Location(In) Station R		γ Kerma Rate Rads/Hr	γ Kerma Rate Rads (10 Hr Exp)	γ Heating Rate Btu/in ³ -sec	Thermal Neutron		Fast Neutron		Epi Thermal	
						Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²	Flux n/cm ² sec	Nvt n/cm ²
SSBV #1	63.2	18.4	2.0 + 6	2.0 ÷ 7	2.8 - 4	8.8 + 8	3.2+13	1.7+11	6.1+15	1.7 + 11	6.1 ÷ 15
SSBV #1			3.4 + 6		ETS - 1 4.5 - 4			2.1+11			

Date: 12-3-69

REV: 0

SHEET: 5

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: K. Sato, Dept. 7730

1.5 Thermal Environment

Data not available at this time.

Date: 12-3-69
Rev: 0
Sheet: 6

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: NERVA Engine Natural Environment Report Data Item
S023-CPO90194-FL - S. A. Varga, Dept. 7810

1.6 Natural Environment

The natural environments to which the component will be exposed are as specified in Table 1.6-1. The tables and figures referenced within Table 1.6-1 are presented in the Reference Data Section of this document.

Table 1.6 - 1

NATURAL ENVIRONMENT SUMMARY

Structural Support Block Valve and Actuator EC-90261

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Orbital and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	Sea Level to 262 N. miles	Sea Level
Atmospheric pressure, psia	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	See Figure 4, - 0.04 psia in 24 hr. Max = - 0.14 psia
Atmospheric temperature (kinetic) °R	2700°R at 262 N.M.	See Figure 2 for nominal profile	min. 188 max. 55° (R values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	min. 7.12×10^{-2} max. 8.27×10^{-2}
Atmospheric composition	See Figure 4	As established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch 11.8 gr H ₂ O/lb	Max 60% rh @ 73°F for 6 hrs, 75% rh @ 82°F for 18 hrs., 5 d cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	TBD
Rain	N.A.	N.A.	N.A.
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	N.A.	N.A.	N.A.

Phase			Vehicle Assembly and Checkout Prelaunch and Launch Operations
Environment	Space Operations	Flight Vehicle Boost	
Wind, ft/sec	N.A.	N.A.	See Table 9
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation - high energy particle	See Table 6	Negligible	N.A.
Radiation - trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/m ³	N.A.	N.A.	N.A.

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve

DATA SOURCE: Drawing 1136300, Section, Klacking/Krivanic

1.7 Dimensional Interfaces

Line I.D. = 2.902" (inlet & outlet)

Flange = none

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanec

1.8 Mechanical Interfaces

Welded (inlet and outlet)

Replaceable as line-valve module

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanic

1.9 Electrical Interfaces

No data available for this issue

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve

DATA SOURCE: Engineering Evaluation, Section 7840, Klacking/Krivanic

1.10 Functional Interfaces

Refer to Section 2.0 Sheet 18

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: Packaging Plan, Section 7810, McClurkin

1.11 Handling & Shipping

1. This component is shipped installed in the Thrust Structure Module or as a valve and piping module.
2. Attach points for lifting the component should be provided for handling during pre-assembly and assembly.
3. Methods for preservation, packaging, and packing for the component or module will be developed to provide adequate protection against corrosion, contamination, and physical damage from shock and vibration. Packaging will be designed to facilitate handling, inspection, and warehousing. Special packing requirements should be defined by the designer if the shock and vibration loads presented in Data Item S-038 "Environment Vibration and Acoustics Report" are considered excessive.

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: Memorandum 7810:1803M, R. A. Henderson to R. W. Froelich,
dated 11-21-69.

1.12 Test

Radiation hardness requirements for components within the engine test compartment will exceed the Flight Engine Requirements due to secondary radiation.

For Ground Test requirements see Nuclear Environment Section.

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve and Actuator, EC-90261

DATA SOURCE: XE Experience, Section 7810, McClurkin/Bailey

1.12 Checkout

Checks to be Performed:

- A. Leak test
- B. Insulation dielectric measurements
- C. Electrical circuit measurements
- D. Functional/Operating tests

Checkout Details:

A. Leak Test

1. Apply closures and attach the leak pressurization unit to the upstream side of the SSBV (valve is initially open).
2. Pressurize the SSBV with GHe to 50 psi.
3. Monitor the pressure decay rate.
4. With a Uson type sniffer check all flanges, seals, and joints for leakage.
5. Verify that the leak rate is less than 10^{-2} cc/sec/in. of flange diameter
6. Close valve.
7. Release pressure on the downstream side of valve.
8. Repeat Steps 3 and 4 and verify the SSBV valve leak rate is less than 10^{-2} cc/sec/in. of seal diameter.
9. Vent test gas to atmosphere.

