APPLICATION	
NEXT ASSY	USED ON

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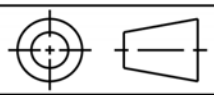
INTERPRET DIMENSIONS AND
TOLERANCES PER ASME Y14.5M-1994.
TOLERANCES NO:

FRACTIONS DECIMALS ANGLES

THIRD ANGLE PROJECTION



CAD MAINTAINED.
CHANGES SHALL BE INCORPORATED
ONLY BY THE DESIGN ACTIVITY

SOFTWARE

FILENAME K0000113580-SPC

MATERIAL

HEAT TREATMENT

FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING (YY/MM/DD) 12/06/12

DRAFTSMAN	CHECKER
J Jingle	H Solanky
ENGINEER	CHECKER
F Jankowski	
ENGINEER	STRESS
V Ward	

ENGINEER B Nufer

SUBMITTED T Aranyos

APPROVED S Green

JOHN F. KENNEDY SPACE CENTER, NASA
KENNEDY SPACE CENTER, FLORIDA

ACCUMULATOR, NITROGEN TETROXIDE, HYDRAZINE, AND MONOMETHYLHYDRAZINE SERVICE, SPECIFICATION FOR

SIZE	CAGE CODE	DWG NO	REV
A	22264	K0000113580-SPC	–

SCALE	UNIT WEIGHT	SHEET	OF
None	—	1	18

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

°C	Degree Celcius
ASME	American Society of Mecanical Engineers
ASNT	American Society of Non-destructive Testing
ASTM	American Society of Testing and Materials
AWS	American Welding Society
BPVC	Boiler and Pressure Vessel Code
CO	Contracting Officer
COTR	Contracting Office Technical Representative
EDU	Engineering Development Unit
g	Acceleration due to gravity
GHe	Gaseous Helium
ISO	International Standard Organization
IT	Information Technology
ITAR	International Traffic in Arms Regulations
KSC	John F. Kennedy Space Center
MEOP	Maximum Expected Operating Pressure
MIL	Military
MMH	Monomethylhydrazine
MP	Mega Pixel
NAS	National Aerospace Standard
NASA	National Aeronautics and Space Administration
NDE	Non Destructive Evaluation
NTO	Nitrogen Tetroxide (N_2O4)
N2H4	Hydrazine
N2O4	Nitrogen Tetroxide
PPM	Parts per Million
PTFE	Polytetrafluroethylene
SAE	Society of Automotive Engineer
SOW	Statement of Work

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1. SCOPE

This specification establishes the requirements for the design, fabrication, qualification and acceptance of an aerospace flight-like high performance and high cycle life titanium Accumulator to be used for Nitrogen Tetroxide (N2O4) Hydrazine (N2H4), and/or Monomethylhydrazine (MMH) service. The accumulator will be pressurized with Gaseous Helium (GHe) to expel the various fluids from the accumulator. The accumulator will be used to dampen the output of a fluid pump and transfer fluid to a spacecraft in geosynchronous orbit. This accumulator will serve as an "Engineering Development Unit (EDU) aerospace "flight like simulation" component for use in conceptual system level integrated testing on a hypergol satellite program.

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. The latest revision applies unless a specific revision is indicated. However, when this document is used for procurement, including solicitations, or is added to an existing contract, the specific revision levels, amendments, and approval dates of said governmental documents are specified in an attachment to the Solicitation / Statement of Work (SOW) / Contract.

Copies of government specifications, standards, drawings, and publications required by vendors in connection with specified procurement functions are obtained from the procuring activity or as directed by the Contracting Officer.

