Development Specification for RV-346/348 Positive Pressure Relief Valves (PPRV)

Engineering Directorate
Crew and Thermal Systems Division

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REVISIONS			
DATE	AUTHOR	DESCRIPTION	REV. LETTER
11/11/09	C. Campbell	Initial Release	N/C
11/8/11	C. Campbell	Para 3.5.6, Lunar Dust – added design intent guidance Para 3.2.4, Crack Pressure – changed requirement to differential reference, with higher value for increased POR/SOR range. Para 3.2.5, Reseat Pressure – changed requirement to differential reference, with higher value for increased POR/SOR range.	A
2/18/2014	I. Anchondo	Para 2.0 – removed term definitions not used Para 3.2.1, 3.2.1, 3.2.4, 3.2.5 - Updated back pressure reference and valve location. 3.5.1.2 – Deleted – the requirement to operate post cabin rapid repress is a system level requirement which duplicated the negative pressure tolerance requirement 3.2.6 3.7.1 – Deleted statistical reference to failure rate	B
10/3/2017	R. Ralston	Updated to include requirements numbers Updated operational, useful, and shelf-life and several environments, design and construction, etc. to address flow-downs from CTSD-ADV-780, Rev A	C

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1.0 INTRODUCTION

1.1 SCOPE

This specification establishes the requirements for design, performance, safety, testing, and manufacture of the RV-346 and RV-348, Positive Pressure Relief Valve (PPRV) as part of the Advanced Extravehicular Mobility Unit (EMU) (AEMU) Portable Life Support System (PLSS). The RV-346 serves as the Positive Pressure Relief Valve (PPRV), and the RV-348 serves as the Secondary Positive Pressure Relief Valve (SPPRV).

1.2 CONVENTIONS AND NOTATIONS

1.2.1 RATIONALE

A rationale statement is included for each requirement. The rationale statement indicates why the requirement is needed, shows the basis for its inclusion in this requirements document, and provides context and examples to stakeholders. It is important to note that rationale is not binding, and it only provides supporting information. In the event that there is an inconsistency between the requirement and the rationale, the requirement is binding and takes precedence. If there is any confusion between the requirement and rationale, seek further guidance from the responsible technical authority.

1.2.2 BACKGROUND

PPRV development for the advanced PLSS began in 2012 with an initial prototype set (4 units) was developed by Airlock via Oceaneering Space Systems (OSS) in accordance with Rev A of this specification. The valve design considered ISS EMU Item 146 valve failures including issues with stiction and modeled the initial valve design from the Bends Treatment Adapter (BTA) relief valve used on the ISS EMU Program which had performed well over the duration of the program without issues from stiction. In 2014, after Airlock developed the updated PPRV design for ISS EMU Item 146 and delivered the valve, OSS/Airlock developed the PPRV 2.0 valve design based on that work and in compliance with Revision B of this specification delivering two units. To date, the PPRV 2.0 has suffered from high crack due to stiction with very little dwell time. The next iteration of the valve will comply with the most recent version of this specification and focus on eliminating stiction as the valve must be capable of sitting dormant without failing to meet functional requirements.

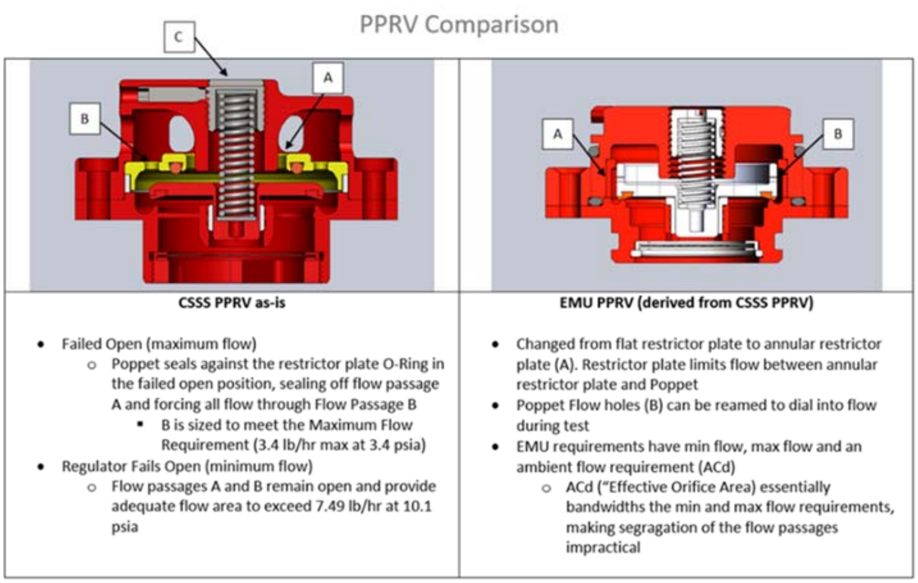


Figure 1-1– PPRV 1.0 to ISS EMU Prototype Comparison

1.2.3 NOMENCLATURE

Each requirement contained in this development specification is denoted by a unique identifier (Table 1-1) that transcends traditional paragraph numbering to keep requirements traceability clearer and more achievable.