B. Insulation Dielectric Measurements

1. Connect all valve and actuator electrical connections to the Electrical Test Set.
2. Measure each actuator wire, instrumentation wire, and shield to verify that the insulation resistance is above 500 megohms at 100 VDC. NOTE: Test current shall not exceed 10 ma.
3. Disconnect connections and replace protective covers.

C. Electrical Circuit Requirements

1. Connect all electrical connectors to the electrical test set.
2. Measure the circuit impedance to verify that the components, or their circuit, are within a prescribed tolerance, with respect to resistance, inductance, and capacitance.
3. Verify that there are no opens, shorts, or grounds, unless specifically connected to bus, between any wires, shields, and valve ground.
4. Verify position potentiometer and limit switch settings with respect to valve position.
5. Disconnect the test set and replace the valve protective covers.

D. Functional/Operating Tests

1. Remove protective covers and connect the electrical test set.
2. Apply 10 VDC to the position potentiometers.
3. Apply 28 VDC (current limited) to the limit switches.
4. Supply valve open command and monitor the following parameters through the entire opening cycle:
 - a. Valve current vs. position
 - b. Voltage across the valve actuator
 - c. Limit switch operation vs. time
 - d. Comparison of all position monitoring sensors
 - e. Valve position vs. time
 - f. Break-away torque
 - g. Valve bounce at end of travel
5. Supply valve close command and monitor items a through g, Paragraph 4 above. In addition, verify that the opening and closing hysteresis characteristics are within prescribed band width tolerance.
6. Perform the test indicated in Paragraphs 4 and 5 at the high and low voltage extremes, and verify the ability of the valve to meet its operating characteristics.
7. Disconnect the test set and replace the valve protective covers.

E. Documentation

During all of the above testing, test records shall be maintained to a detail that will allow a trend analysis to be performed on the SSBV and its subassemblies. Data log sheets, printouts, X-Y plots, and strip chart recordings shall support the test records, as applicable.

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: Data Item S038, Section 7730

1.13 Static Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. Longitudinal static acceleration: +5.2g's; -1.0g
2. Max. lateral static acceleration: ± 1.0g

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: Data Item S038, Section 7730

1.14 Dynamic Loads

Valve components are designed primarily by pressure loads. Structural considerations are relatively insignificant for preliminary design of these components. Structural aspects of these components will be evaluated during preliminary design phase or when geometric, material, temperature and performance parameters are sufficiently defined.

Load Condition: Launch Vehicle Operations

1. Max. longitudinal dynamic acceleration: (3-35HZ freq. range) = $\pm 6.75g's$
2. Max. lateral dynamic acceleration: (.1-15HZ freq. range) = $4.5g's$.

Vibration

The component shall withstand random vibration along each of three mutually perpendicular axes for 30 minutes in each axis at the following levels:

<u>20 to 200 cps</u>	<u>200 to 800 cps</u>	<u>800 to 2000 cps</u>
Linear Increase From 0.03 to $1.5 g^2/Hz$ (3db/Octave)	at $1.5 g^2/Hz$	Linear Decrease From 1.5 to $0.05 g^2/Hz$ (3db/Octave)

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve

DATA SOURCE: Drawing 1136390

1.15 Envelope Dimensions

Length = 9.5 "

Width = 8.5 "

Height = 10.5 "

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve and Actuator

DATA SOURCE: Data Item S-047, Section 7730

1.16 Weight Allocation - 40 pounds

NOTE: This figure is an allocation only, not an estimate
based on any design

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Sheet: 17

DESIGN REQUIREMENT SHEET

COMPONENT: SSBV

DATA SOURCE: NFRD-1 Revision 6 (Draft) Para. III.B.1.p
(As interpreted by Dept. 7810)

1.17 Safety

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

Under degraded conditions component design shall provide for continuous engine operation at approximately 40% thrust and an I of not less than 500 seconds for a minimum of 1 hour at any time^{sp} during the engine's operating life.