2.1 Governmental

National Aeronautics and Space Administration (NASA)

NASA NPR 6000.1	Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems, Equipment, and Associated Components
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses and Wiring

Military (MIL)

MIL-PRF-26536	Propellant Pressurization Agent, Hydrazine
MIL-PRF-26539	Propellant Pressurization Agent, Nitrogen Tetroxide
MIL-PRF-27404	Propellant Pressurization Agent, Monomethylhydrazine
MIL-PRF-27407	Helium (Type I Grade A)
MIL-P-27401	Nitrogen (Type I/II Grade B)
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

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2.2 Non-Governmental

American Welding Society (AWS)

AWS G2.4/G2.4M	Guide for the Fusion Welding of Titanium and Titanium Alloy
AWS D17.1/D17.1M	Specification for Fusion Welding for Aerospace Application
AWS B1.10M/B1.10	Guide for the Nondestructive Examination of Welds

American Society of Mechanical Engineers (ASME)

ASME BPVC Section V Appendix IV	Nondestructive Evaluation

American Society of Non-Destructive Testing (ASNT)

ASNT-TC-1A	Recommended Practice for Personal Qualification and Certification in Non-destructive Testing

American Society of Testing and Materials (ASTM)

ASTM B265	Standard Specification for Titanium and Titanium Alloy Strip, Sheet and Plate
ASTM E1742	Standard Practice for Radiographic Examination
ASTM E1417/E1417M	Standard Practice for Liquid Penetrant Examination
ASTM D1193	De-mineralized Reagent Water, Type H

Society of Automotive Engineers (SAE)

SAE AMS 4928	Standard Specification for Titanium Bar
SAE AS9132	Data Matrix Quality Requirement for Parts Marking
SAE AS4350	Plug, Straight Thread
SAE AS5202	Port Fitting End, Straight Thread
SAE AS9956	Packing, Preformed (PTFE) –Seal

International Standard Organization (ISO)

ISO 14952-1	Surface Cleanliness of Fluid Systems (Vocabulary)
ISO 14952-4	Surface Cleanliness of Fluid Systems (Rough Cleaning Processes)

Aerospace Industries Association/National Aerospace Standards (AIA/NAS)

NAS 410	NAS Certification & Qualification of Nondestructive Test Personnel

National Fire Protection Agency (NFPA)

NFPA 70	National Electric Code

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3. REQUIREMENTS

3.1 Definition

The accumulator is an active volume changing differential pressure vessel to store and assist with the transfer of and increase/decrease fluid line pressure of the following fluids: Hydrazine, Nitrogen Tetroxide, and Monomethylhydrazine. The pressurization side media is GHe. The accumulator functions include pump backup, support of thermal expansion, and stabilize pressure. The accumulator shall have a positioning sensor with remote readout/recording.

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3.2 Characteristics

3.2.1 Performance Characteristics

3.2.1.1 The service shall be for N2O4, N2H4, or MMH liquid media side and GHe gas side. Gas side shall be compatible for commodity vapor N2O4, N2H4, and/or MMH.

3.2.1.2 The usable liquid volume shall be a minimum of 1.25 liters (excluding bellows ullage).

3.2.1.3 Liquid side maximum expected operating pressure (MEOP) is 500 pounds per square inch absolute (psia) with 0 psia on gas side. Gas side MEOP is 500 psig with 0 psig on liquid side.

3.2.1.4 Design fluid flow rate as follows for the following specific media:

3.2.1.4.1 N2O4 MIL-PRF-26539 is 0.4 to 4.0 liters/minute

3.2.1.4.2 N2H4 MIL-PRF-26536 is 0.6 to 6.0 liters/minute

3.2.1.4.3 MMH MIL-PRF-27404 is 0.7 to 7.0 liters/minute

3.2.1.4.4 GHe MIL-PRF-27407 Type I Grade A (Flow rate to accommodate compensations on liquid side)

3.2.1.5 Design temperature range 5 to 55 degrees Celsius.

3.2.1.6 The accumulator shall have bellows position sensor with an accuracy of no less than 10%, with a goal of 1% or better, as verified by 1700 cycle test (ref. Bellows Cycle Test section 4.1.7.1).

3.2.1.7 When evaluating electromagnetic interference characteristics of the bellows position sensor, MIL-STD-461 may be used as a guide.

