Gravity Probe B
W. W. Hansen Experimental Physics Laboratory
STANFORD UNIVERSITY
Stanford, CA 94305-4085

S0508
Rev A
Vatterfly Valve Filter Specification
Nov. 7, 2002

Richard Whelan — 11/11/02

Richard Whelan
Systems Engineer

11/11/02

Approved by Barry Muhlfelder
Program Technical Manager

11/11/02

Approved by Dorrene Ross
Quality Assurance

T. Langenstein — 11/11/02

T. Langenstein
ITAR REVIEW

ITAR Control YES ☐ NO ☒

1 Purpose:

The purpose of this document is to define the requirements for the Vatterfly Valve Filters.

2 Scope

This document pertains to the filters for the two (2) 6 inch vatterfly valves (leakage) ~~and four (4) 2.5 inch vatterfly valves (spin up exhaust)~~ that are mounted on Probe C.

Note: strikethroughs are changes from rev -.

3 Performance Requirements:

3.1 Ambient Environment

The Filters shall be compatible with the following environment (standard CA variation: Palo Alto to VAFB):
temperature range: -10 C to +30 C
humidity: 25-90%
barometric pressure: 740 – 770 Torr

3.2 Launch Environment

3.2.1 Random Vibration

The Filters shall perform as specified after exposure to the protoqual random vibration levels as specified in Table 3.2.1.

Frequency (Hz)	Protoqual Level (g^2/Hz)	Qual Level (g^2/Hz)
20	0.016	0.032
50	0.1	0.2
800	0.1	0.2
2000	0.016	0.032
Composite (grms)	11.2	15.8

Table 3.2.1 Random Vibration Spectra

3.3 On-orbit Environment

3.3.1 Temperature Range

The filters shall survive and operate as specified over the temperature range as specified in Table 3.3.1.

Cold		Hot
-76 C	Qual	40 C
-71 C	ATP	35 C
-60 C	Predicted	24 C

Table 3.3.1 Temperature Limits

3.4 Materials

Materials shall be chosen from an approved materials list.

3.4.1 Dissimilar Metals

The selection and use of dissimilar metals shall conform to the requirements of the Spacecraft Specification (SCSE-12). Where it is impractical to avoid dissimilar metals in direct contact with each other or their exposure to the same electrolyte, suitable protection shall be provided as required to meet the environmental requirements specified herein.

3.4.2 Corrosion Resistance

The selection and use of metals shall conform to the requirements of the SCSE-12 so as to limit hardware corrosion.

3.5 6 Inch Leakage Valve Filter

3.5.1 Contamination

3.5.1.1 Debris Entry

~~Filter shall prohibit entry of particles larger than 26 micrometers~~. N/A
Not required per LM EM SYS 246.

3.5.1.2 Inner Surfaces

~~The inner surfaces of the filter assembly shall be clean to level 100~~. The filters shall be cleaned to level 100A prior to delivery per Mil-Std 1246 (same as vatterfly valves). The filters will be tested in random vibe and acoustic to ensure particle emission is below level 100.
Approach supported per LM EM SYS 253 and EM SYS 244.

3.5.2 Flow Restriction

The filter shall have an effective open area greater than ~~150~~ 130 cm^2 . The ratio of the filter material thickness to pore size shall be less than or equal to ~~2~~ 1.5.
Relaxation in flow restriction maintains constraint that ground-based testing was worst case restriction.

3.5.3 EMI shielding

The filter shall attenuate EMI by ~~35~~ 15 dB between the frequencies of 1 MHz and 10 GHz.

EMI attenuation relaxation based upon 20 dB attenuation measurement by Liberty Bell for isolated valve. Test will be performed by Stanford at valve level to verify 35 dB of attenuation of valve/filter assembly.

3.5.4 Envelope

The filter shall not exceed the envelope defined in LM drawing 8A03429. The drawing will show a keep out zone to allow for operation of the valve. The drawing will show an exterior envelope.