DESIGN REQUIREMENT SHEET

COMPONENT: Structural Support Block Valve

DATA SOURCE: RN-PD-T-1601, and Engineering Estimates, Dept. 7830 - Petite

<u>Paragraph</u>	<u>Item</u>	<u>Sheet</u>
2.0	Steady State Functional Performance	18
3.0	Startup Transient Functional Performance	19
4.0	Throttling Transient Functional Performance	20
5.0	Shutdown Transient Functional Performance	21
6.0	Cooldown Functional Performance	22

Refer to Table 2.0 and Figure 2.0 for component steady state, startup, throttling, shutdown, and cooldown functional performance data.

<u>Component</u>		<u>SSBV #1 and #2</u>			
1.0	<u>Fluid</u>	<u>GH₂</u>			
2.0	<u>Steady State Conditions</u>	<u>(2 pump) Normal Performance</u>	<u>(1 pump) Malfunction Performance</u>	<u>Extreme Condition</u>	<u>Throttled Condition</u>
2.1	Inlet Pressure, psia	1325.5	1630.0	2116.0	680.6
2.2	Outlet Pressure, psia	1324.2	1629.2	2115.0	679.2
2.3	Inlet Temperature, °R	61.1	67.3	67.5	51.7
2.4	Outlet Temperature, °R	61.1	67.3	67.5	51.7
2.5	Inlet Flowrate, lb/sec	5.3	5.3	5.3/16.25*	5.3
2.6	Outlet Flowrate, lb/sec	5.3	5.3	5.3/16.25*	5.3
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	<u>No Limit</u>			
3.2	Valve Opening Time, sec, max	<u>NA</u>			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	<u>No Limit</u>			
4.2	Valve Closing Time, sec, max	<u>NA</u>			
5.0	<u>Cooldown</u>				
5.1	Flow Rate Max. lb/sec	<u>4.0 gas</u>			
5.2	Valve Response time, sec, max	<u>1-3</u>			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	<u>8/80</u>			
6.2	Cooldown Pulses, per trip/total	<u>340/3450</u>			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	<u>L</u>			
8.0	Line size, in, O.D.	<u>3.0</u>			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

*End of engine life - corrosion reactivity correction.

<u>Component</u>		<u>SSBV #3 and #4</u>			
1.0	<u>Fluid</u>	GH ₂			
2.0	<u>Steady State Conditions</u>	(2 pump) Normal Performance	(1 pump) Malfunction Performance	Extreme Condition	Throttled Condition
2.1	Inlet Pressure, psia	1324.0	1630.0	2105.0	679.0
2.2	Outlet Pressure, psia	1317.4	1624.6	2098.0	674.0
2.3	Inlet Temperature, °R	61.1	67.3	67.5	51.7
2.4	Outlet Temperature, °R	61.1	67.3	67.5	51.7
2.5	Inlet Flowrate, lb/sec	15.3	14.7	15.7/4.75*	9.5
2.6	Outlet Flowrate, lb/sec	15.3	14.7	15.7/4.75*	9.5
3.0	<u>Startup Conditions</u>				
3.1	Valve Opening Time, sec, min	No Limit			
3.2	Valve Opening Time, sec, max	1-3			
4.0	<u>Shutdown</u>				
4.1	Valve Closing Time, sec, min	No Limit			
4.2	Valve Closing Time, sec, max	1-3			
5.0	<u>Cooldown</u>				
5.1	Flow Rate Min lb/sec	0			
5.2	Valve Response time, sec, max	N/A			
6.0	<u>Number of Operations</u>				
6.1	Main Burns, per trip/total	8/80			
6.2	Cooldown Pulses, per trip/total	N/A			
7.0	Position Limit Indicator continuous(c) or limit switch(L)	L			
8.0	Line size, in, O.D.	3.0			

Estimates as of 4 December 1969

Data Source: RN-PD-T-1601C

*End of engine life - corrosion reactivity correction.

9.0	<u>Leakage</u>	(Thrust Mode)	5 SCFM under conditions in 2.0
9.1	Internal	(Cooldown Mode)	500 SCC per sec under conditions in 2
9.2	External		
	9.2.1	Static Seal, SCC per sec per inch joint diam	<u>0.01</u>
	9.2.2	Dynamic Seal, SCC per sec per inch joint diam	<u>10.0</u>
10.0	Pressure Drop (AP at Design Point)	psi	<u>6.6 ± 1.0 (SSBV 3&4)</u>
11.0	Actuator Power		
	11.1	Hold Position, watts	<u>100 Max.</u>
	11.2	Change Position, watts	
	11.2.1	Open	<u>200 Max.</u>
	11.2.1	Close	<u>300 Max.</u>
12.0	Opening and Closing Characteristics		
	12.1	Cracking Pressure, psid	<u>N/A</u>
	12.2	Closing Pressure, psid	<u>N/A</u>
13.0	Controlled Flow Rate		<u>N/A</u>

DATA SOURCE: Engineering Estimate, Dept. 7830 - Petite
Engineering Estimate, Dept. 7770 - Shearer

STEAM SUPPORT OUTLET - to SSBV₁(2) IN

STATE POINT NO. 11

1514 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-ITEM
SPEC TREE NO.
PLOTTED BY: CHECKED BY:

FIGURE 2.0-1

SSEV142 IN.