3.2.1.8 Maximum transmitter limits for Launch RF environment - Not Applicable for EDUs.

3.2.1.9 Galactic Radio Noise - Not Applicable for EDUs.

3.2.1.10 Solar Induced Electromagnetic Levels - Not Applicable for EDUs.

3.2.1.11 Ground Sourced Electromagnetic Levels - Not Applicable for EDUs.

3.2.1.12 Geosynchronous Satellite Induced Electromagnetic Levels - Not Applicable for EDUs.

3.2.1.13 The accumulator shall be designed for a minimum proof test safety factor of 1.5 x MEOP.

3.2.1.14 The accumulator shall be designed for a minimum burst safety factor of 2.5 x MEOP.

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3.2.2 Physical Characteristics

3.2.2.1 The accumulator shall have ¼ inch fluid inlet and outlet ports and 1/4 inch GHe pressurization port per Society of Automotive (SAE) AS5202.

3.2.2.2 Bellows and accumulator body on both fluid and gas side shall be made of Titanium per ASTM B265 and/or AMS 4928 as applicable.

3.2.2.3 Internal bellows shall be retained by upper and lower stops and guides as shown notionally in Figure 1.

3.2.2.4 The accumulator and its subcomponents (bellows, position sensor, stops and guides) shall be evaluated for side loads and vibration to withstand lateral loads of +2 /- 2 G force (Gravitational load).

3.2.2.5 The accumulator and its subcomponents (bellows, position sensor, stops and guides) shall be evaluated for side loads and vibration to withstand axial loads of +6 /- 2 G force.

3.2.2.6 Sinusoidal Vibration Flight-Level Loads – Not Applicable for EDUs

3.2.2.7 Random Vibration Flight-Level – Not Applicable for EDUs

3.2.2.8 Acoustic Impingement Flight-Level - Not Applicable for EDUs

3.2.2.9 Mechanical Shock Flight-Level - Not Applicable for EDUs

3.2.2.10 All materials, metallic and non-metallic, exposed to N2O4, N2H4, or MMH shall be evaluated by NASA in order to determine whether they are compatible with the commodity. If the materials selected by the vendor have not been tested for compatibility, a material that is known to be compatible with the commodity shall be selected by NASA as a substitute.