Requirement Nomenclature	PLSS Sub-Assembly or Loop
[R.PPRV.346.{001-199}]	Performance Requirements
[R.PPRV.346.{200}]	Interface Requirements
[R.PPRV.346.{300}]	Firmware Requirements
[R.PPRV.346.{400}]	Environmental Requirements
[R.PPRV.346.{500}]	Design and Construction Requirements
[R.PPRV.346.{600}]	Safety Requirements

Table 1-1– Requirements Nomenclature Key

1.2.4 PLSS COMPONENT IDENTIFIERS

The PLSS uses unique identifiers for each of the components as shown in Table 1-2.

Item	Description
RV-346	Positive Pressure Relief Valve, Primary
RV-348	Positive Pressure Relief Valve, Secondary

Table 1-2 – PPRV Component Identifiers

1.3 RESPONSIBILITY AND CHANGE AUTHORITY

The Space Suit and Crew Survival Systems Branch within the Crew and Thermal Systems Division (CTSD) is responsible for the development and management of the PPRV Development Specification.

2.0 DOCUMENTS

The documents listed in this section represent the documents that have been identified either in part or in whole within this document.

2.1 APPLICABLE DOCUMENTS

The applicable documents are documents that have been explicitly identified within requirements statements (i.e., “shall” statements) and invoked as technical requirements for implementation. Each requirement statement identifies the applicable subsections of a document unless it has been deemed appropriate to invoke the entire document.

JPR 5322.1 Rev H	Contamination Control Requirements Manual
MIL-PRF-27210 Ref J	Performance Specification for Oxygen, Aviators Breathing, Liquid and Gas
MIL-PRF-27401 Rev G	Performance Specification for Propellant Pressurizing Agent, Nitrogen
NASA-STD-6016 Baseline	Standard Materials and Processes Requirements for Spacecraft
SLN13102286 Rev N/C	Positive Pressure Relief Valve Source Control Drawing

2.2 REFERENCE DOCUMENTS

Documents that are identified but are not invoked within requirements statements are listed below.

CTSD-ADV-780	Development Specification for the Advanced EMU (AEMU) Portable Life Support System (PLSS)

CTSD-ADV-959	Schematics and Behavioral Description for the Advanced EMU (AEMU) Portable Life Support Subsystem (PLSS)
NASA-STD-6002 Rev B	Applying Data Matrix Identification Symbols on Aerospace Parts
SSP 50835 Rev D	ISS Pressurized Volume Hardware Common Interface Requirements Document

3.0 PERFORMANCE REQUIREMENTS

3.1 FUNCTIONAL OVERVIEW

The function of the PPRV is to limit the pressure in the PLSS ventilation loop to the maximum design pressure in the event of a failed open primary or secondary regulator. It is also the means of relieving and controlling suit ventilation loop pressure during a controlled vacuum chamber or airlock depress. It is not intended to provide relief for rapidly occurring external events such as a rapid cabin depressurization scenario; doing so would drive the reaction time and over-drive the valve size.

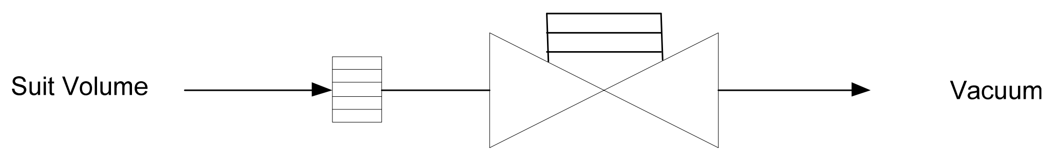


Figure 3-1 - PPRV Functional Schematic

3.2 LIFE

3.2.1 [R.PPRV.346.001] OPERATIONAL LIFE

The PPRV shall have operating life as specified in **Error! Reference source not found.**:

Component	Function	Cycles (minimum)	Minimum Duration (hrs)
Relief Valve	Open/Close	1200(1,2)	---
Filters	Full Open Flow	---	167(3)

Table 3-1 - Positive Pressure Relief Valve (PPRV) Operating Life

Rationale: The goal is to make the hardware and its associated certification "robust-enough" such that detailed tracking of operating cycles and the resultant operational over-head is not required.