STATE POINT No 11

FIGURE 2.0-2

SSB/102 OUT

STATE POINT NO 12

FIGURE 2.0-3

STATE POINT NO 12

MISSION-A-L-M, 1ST BURN 1457 SEC SS, STOP=52, SHDN=45 SEC, CST=71.6 W2

FIGURE 2.0-4

BYPASS PORT OUTLET to SSBV₃₋₄

STATE POINT NO 16

FIGURE 2.0-5

SSBV 343 IN

STATE POINT No 16

FIGURE 2.0-6

SSBV₃₄ OUT to STRUCT. SUPPORT BYPASS LINE

STATE POINT No 17

FIGURE 2.0-7

1550/342-017

STATE POINT No 17

FIGURE 2.0-8

III. REFERENCE DATA

This section contains reference data common to two or more of the components described in Section II. The following reference data is provided as of the date of issue of this report.

A. Natural Environment

The following figures and tables provide data which may be used to establish the natural environment that the NERVA Engine will be exposed to during prelaunch, launch and boost, and space operations. Table 1 provides an engine-level summary of these environments, and the balance of the tables and figures are used to establish environments as a function of mission operation and/or geographic location. Design Requirement Sheet 6, (Design Criteria 1.6, Natural Environment,) includes, for each component, a component-level Table 1 defining the specific natural environments affecting that particular component.

Table 1
NATURAL ENVIRONMENTS SUMMARY

Phase Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Pre-launch and Launch Operations
Altitude - Miles	262 to 210,000 N. miles	See Level to 262 N. miles	Sea Level
Atmospheric pressure, psi	2×10^{-12} at 262 N.M.	Pressure - Altitude profiles established by Figures 1 and 2	In 14., at 15.0 $\Delta P = 0.04 \text{ lb/in}^2$ in 24 hr. $\Delta P_{\text{max}} = -.09 \text{ lb/in}^2$ in 1 hr.
Atmospheric temperature (F or C) °R	2700°R at 262 N.M.	See Figure 3 or nominal profile	$M_1 = 450$ $M_2 = 350$ (Values)
Atmospheric Density - lb/ft ³	1×10^{-13} at 262 N.M.	Density - Altitude profiles established by Figures 1 and 2	$M_1 = 7.12 \times 10^{-2}$ $M_2 = 8.27 \times 10^{-2}$
Atmospheric composition	See Figure 4	Established from Figure 4 and Table 2	See Table 2
Atmospheric humidity	Negligible	Max vapor concentration at launch 11.8 gr H ₂ O/lb	Extreme 100% r.h. @ 73°F for 6 hrs, 75% r.h. @ 82°F for 18 hrs, 15 day cycle
Solar radiation - Btu/ft ² /hr	442.4	N.A.	13D
Rain	N.A.	N.A.	See Table 8
Snow	N.A.	N.A.	N.A.
Solar Radio Noise	See Table 10	See Table 10	See Table 10

Phase			
Environment	Space Operations	Flight Vehicle Boost	Vehicle Assembly and Checkout Prelaunch and Launch Operations
Wind, ft/sec	N.A.	N.A.	See Table 9
Sand and dust	N.A.	N.A.	See Table 3
Salt Spray	N.A.	N.A.	See Table 4
Fungi and bacteria	N.A.	TBD	TBD
Atmospheric electricity	N.A.	N.A.	See Table 5
Seismic environment	N.A.	N.A.	TBD
Magnetic field avg. total gauss, max	0.53	0.53	0.52
Meteoroids	See Figures 5 and 6. Meteoroid Mass density 0.5 gm/cm ³	N.A.	N.A.
Radiation -- high energy particle	See Table 6	Negligible	N.A.
Radiation -- trapped	See Figures 7 and 8	Negligible	N.A.
Radiation - ultraviolet and X-ray	See Table 7	Negligible	N.A.
Radiation - earth thermal avg., $\bar{E}$, Btu/ft ² /hr	$\bar{E} = 68.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$ alt = altitude location in miles	N.A.	N.A.
Radiation - earth albedo avg., $\bar{a}_E$, Btu/ft ² /hr	$\bar{a}_E = 173.4 \left(\frac{3,963}{3,963 + \text{alt}} \right)^2$	N.A.	N.A.
Ionosphere - ionized electron density - N/in. ³	N.A.	N.A.	N.A.