3.2.2.11 Maximum weight of accumulator shall be approximately 3 Kilograms.

3.2.2.12 The accumulator shall have two external support brackets for test hold down as shown on Figure 1.

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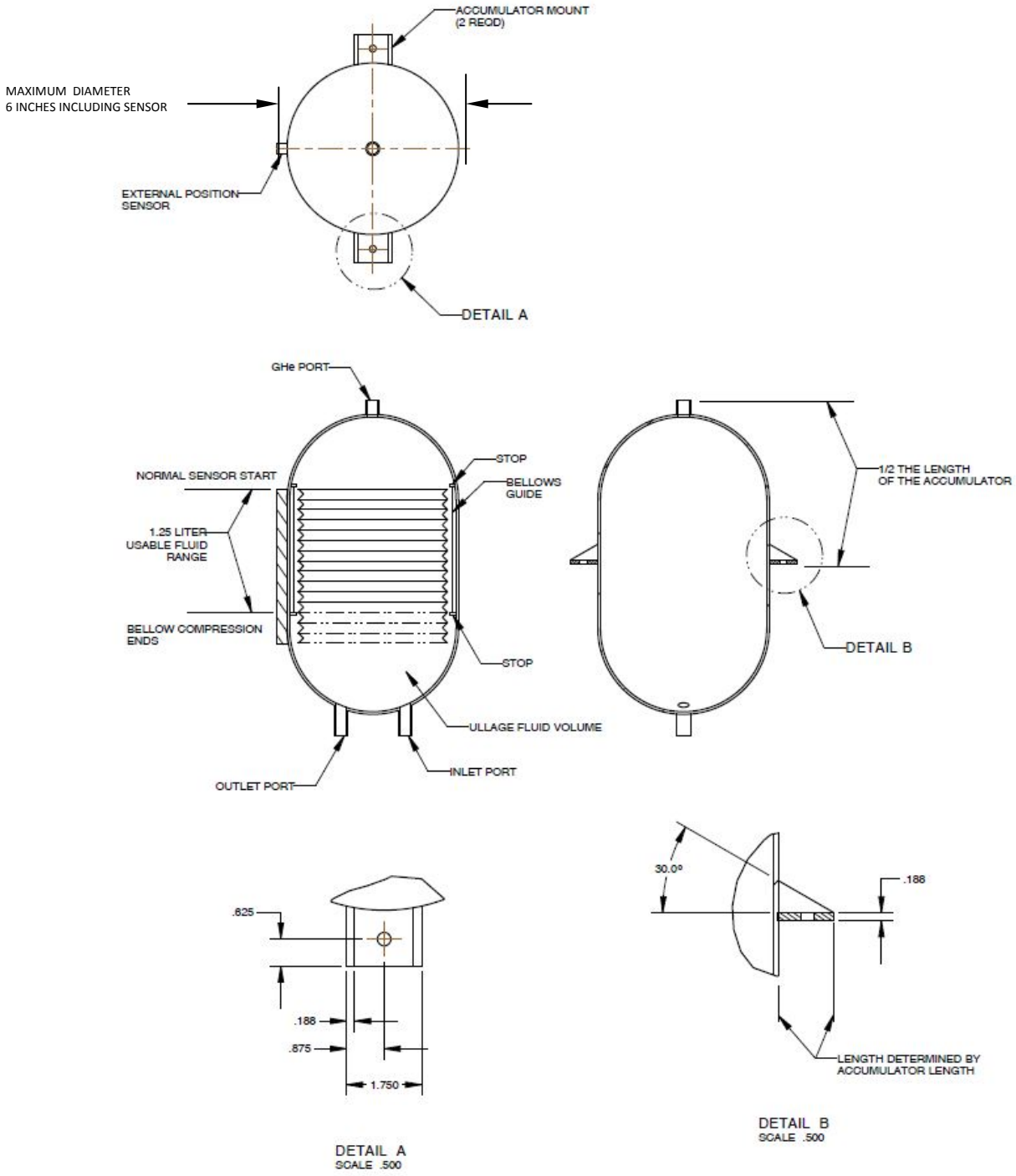

*Above dimensions in inches +/- 0.010

Figure 1 – Bellows Guide and External Support Brackets

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3.3 Design and Fabrication

3.3.1 Welding shall be performed per AWS D17.1/D17.2M and AWS G2.4/G2.4M.

3.3.2 Welding procedures per AWSD17.1/D17.2M section 5.4.1, shall be submitted to NASA COTR for review and approval prior to welding.

3.3.3 All welders shall be qualified per AWS D17.1/D17.1M section 5.

3.3.4 All welding inspections shall be qualified per AWS D17.1/D17.1M or ASNT-TC-1A.

3.3.5 Non Destructive Evaluation inspectors shall be certified to NAS-410 or AWS B1.10M/B1.10M.

3.3.6 All Class A welds shall be radiographically inspected in accordance with ASTM E1742 and meet the acceptance criteria of Table 7.1 Class A of AWS D17.1/D17.1M.

3.3.7 All non-Class A welds on pressure containing parts must be 100% Non-Destructive Evaluation (NDE) volumetric inspected or equivalent methods ensuring similar quality such as automated processes / alternative NDE.

3.3.8 If NDE digital radiography is used, digital photo resolution must be no larger than 10% of the potential flaw per pixel per ASME BPVC Section V Appendix IV.

3.3.9 Penetrant inspection shall be in accordance with ASTM E1417 or equivalent.

3.3.10 Do not perform dye penetrant inspection on internal accumulator welds.

3.3.11 Weld traceability maps shall be utilized for each accumulator.

3.3.12 Welded parts of the accumulator shall have an allowable leakage (both sides of the bellows to be tested) of less than 1 x 10-9 standard cc/sec gaseous helium when pressurized to 750 psia for 30 minutes and to be inspected with a mass spectrometer rated to 1 x 10-10 standard cc/sec gaseous helium of better.