(1) This is based on one cycle per EVA with 300 EVAs and a scatter factor of 4 as derived from operational concepts discussions regarding the Lunar Electric Rover (LER), Small Pressurized Rover, and other exploration concepts that involve multiple short duration EVAs rather than fewer but longer EVAs.

(2) A relief valve cycle is defined as travel of the valve poppet from the fully closed position to full open and back to the fully closed position.

(3) This is based on a flow duration of 10 minutes per cycle.

3.2.2 [R.PPRV.346.002] USEFUL LIFE

The PPRV shall have a useful life of 15 years minimum without refurbishment assuming that the usage rate does not exceed operational life.

Rationale: The usage life is the total chronological time that an assembly, component, or detail part may be used. It is the total of shelf life and operational life. Useful life begins at the item's birth date, which can be initial acceptance, date of manufacture, date of cure, etc. The component may sit on the shelf in controlled storage for 10 years until it expires, it may be placed into service for 10 years (but within the operational life) until it expires, or some combination with the total tracked time of 10 years and total operating hours as defined in the operational life.

3.2.3 [R.PPRV.346.003] SHELF LIFE

The PPRV shall have a shelf-life of 15 years minimum.

Rationale: This allows for program logistics flexibility without recertification.

3.2.4 [R.PPRV.346.004] LIMITED LIFE

The PPRV shall meet requirements after sitting dormant between cycles for 915 days minimum.

Rationale: This is based a 6 month preflight check-out and stowage followed by a 2 year mission dormancy followed by the operational phase of the mission. This supports the goal of having no limited life hardware in the PLSS.

3.2.5 [R.PPRV.346.005] LAUNCH/LANDING CYCLES

The PPRV shall tolerate and operate after 6 launch and landing cycles minimum.

Rationale: The intent is to dictate that the PPRV will be designed for multiple launches and landings to support its as yet undetermined missions. The details of what each launch/landing cycle entails depends on the vehicle chosen, but is encompassed by the requirements provided in the environments section.

3.3 OPERATING FLUIDS

3.3.1 [R.PPRV.346.006] GASEOUS NITROGEN

The PPRV shall be compatible with and operate using gaseous nitrogen per MIL-PRF-27401, Performance Specification for Propellant Pressurizing Agent, Nitrogen, Type I, Grade B as a test fluid.

Rationale: Gaseous nitrogen provides a safe and effective method for performing development tests before oxygen compatibility testing and approval. It will be the gas used for a variety of PPRV and PLSS-level tests.

3.3.2 [R.PPRV.346.007] GASEOUS OXYGEN

The PPRV shall be compatible with and operate using gaseous oxygen per MIL-PRF-27210, Performance Specification for Oxygen, Aviators Breathing, Liquid and Gas, Type I as the working fluid.

Rationale: Oxygen is the required EVA operating fluid. To fulfill this function, all wetted components must be oxygen-compatible and cleaned for oxygen use.

3.4 OPERATION AND PHYSICAL REQUIREMENTS

3.4.1 [R.PPRV.346.008] CRACKING PRESSURE

The PPRV shall crack at a pressure of 59.3 – 60.7 kPa differential [8.6 - 8.8 psid] in all possible orientations.

Rationale:

(1) Cracking pressure is defined as the pressure which produces a flow of $\geq$ .05 lb/hr. The crack pressure is based on the CxSuit Purge Valve-Regulator-PPRV sizing analysis 10/24/09.

3.4.2 [R.PPRV.346.009] RESEAT PRESSURE

The PPRV shall reseat at a pressure of 59.3 – 60.7 kPa differential [8.6 - 8.8 psid] in all possible orientations.

Rationale:

(1) Reseat pressure is defined as the differential pressure where the valve as it approaches closure reduces the flow to $\leq$ .05 lb/hr at a temperature of 21.1°C [70°F]. The reseat pressure is based on the CxSuit Purge Valve-Regulator-PPRV sizing analysis 10/24/09.

3.4.3 [R.PPRV.346.010] FULL OPEN FLOW

The PPRV shall flow a minimum of 3.4 kg/hr [7.49 lbm/hr] dry O2 at 21.1°C [70°F] with a suit pressure of 69.6 kPa [10.1 psia] and vacuum as the external reference.

Rationale:

(1) This is required to tolerate a failed open Primary Oxygen Regulator or Secondary Oxygen Regulator.
(2) Vacuum can be roughing quality at < 20 torr.

3.4.4 [R.PPRV.346.011] FAILED OPEN FLOW

The PPRV, under a failed open condition, shall flow a maximum of 1.54 kg/hr [3.4 lbs/hr] dry O2 at 4.4°C [40°F] with a suit pressure of 23.4 kPa [3.4 psia] with the flow direction perpendicular to the direction of the force of gravity.