TABLE 2
NORMAL ATMOSPHERIC COMPOSITION FOR CLEAN,
DRY AIR AT ALL LOCATIONS
(VALID TO 55.9 MILES GEOMETRIC ALTITUDE)

<u>Gas</u>	<u>Percent by Volume</u>	<u>Percent by Weight</u>
Nitrogen (N ₂)	78.034	75.520
Oxygen (O ₂)	20.9476	23.142
Argon (Ar)	0.934	1.288
Carbon dioxide (CO ₂)	0.0314	0.048
Neon (Ne)	1.818×10^{-3}	1.27×10^{-3}
Helium (He)	5.24×10^{-4}	7.24×10^{-5}
Krypton (Kr)	1.14×10^{-4}	3.30×10^{-4}
Xenon (Xe)	8.7×10^{-6}	3.9×10^{-5}
Hydrogen (H ₂)	5×10^{-5}	3×10^{-6}
Methane (CH ₄)	2×10^{-4}	1×10^{-4}
Nitrous oxide (N ₂ O)	5×10^{-5}	8×10^{-5}
Ozone (O ₃) summer	0 to 7×10^{-6}	0 to 1.1×10^{-5}
winter	0 to 2×10^{-6}	0 to 3×10^{-6}
Sulfur dioxide (SO ₂)	0 to 1×10^{-4}	0 to 2×10^{-4}
Nitrogen dioxide (NO ₂)	0 to 2×10^{-6}	0 to 3×10^{-6}
Ammonia (NH ₃)	0 to trace	0 to trace
Carbon monoxide (CO)	0 to trace	0 to trace
Iodine (I ₂)	0 to 1×10^{-6}	0 to 9×10^{-6}

TABLE 3
SAND AND DUST

	<u>Sand</u>	<u>Dust</u>
Size of Particles Diameter, in.	0.0031 to 0.039 90% between 0.0031 and 0.012	3.9×10^{-6} to 3.1×10^{-3} 90% between 3.9×10^{-6} and 7.9×10^{-6}
Hardness and Shape	>50% of particles composed of angular quartz or harder, 7 to 8 on MOH's scale	
Number, Distribution and Associated Conditions	1.2 lb/ft ³ during sand storm 10% between 0.079 and 3.3 ft above ground 90% below 0.079 ft	3.7×10^{-7} lb/ft ³ uniform distribution
Relative humidity 30% or less wind velocity 32.8 ft/sec at 10 ft altitude		

TABLE 4
SALT SPRAY

Salt Spray Exposure	TBD
Salt Accumulation (Extremes)	3.94×10^{-6} to 7.87×10^{-4}
Particle Size, inches	98% of total greater than 3.15×10^{-5}
Accumulation (Fallout)	10.2×10^{-7}
lb/ft ² /day, Max	During Rain Storm
Min	5.12×10^{-8} Unevenly Distributed.

TABLE 5.
CHARACTERISTICS OF LIGHTNING STROKES

	Average	Maximum
Peak Current, Amps	10,000	Not greater than 100,000 90% of time.
Time interval, micro seconds	6	10
Start of stroke to peak current		
Fall from peak current to 1/2 of peak value	24	20
Total stroke charge (Coulombs)	25	100
Transmitted to earth (90% of Current Flow)		

TABLE 6
SOLAR HIGH ENERGY PARTICLE RADIATION AT 1 AU

Particle Energy, MEV	>30	>100
Integrated Yearly Particle Flux Protons/in. ²		
Near solar min	7.75×10^7	1.55×10^7
Near solar max	1.24×10^9	9.3×10^7
Composition	Predominantly H ⁺ and He ⁺⁺	
Flux variation with Distance from Sun	$\left[\frac{1 \text{ AU}}{X \text{ AU}} \right]^2$	

TABLE 7

ULTRAVIOLET AND X-RAY RADIATION CHARACTERISTICS

UltravioletPrincipal Line Emission Fluxes (watts/ft²)

Lyman Alpha H ⁺ I (1216Å)	5×10^{-4}
He II (303.8Å)	2.4×10^{-4}
H ⁺ I (1026Å)	5.6×10^{-6}
C III (977Å)	4.7×10^{-6}