3.3.13 Joints on the accumulator shall have an allowable leakage of less than 1 x 10-6 standard cc/sec gaseous helium when pressurized to 750 psia for 30 minutes and to be inspected with a mass spectrometer rated to 1 x 10-7 standard cc/sec gaseous helium of better

3.3.14 Socket weld joints shall not be used.

3.3.15 Position sensor electrical components must be compatible with N2O4, N2H4, and/or MMH and be installed in accordance with NFPA 70.A, Section 500 (National Fire Protection Agency).

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3.3.16 Position sensor wiring and connector shall be crimped per NASA-STD-8739.4 (Crimping, Interconnecting Cables, Harnesses and Wiring).

3.3.17 The position sensor (external component) shall have a removable protective cover that interfaces with a support bracket mounted to the accumulator. The bracket shall support the position sensor interfacing electrical connector.

3.4 Cleaning and Drying

3.4.1 All components/sub-assemblies shall be cleaned from dirt, grit, scale, grease, oil and other foreign matter prior to and after assembly per ISO 14952-4.

3.4.2 Units shall be verified to be visually clean with absence of all particulate and non-particulate matter visible to the normal unaided eye or corrected-vision eye, and visibly clean when inspected with an ultraviolet light wavelength of 320 nm to 380 nm per ISO14952-1 standard.

3.4.3 Based on the media (recommended de-mineralized water) utilized for functional verification tests, the Accumulator shall be dried and tested to a dew point of less than 5 PPM. It is recommended that the units be purged with Nitrogen per MIL-P-27401 Type I Grade A, or NASA approved equivalent, passing through a 5 micron filter.

3.5 Reliability

3.5.1 The accumulator shall be designed for an operational life of 5 years and a storage life of 2 years.

3.5.2 The accumulator shall be designed for approximately 1700 fluid transfer cycles.

3.5.3 The accumulator shall be fatigue tested to 1700 cycles (as defined in para 4.1.6.1).

3.6 Sustainability

N/A

3.7 Transportability

The accumulator shall be compatible with the planned packaging and transportation system to the extent that loads induced in the equipment during transportation will not produce stresses, internal loads, or deflections resulting in damage to the equipment.

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3.8 Name Plates and Product Marking

The accumulator shall be permanently and legibly electrochemically etched for identification on an outer surface per AS9132 to include the information listed below that is not included in these standards:

- Manufacturing vendor name
- Part or model number
- Serial number as specified in Statement of Work
- Fabrication date
- Design pressure rating
- Service media
- Acceptance test pressure and date

3.9 Interchangeability

Hardware assemblies, components, and parts with the same part number shall be physically and functionally interchangeable.

3.10 Government-Furnished Property

Not Applicable.

3.11 Documentation

Documentation shall be furnished per the requirements of the SOW.

3.12 Personnel and Training

Not Applicable

3.13 Precedence

The technical requirements of this specification take precedence, in the case of conflict, over the technical requirements cited in the listed applicable documents or referenced guidance documents. The vendor shall notify NASA COTR of each instance of conflicting or apparently conflicting requirements.

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4. ACCEPTANCE TESTS

The purpose of the acceptance testing is to verify that each accumulator meets the design specification requirements necessary to ensure operational suitability in their anticipated environments.

Acceptance testing is required for each accumulator designed and fabricated in accordance with this specification.

After successful acceptance testing, any changes to the accumulator design, material changes, and process changes will result in invalidating the acceptance testing certification for this purchase. Such changes would drive the vendor to re-perform the acceptance testing unless the change is approved by NASA Engineering.

4.1 Accumulator Acceptance Testing Requirements Test Matrix

4.1.1 Test Matrix

The following Table 1 presents the required tests to be performed as part of the accumulator acceptance criteria, unless otherwise approved by NASA Engineering. Alternate test methods shall be approved by NASA Engineering before implementation.