Stanford will supply interface information as needed.

3.5.5 Mass

Each 6" filter shall not exceed a mass of 2.3 Kg. Mass properties will be provided to systems engineering.

3.6 2.5 Inch Spin Up Exhaust Valve Filter: Deleted from Spec

3.6.1 Contamination

3.6.1.1 Debris Entry

~~Filter shall prohibit entry of particles larger than 26 micrometers.~~ N/A

Not required per LM EM SYS 246.

3.6.1.2 Inner Surfaces

~~The inner surfaces of the filter assembly shall be clean to level 100~~. N/A

Not required per LM EM SYS 246.

3.6.2 Flow Restriction

~~The filter shall have an effective open area greater than 40 cm^2. The ratio of the filter material thickness to pore size shall be less than or equal to 2~~. N/A

Filter not required per LM EM SYS 246 for particulate contamination, not required for EMI by Liberty Bell EMI results (S0678) combined with FEE EMI attenuation and spinup line EMI attenuation. Therefore filter is not required.

3.6.3 EMI Shielding

~~The filter shall attenuate EMI by 35 dB between the frequencies of 1 MHz and 10 GHz.~~ N/A

Filter not required per LM EM SYS 246 for particulate contamination, not required for EMI by Liberty Bell EMI results (S0678) combined with FEE EMI attenuation and spinup line EMI attenuation. Therefore filter is not required.

3.6.4 ICD

~~The filter shall not exceed the envelope defined in LM drawing TBR. The drawing will show a keep out zone to allow for operation of the valve. The drawing will show an exterior envelope.~~ N/A

Filter not required per LM EM SYS 246 for particulate contamination, not required for EMI by Liberty Bell EMI results (S0678) combined with FEE EMI attenuation and spinup line EMI attenuation. Therefore filter is not required.

3.6.5 Mass

~~Each 2.5" filter shall not exceed a weight of 1.4 Kg. Mass properties will be provided to systems engineering~~. N/A

Filter not required per LM EM SYS 246 for particulate contamination, not required for EMI by Liberty Bell EMI results (S0678) combined with FEE EMI attenuation and spinup line EMI attenuation. Therefore filter is not required.

4 Quality Assurance

4.1 Overview

Quality Assurance shall assure conformance with the requirements of this document and applicable drawings and documents. ~~QA shall perform, witness or verify the tests defined herein and record results on applicable data sheets contained in the test procedure.~~

4.1.1 Responsibility for Tests

LM is responsible to perform all tests as specified in this document unless otherwise indicated. LM will provide results of tests as engineering data to Stanford. Stanford is responsible to provide the formal verification of the flight hardware. Tests may be witnessed by Stanford or NASA personnel.

4.1.2 Test Conditions

4.1.2.1 Standard Ambient Test Conditions

Unless otherwise specified herein, all tests required by this specification shall be conducted under the standard ambient test conditions specified in Table 4.1.2.1.

a	Temperature (°C):	16 to 32 °C
b	Barometric Pressure (Torr):	650 to 840 Torr
c	Relative Humidity	30-70 percent

Table 4.1.2.1Standard Ambient Test Conditions

4.1.2.2 Test Connections

Not applicable to this hardware. There are no electrical connectors.

4.1.2.3 Test Parameter Measurement Accuracy

Unless otherwise noted the measurement accuracy for all parameters will be as specified in Table 4.1.2.3. All measurements will be made with instruments which have been certified/calibrated.

a.	Temperature (°C):	± 3 °C
b.	Barometric Pressure (Torr):	900 to 1 Torr, ± 10%; 0.1 Torr or less, ± 1 order of magnitude.
c.	Relative Humidity	± 5%
d.	Acceleration (g):	± 5% at reference point.
e.	Vibration Amplitude or Acceleration (inches or g)	± 10% of peak level
f.	Vibration Frequency (Hz)	± 2% or ± 1 Hz, whichever is greater
g.	Random Vibration Spectral Density (g^2/Hz)	± 1.5 dB, 20 to 2000 Hz (by narrowband analysis, 25 Hz maximum below 1000 Hz and 1/3 octave above 1000 Hz).
h.	Random Vibration (rms acceleration)	± 10%
i.	Random Vibration Instantaneous Peaks	Limited to three times the rms acceleration
j.	Current	N/A
k.	Voltage	N/A
l.	Pulse Duration	N/A
m.	Impedance	N/A
n.	Weight	± 1%
o.	Pressure	± 1%