Rationale:

(1) This is required for the Primary Oxygen Regulator and Secondary Oxygen Regulator to maintain a habitable suit pressure with a failed open Positive Pressure Relief Valve (PPRV).
(2) Direction definition based on the fact that a poppet's weight will affect flow magnitude if oriented towards or away from a gravity field.
(3) This requirement is based on a vacuum reference condition, hence the "psia" units. This will ensure that the relief valve meets requirements under EVA conditions. At sea level conditions, where the environment is non-hazardous, the same valve will flow considerably more than the POR or SOR can flow at the given suit pressure which is acceptable.

3.4.5 [R.PPRV.346.012] NON-PROPULSIVE VENTING

The PPRV shall vent in a non-propulsive manner either by design of the component or by integration into the system.

Rationale: This is required to mitigate propulsive effects from the venting of the relief valve.

3.4.6 [R.PPRV.346.013] NEGATIVE PRESSURE

The PPRV shall meet all functional requirements after exposure to a 13.8 kPa [2.0 psid] differential pressure towards the closed position.

Rationale: This allows the PPRV to function after a negative pressurization event such as a rapid airlock or vacuum chamber repress.

3.4.7 [R.PPRV.346.014] Inlet or Supply Temperature

The PPRV shall operate with a gas supply temperature of 1.7 °C [35 °F] to 51.7 °C [125 °F].

Rationale: This is a preliminary range that covers the ISS EMU and AEMU specifications. Further analysis and development of the PLSS packaging will refine this range.

3.4.8 [R.PPRV.346.015] Leakage

The PPRV shall limit external leakage to 1 sccm maximum at a pressure of 57.9 kPa [8.4 psia] regardless of orientation and immediately after crack and reseat.

Rationale: With this valve now installed on the SSA and part of that system leakage allocation, this will be tight enough to ensure that it does not contribute significantly to the overall suit leakage. The leakage rate is more conservative than EMU which specified the same leakage rate but with a much lower source pressure.

3.4.9 [R.PPRV.346.016] Mass

The PPRV shall have a mass that is less than .14 kg [0.3 lbs] in flight configuration.

Rationale: The mass value is seeking an improvement noting that the Shuttle EMU Positive Pressure Relief Valve (PPRV) is .28 lbs.

3.4.10 [R.PPRV.346.017] Envelope

The PPRV shall fit within a volume defined by a 3.8 cm [1.5in] diameter cylinder with a 1.9cm [.75 in] length.

Rationale: This is based on an allocation for size as mounted on the Space Suit Assembly.

3.4.11 Pressure Schedule

3.4.11.1 [R.PPRV.346.018] Maximum Design Pressure (MDP)

The PPRV shall have an MDP of 73.1 kPa [10.6 psid].

Rationale: This is based on the maximum flow condition with a maximum over-pressure of 10.1 psid with a margin of 0.5 psid. For the operating condition in which the airlock depress is performed, the system is only single-fault tolerant to over-pressure, hence the use of MEOP at 10.1 psid with margin.

3.4.11.2 [R.PPRV.346.019] Proof Pressure

The PPRV shall tolerate a proof pressure of 110 kPa [15.9 psid].

3.4.11.3 [R.PPRV.346.020] Burst Pressure

The PPRV shall have a burst pressure of 183kPa [26.5 psid] minimum.

4.0 INTERFACE REQUIREMENTS

4.1 [R.PPRV.346.200] RV CAP FOR TESTING

The PPRV shall accommodate a cap capable of tolerating at least 17.6 psid.

Rationale: The PPRV is located on the Pressure Garment Subsystem (PGS) which is a soft pressure vessel with an MDP at 10.6 psid and a proof testing at 17.6 psid.

4.2 [R.PPRV.346.201] MECHANICAL INTERFACES

The PPRV shall mechanically mate to the Hard Upper Torso (HUT) per SLN13102286.

4.3 CREW/HUMAN FACTORS

4.3.1 [R.PPRV.346.202] TOUCH TEMPERATURE

The PPRV shall maintain exposed surface temperatures to less than 111.2°F for surfaces where the crew could contact or is intended to contact.

Rationale: It is anticipated that the HUT TMG will be covering this valve to maintain it within a reasonable operating temperature range and hence, address this requirement at the same time.

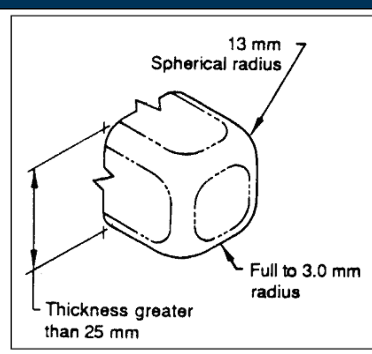
4.3.2 [R.PPRV.346.203] INADVERTENT KICK-LOAD

The PPRV shall tolerate an inadvertent EVA or IVA kick-loads of 125 lbf minimum applied statically across a 4in x 4in area.