X-Ray Flux (watts/ft²)

	<u>2-8Å</u>	<u>8-20Å</u>	<u>20-200Å</u>
Sunspot min (quiet sun)	2.8×10^{-10}	3.8×10^{-8}	1.2×10^{-5}
Sunspot max (quiet sun)	1.9×10^{-9}	2.2×10^{-6}	9.5×10^{-5}
Upper Limit During Flare Activity	2.1×10^{-5}	4.2×10^{-5}	8.6×10^{-4}

TABLE 8

DESIGN RAINFALL RATES FOR EASTERN TEST RANGE, MICHoud,
MISSISSIPPI TEST FACILITY, GULF TRANSPORTATION, TRANS-
PORTATION LARGE TO MICHoud, AND TRANSPORTATION SACRAMENTO
TO MICHoud

<u>Time Period</u>	<u>1 min</u>	<u>1 hour</u>	<u>24 hours</u>	<u>Year</u>
Total Amount, in.	0.5	4	20	To be determined
Rate, in./hr	30.0	4.0	0.8	
Average Drop Diameter, in.	0.16	0.11	0.07	
Average Rate of Fall, ft/sec	28.8	24.9	20.0	
Peak Wind Speed, ft/sec	98.4	65.6	65.6	
Average Wind Speed, ft/sec	55	19.6	14.7	

TABLE 9

SURFACE WIND SPEED ENVELOPE DURING STRONGEST WIND MONTH FOR ALL LOCATIONS
WINDS BETWEEN SURFACE AND 492 FOOT HEIGHT

Height Above Ground (ft)	Quasi-Steady-State* Wind (ft/sec)			Peak Wind** (ft/sec)		
	99.9	99	95	99.9	99	95
	<u>Percentile</u>	<u>Percentile</u>	<u>Percentile</u>	<u>Percentile</u>	<u>Percentile</u>	<u>Percentile</u>
9.84	43.9	40.6	31.8	61.6	56.7	44.2
29.5	54.7	50.5	39.3	76.7	70.8	55.4
59.0	62.9	58.0	45.2	88.5	81.3	63.6
100	69.8	64.6	50.1	97.7	90.2	70.5
200	80.0	74.1	57.7	112.2	103.6	80.7
300	86.9	80.3	62.6	121.7	112.5	87.6
400	92.1	84.9	66.2	128.9	119.1	92.8
500	96.4	88.9	69.2	134.3	124.6	97.1

*Two minute average.

**Two minute average (1.4 times Quasi-Steady-State Wind)

TABLE 10
SOLAR RADIO NOISE

Quiet Sun Noise Power watts/ft ² /cps	Varies from 10^{-20} at 0.4 in. wavelength to 10^{-23} at 160 inch wavelength
Solar Storm Noise Power Increase (orders of magnitude)	1 to 8
Variation with Sunspot Between 2.5 and 80 inch wavelength Orders of Magnitude	Up to 4

Figure 1A

FIGURE 1b

ALTITUDE VS TIME FOR MISSION A

TOTALS FOR 3 YEAR LIFE

1. LUNAR ORBIT 360 DAYS
2. IN FLIGHT 70 DAYS
3. EARTH ORBIT 665 DAYS

FIGURE 2a

ATMOSPHERIC PRESSURE-HEIGHT EXTREMES FOR ALL AREAS
OF CONCERN AND DENSITY-HEIGHT EXTREMES FOR THE
EASTERN TEST RANGE

FIGURE 2B

ATMOSPHERIC PRESSURE AND DENSITY VERSUS ALTITUDE
(ABOVE 300,000 FEET)

FIGURE 3

TEMPERATURE VERSUS ALTITUDE
(EASTERN TEST RANGE REFERENCE ATMOSPHERE)

Figure 4

ESTIMATED MEAN CONCENTRATIONS OF
PRINCIPAL ATMOSPHERIC CONSTITUENTS
ABOVE 37.9 STATUTE MILES

FIGURE 5

ATMOSPHERIC ENTRY VELOCITY DISTRIBUTION
FOR SPORADIC METEORIDS

Figure 6

FIGURE 7 PROTON OMNIDIRECTIONAL FLUX
AT THE GEOMAGNETIC EQUATOR

FIGURE 8

ELECTRON MAP OMNIDIRECTIONAL FLUX
(ELECTRONS/IN.² - SEC) AT THE GEOMAGNETIC EQUATOR