Table 4.1.2.3 Test Parameter Accuracy

4.2 Quality Conformance Inspections

4.2.1 Verification Methods

Verification of compliance with the requirements of Section 3 will be performed as specified in Table 4.3.2 Verification Matrix. The verification methods defined below establish how each requirement will be met:

Analysis: A process used in lieu of or in addition to testing to verify compliance with specifications. The techniques typically include an interpretation or interpolation/extrapolation of analytical or empirical data under defined conditions or reasoning to show theoretical compliance with stated requirements.

Inspection: A visual examination of the item against the applicable documentation to confirm compliance with requirements.

Test: An action by which the operability, performance capability or other specified qualities of an item are verified when subjected to controlled conditions that are real or simulated. These verifications may require the use of special test equipment and instrumentation to obtain quantitative data for analysis as well as qualitative data derived from displays and indicators inherent in the items for monitor and control.

Similarity: Similarity is the process of comparing a current item with a previous item, taking into consideration configuration, test data, application and environment. The evaluation must be documented and will include: (1) the test procedures/reports of the item to which similarity is claimed; (2) a description of the differences between the items; (3) and the rationale for verification by similarity; (4) and pedigree of the previous item. All in-orbit experience must be documented and available for review.

Not Applicable: Use of the term "Not Applicable" will be limited to those paragraphs/paragraph headings for which there are no requirements.

Verification Legend: Analysis (A)
Inspection (I)
Test (T)
Similarity (S)
Not Applicable (N/A)

4.3 Testing

4.3.1 Test Flow

The filters will be subjected to acceptance and qualification testing as defined in this specification.

4.3.1.1 Test Flow

The test flow will be a vibration test, a thermal survival test, and an inner surfaces test. The exact order of the tests may be based upon facility availability, however the inner surfaces test must be performed last.

4.3.1.2 Random Vibration Test

The unit shall be subjected to the random vibration protoqual levels specified in paragraph 3.2.1.

4.3.1.3 Thermal Survival Test

The unit shall be subjected to the on-orbit thermal environment as specified in paragraph 3.3.1.

4.3.1.4 Inner Surfaces

~~The unit will be tested for surface contamination as specified in paragraph 3.5.1.2 and 3.6.1.2. This verificication is done by analysis~~. The unit will be tested for contamination as specified in paragraph 3.5.1.2.

4.4 Verification Cross Reference Matrix

¶ no.	Title	Method of Verification
3.1	Ambient Environment	A
3.2	Launch Environment	N/A
3.2.1	Random Vibration	T
3.3	On-orbit Thermal Environment	N/A
3.3.1	Temperature Range	T
3.4	Materials	I
3.5	6 Inch Leakage Valve Filter	N/A
3.5.1	Contamination	N/A
3.5.1.1	Debris Entry	N/A
3.5.1.2	Inner Surfaces	~~TA~~ T
3.5.2	Flow Restriction	I
3.5.3	EMI shielding	I
3.5.4	Envelope	I
3.5.5	Weight	I
3.6	2.5 Inch Spin Up Exhaust Valve Filter	N/A
3.6.1	Contamination	N/A
3.6.1.1	Debris Entry	~~I~~ N/A
3.6.1.2	Inner Surfaces	~~T~~ N/A
3.6.2	Flow Restriction	~~I~~ N/A
3.6.3	EMI Shielding	~~I~~ N/A
3.6.4	Envelope	~~I~~ N/A
3.6.5	Weight	~~I~~ N/A