Rationale: This requirement as written, is actually contained in SSP 50835, Table 3.1.1.3-1 Crew-Induced Loads with IVA crew applicability. CxP 70130, Constellation Program EVA Design and Construction Requirements defined the 125 lbf static load but across a smaller area of 0.5in dia; for the purposes of tolerating inadvertent contact with structure of an EVA boot for example, the 4 x 4in area better fits that application than does the 0.5in dia value.

4.3.3 [R.PPRV.346.204] EXPOSED BURRS/SHARP EDGES

The PPRV shall comply with the limits established in **Error! Reference source not found.** for exposed edges that are accessible during nominal operation or planned intromission maintenance.

Material Thickness, t	Minimum Corner	Minimum Edge Radius	Figure
t > 1 in (t > 25 mm)	0.5 in (13 mm (spherical))	0.125 in (3.0 mm).	

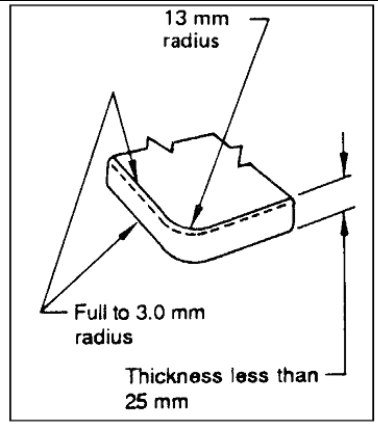
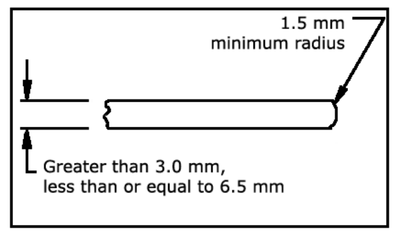
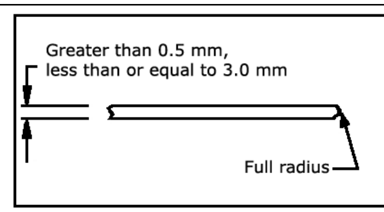
Material Thickness, t	Minimum Corner	Minimum Edge Radius	Figure
0.25 in. < t ≤ 1 in. (6.5 mm < t ≤ 25 mm)	0.5 in. (13 mm)	0.125 in. (3.0 mm)	
0.125 in. < t ≤ 0.25 in. (3.0 mm < t ≤ 6.5 mm)	0.25 in. (6.5 mm)	0.06 in. (1.5 mm)	
0.02 in. < t ≤ 0.125 in. (0.5 mm < t < 3.0 mm)	0.25 in. (6.5 mm)	Full radius	

Figure 4-1 - Exposed Corners and Edge Requirements

Rationale: This table is derived from NASA-STD-3001, Volume 2, Section 9.3.1.5 and is also consistent with SSP 50005, Section 6.

5.0 ENVIRONMENTAL REQUIREMENTS

5.1.1 [R.PPRV.346.400] Ambient Pressure

The PPRV shall operate in a pressure environment ranging from 0.0 to 105 kPa [0.0 to 15.2 psia].

Rationale: This range spans from hard vacuum experienced in space away from support vehicles to ambient pressure permitted in the ISS.

5.1.2 [R.PPRV.346.401] Ambient Pressure – Non-Operational

The PPRV shall operate after exposure to a pressure environment ranging from 0.0 to 130 kPa [0.0 to 18.8 psia].

Rationale: This addresses the range of pressure regimes across the potential launch vehicles with Progress being the driving case on the upper end and vacuum being common to most cargo vehicles.

5.1.3 [R.PPRV.346.402] TEMPERATURE

The PPRV shall operate during and after exposure to temperatures of 4 °C [40 °F] to 71 °C [160 °F].

Rationale: The current specification is a working range for development and will be further refined as the packaging and thermal load cases are better refined.

5.1.4 [R.PPRV.346.403] HUMIDITY

The PPRV shall be designed so that its performance will not be degraded by the presence of humidity or free water droplets.

Rationale: The PPRV must meet requirements with a range of relative humidity and the potential for free water from the space suit volume. This includes the fact that the valve shall not freeze up when operating at vacuum conditions with free water droplets flowing through the valve seat.

5.1.5 [R.PPRV.346.404] GRAVITATIONAL FIELDS

The PPRV shall operate in any orientation in the gravitational fields defined in **Error! Reference source not found.**.

Environment	Gravity Field (g)
Terrestrial	1
Lunar	0.17
Mars	0.38
LEO	~0

Table 5-1 - Gravitational Fields

Rationale: The PPRV must perform in a variety of gravity fields to meet system performance requirements across all of the applicable environments.

5.1.6 DYNAMIC LOADS

5.1.6.1 [R.PPRV.346.405] ACCELERATION LOAD FACTORS

The PPRV shall meet requirements after exposure to the accelerations defined in Table 5-2 - Design Load Factors for Launch Vehicles

.

Nx (g)	Ny (g)	Nz (g)	Rx (rad/sec^2)	Ry (rad/sec^2)	Rz (rad/sec^2)
+/- 7.0	+/- 4.0	+/- 4.0	--- (1)	--- (1)	--- (1)

Table 5-2 - Design Load Factors for Launch Vehicles

Rationale: Given the design load factors for all available vehicles, it is already impractical to attempt to ensure that the PPRV design can tolerate all of them in any given orientation as it results in untenable design loads which prevent the design from meeting its other physical requirements to cover the extremes.

NOTE:

(1) The PLSS will not be launched in ATV or Soyuz so the rotational accelerations associated with those vehicles are excluded from what is provided in SSP-50835.

(2) The reference frame for the enveloped load factors is as follows:

a. X: The longitudinal axis of the vehicle. Positive x axis extends from the base or bottom of the spacecraft to the nose of the spacecraft.
b. Y: Y axis is perpendicular to the x axis.
c. Z: Z axis is perpendicular to the x and y axes and completes the right handed coordinate system

(3) Payloads that weight less than 907 Kg (2000 lb) and launching on the Delta IV will need to contact Delta Program office for additional information on the load factors.
(4) This does not fully encompass the ground handling and transportation load factors provided in Para 3.1.1.1.1 of SSP 50835 as the Ny and Nz are .5 - .9 g low in magnitude. This does not account for ground transportation packaging which can be even larger than that provided for launch.

5.1.6.2 [R.PPRV.346.406] Acceleration Load Factors - Survivable

The PPRV shall remain contained and intact as to not present a hazard during and after exposure to the accelerations defined in **Error! Reference source not found.**.

	Nx (g)	Ny (g)	Nz (g)	Rx (rad/sec²)	Ry (rad/sec²)	Rz (rad/sec²)
Launch	+9.0/-7.0	+/- 4.0	+/- 4.0	+/- 13.5	+/- 8.5	+/- 11.5
Landing	+/-10.0	+/-6.6	+/-6.6	---	---	---

Table 5-3 - Launch and Landing Survivable Load Factors

Rationale: Values obtained from SSP-50835 Rev D. section 3.1.1.2.1.1.1-1, inclusive of PIRN 0022b.

5.1.6.3 [R.PPRV.346.407] Random Vibration - Operating

The PPRV shall operate during and after exposure to the vibration profile shown in Table 5-4 for a minimum of 30 minutes in each axis.

FREQUENCY (Hz)	LEVEL
10 – 40	0.0549 g^2/Hz
40 – 500	-5.49 dB/oct
500	0.0006 g^2/Hz
COMPOSITE	**2.00 grms**
Duration	**30 min**

Table 5-4 - AEMU Random Vibration Profile - Operating

Rationale:
(1) The PPRV needs to tolerate transport across terrestrial surfaces as part of a roving vehicle demonstration followed by eventual flight usage on a roving vehicle in the lunar and Martian environments. The selection of time per axis is currently arbitrary given that the final vehicle configurations and operations concepts are not known. The vibration profile is more aggressive than the original MIL-STD-810G, Method 514.6, Category 4, Common Carrier US Truck vibration reference.

5.1.6.4 [R.PPRV.346.408] Random Vibration - Non-Operating

The PPRV, when packaged for flight, shall operate after exposure to the vibration profile Table 5-5 in each orthogonal axis.

FREQUENCY (Hz)	LEVEL
20 – 153	0.057 g^2/Hz
153 – 190	+7.67 dB/oct
190 – 250	0.099 g^2/Hz

FREQUENCY (Hz)	LEVEL
250 – 750	-1.61 dB/oct
750	0.055 g^2/Hz
750 – 2000	-3.43 dB/oct
2000	0.018 g^2/Hz
COMPOSITE	**9.47 grms**
Duration	**60 sec for 1 launch**

Table 5-5 - AEMU Random Vibration Profile

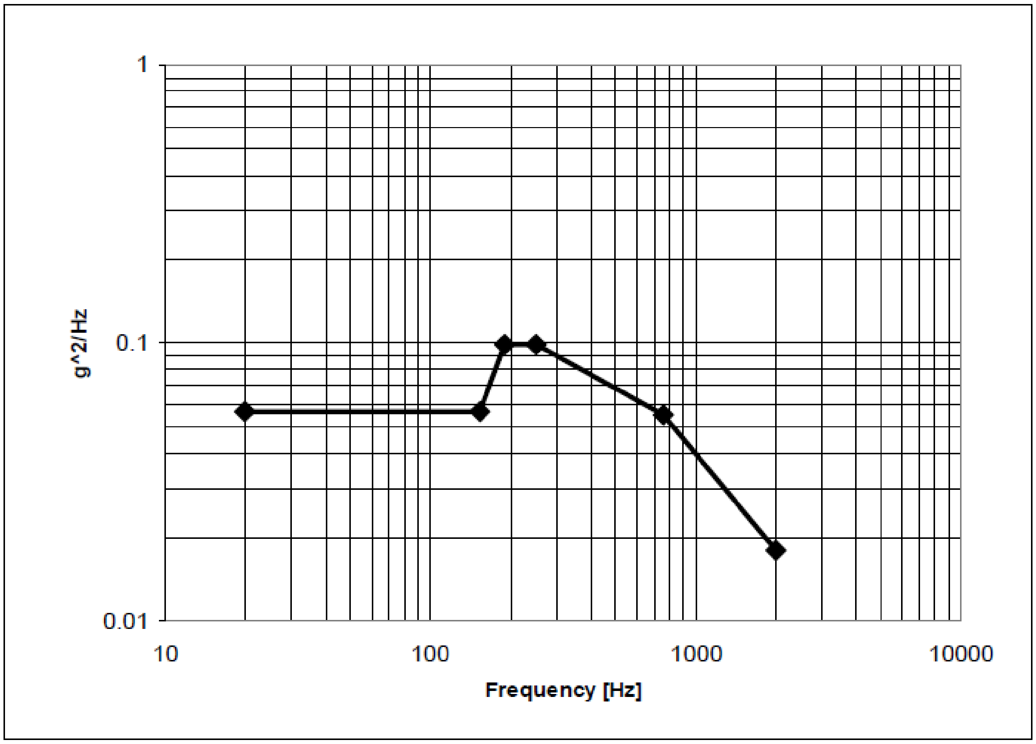


Figure 5-1 - AEMU Random Vibration Profile

Rationale:

(1) *The flight package for the PPRV has not yet been defined but is assumed to be attached to the HUT in a "Soft Stow" configuration.*
(2) *This environment envelopes the maximum unattenuated flight launch shock and random vibration environments for Progress in orbital flight. This environment does not envelope the maximum flight shock environment for the Progress launch escape system shock loads nor does it envelope the maximum flight launch shock environment for Dragon shock loads.*
(3) *Criteria are the same for all directions (X, Y, Z).*
(4) *Qualification and Acceptance test margins are described in SSP 41172.*
(5) *A separate shock test is not required when the end item is tested to the equivalent damage potential random vibration environment defined in this table.*
(6) *Equivalent shock environments were determined using the methodology from TR-2004(8583)-1, Test Requirements for Launch, Upper Stage, and Space Vehicles, Paragraph 10.2.6, Threshold Response Spectrum for Shock Significance.*
(7) *Dragon is excluded because the shock levels are too high to perform an equivalent random vibration damage potential test.*

5.1.7 [R.PPRV.346.409] SALT FOG

The PPRV, as packaged for flight, shall operate after exposure to a salt fog environment as defined by MIL-STD-810G, Method 509.5 with a NaCl concentration of 1% by weight for a period of 30 days.

Rationale: The PLSS and components must be capable of being shipped and handled in coastal regions such as the Kennedy Space Center (KSC) without compromising the mission.

5.1.8 [R.PPRV.346.410] FUNGUS

The PPRV, as packaged for flight, shall operate after exposure to fungus as defined in MIL-STD-810G, Method 508.6.

Rationale: The PLSS and components must be capable of being handled in coastal regions such as the Kennedy Space Center (KSC) and Johnson Space Center (JSC) without compromising the mission. The test itself requires a 28 day dwell in specified elevated temperature and humidity conditions after doping with specified fungi.

5.1.9 [R.PPRV.346.411] OZONE

The PPRV, as packaged for flight, shall meet all performance requirements after exposure to environmental ozone at concentrations of 3 to 6 parts per 100 million at sea level to a maximum of 100 parts per 100 million during air transportation at an altitude of 35,000 feet for up to 30 days total exposure duration.

5.1.10 [R.PPRV.346.412] PLASMA

The PPRV shall meet requirements when exposed to the natural and induced plasma environment defined within SSP 30425, Section 5 and SSP 30420 with the greatest allowable potential difference between the floating EVA hardware and vehicle structure maintained at less than +/- 40V.

5.1.11 [R.PPRV.346.413] ATOMIC OXYGEN

The PPRV shall operate with an exposure of 4.4×10^{19} particles/cm2-day over the duration of the operational life.

Rationale: Since the PLSS does not have a prolonged exposure under nominal operations with airlock-based LEO missions, the short-term daily ram fluence value for ISS is applied.

6.0 DESIGN AND CONSTRUCTION

6.1 [R.PPRV.346.500] MATERIALS AND PROCESSES

The PPRV shall comply with NASA-STD-6016A, Requirements for Materials and Processes for Spacecraft.

6.2 [R.PPRV.346.501] TOXIC OFF-GASSING

The PPRV shall meet the requirements of [MPR 45]/ [MPR 46] of NASA-STD-6016A.

Rationale: This examines both the need for low quantities of off-gassed products when operating in closed loop mode and low quantities of off-gassed products when stored in a vehicle cabin with continuous exposure to the crew volume.

6.3 [R.PPRV.346.502] VACUUM STABILITY

The PPRV surfaces that are exposed to vacuum shall be rated as vacuum compatible per [MPR 95] of NASA-STD-6016A.

Rationale: Components or surfaces that are nominally exposed to vacuum should not lose a significant amount of mass if they are to retain their function over time. Mission specific requirements such as a Hubble Servicing mission will further restrict allowable volatile condensable materials.

6.4 [R.PPRV.346.503] GENERAL WORKMANSHIP

The PPRV shall adhere to NASA-STD-8739.6, Implementation Requirements for NASA Workmanship Standards.

6.5 [R.PPRV.346.504] HARDWARE IDENTIFICATION

The PPRV shall be labeled with name, part number, dash number, and serial number in letters at least .080in high where size and shape permit.

Rationale: This satisfies the requirements of NASA-STD-6002 and MIL-STD-130 which are intended to provide proper marking and identification of hardware.

6.6 [R.PPRV.346.505] LIKE-COMPONENT INTERCHANGEABILITY

Each PPRV shall be interchangeable.

Rationale: The definition as provided in JSC EA-WI-027 is as follows:
Two or more parts are interchangeable when they possess such physical and functional characteristics as to be equivalent in performance and durability, and are capable of being exchanged one for another without alteration of the items themselves or adjoining items. Functional and physical characteristics, which would constitute interchangeability, are:

- *Parts must have the same design envelope and have no limitations imposed on use.*
- *Parts must utilize the same attachments, mountings or mating surfaces. Attachments, connectors, wiring, ground support equipment, and tubing must be the same to the extent that no re-work is required on installation.*
- *Parts must meet all baselined design requirements for performance and durability. Performance or durability design requirements include the same safety, strength, electrical, mechanical, reliability, maintainability, tolerance, and weight and center of gravity requirements.*
- *Parts must have the same adjustments, testing, operations, and maintenance requirements and design to the extent that the same test procedures, specifications, and operating procedures have been and/or may be utilized.*

6.7 [R.PPRV.346.506] CLEANLINESS

The PPRV shall be cleaned Level 150A per JPR 5322.1 prior to assembly and maintained clean to level VC afterwards.

Rationale: This ensures that the components of the valve are clean and absent of any significant amount of hydrocarbon contamination prior to assembly where oxygen compatible fluorocarbon lubricants such as Krytox 240AC or Braycote 601 are used for lubrication upon assembly.

7.0 ACRONYMS AND ABBREVIATIONS

CTSD	Crew and Thermal Systems Division
Cx	Constellation
CxP	Constellation Program
DCS	DeCompression Sickness
EMU	Extravehicular Mobility Unit
EV	Extra-Vehicular
EVA	Extravehicular Activity
FMEA	Failure Mode and Effects Analysis
GOX	Gaseous Oxygen
GSE	Ground Support Equipment
HSIR	Human Systems Integration Requirements
IV	Intra-Vehicular
IVA	Intra-Vehicular Activity
JPR	JSC Procedural Requirement
JSC	Johnson Space Center
MEOP	Maximum Expected Operating Pressure
NASA	National Aeronautics and Space Administration
NVR	Non-Volatile Residue
PLSS	Primary Life Support System or Portable Life Support System
PPRV	Positive Pressure Relief Valve
RH	Relative Humidity
T&V	Test and Verification
TBD	To Be Defined

8.0 DEFINITIONS

STP	Standard Temperature and Pressure (STP) The STP reference for all mass-referenced volumetric flows discussed here-in shall be that as defined by the National Institute of Standards and Technology (NIST) Pressure = 1 atm = 14.676 psia = 101.325kPa Temperature = 0C = 273.15K = 32F