Table 1 Acceptance Test Matrix

Requirement	Section	Vendor Test Article	NASA Test Article
Dimensional Verification	4.1.3	X	X
Volumetric/Flow Rate & Instrumentation Verification	4.1.4	X	X
Proof / Leak Test	4.1.5	X	X
Bellows Full Cycle Test	4.1.7	X	
Bellows Limited Cycle Test	4.1.8		X
Burst Test (Vendor Test Article) *	4.1.9	X	

*Burst Test shall be performed after all acceptance testing is completed.

NOTE:
The acceptance of the component procured by this specification shall be conducted at the component level unless otherwise specified in the performance specifications SOW. Testing as shown may be combined for maximum efficiency/cost effectiveness.

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4.1.2 Testing Medium

4.1.2.1 Clean, dry GHe per MIL- PRF-27407 Type 1, Grade A or NASA approved equivalent, with a moisture content of 6 ppm maximum and filtered through a stainless steel 25 micron absolute rated filter shall be used for all testing where gaseous helium is required.

4.1.2.2 De-mineralized water in lieu of N_2O_4, N_2H_4 or MMH may be used for testing. On fluid side, only lubricants compatible with N2O4, N2H4 or MMH shall be used after clean process.

4.1.3 Dimensional Verification

4.1.3.1 The vendor fabrication drawings shall be verified to meet the requirements of this specification before starting fabrication of parts.

4.1.3.2 The accumulator assembly dimensions shall be verified to be in accordance with vendor fabrication drawings prior to beginning acceptance testing.

4.1.4 Volumetric/Instrumentation Verification

4.1.4.1 The accumulator assembly liquid volume shall be verified to meet the requirements of this specification, minimum of 1.25 liters (plus bellows ullage).

4.1.4.2 The accumulator assembly flow capability shall be verified to meet the requirements of this specification.

4.1.4.3 The liquid volume level indicator shall be verified to be accurate to no less than 10% of fluid levels (with extension / compression of bellows) within upper and lower stop positions.

4.1.5 Proof / Leak Test

4.1.5.1 The accumulator shall be acceptance tested at 750 psia (1.5 times MEOP) with GHe for 30 minutes, to include the GHe chamber and the fluid chamber. The acceptance test shall be performed as follows:

4.1.5.1.1 Gas side – The gas side shall be pressurized to 750 psia with the liquid side at ambient pressure

4.1.5.1.2 Fluid side – The fluid side shall be pressurized to 750 psia with the gas side at ambient pressure.

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4.1.5.1.3 The accumulator shall have a leak rate of <1 x 10 -9 cc/sec/GHe or better across the bellows (both directions), when pressurized to 750 psia, and verified by a mass spectrometer rated to 1 x 10-10 standard cc/sec gaseous helium or better.

4.1.6 Bellows Cycle Test

4.1.6.1 **Definition of one pressure cycle**

4.1.6.1.1 Slowly pressurize GHe cavity (above bellows) to a pressure up to 500 psia on gas side while maintaining approximately 450 psia on liquid side, sufficient to compress bellows to lower stop. Bellows position shall be recorded continuously.

4.1.6.1.2 Record bellows lower stop position.

4.1.6.1.3 Slowly reduce GHE cavity pressure (above bellows) while maintaining approximately 450 psia on liquid side, sufficiently to extend bellows to forward stop. Bellows position shall be recorded continuously.

4.1.6.1.4 Record bellows forward stop position.

4.1.6.1.5 Slowly depressurize GHe cavity (above bellows) and liquid side pressure to return bellows to nominal position.

4.1.6.1.6 Record bellows nominal position.

4.1.7 Bellows Full Cycle Test

4.1.7.1 Perform 1700 cycles of tests (defined in 4.1.6.1). At completion of 1700 cycles, perform proof/leak test per 4.1.5.

4.1.8 Bellows Limited Cycle Test

4.1.8.1 Perform 10 cycles of tests (cycles defined in 4.1.6.1) and perform proof /leak test per 4.1.5.

4.1.9 Burst Test (Vendor Test Article only)

4.1.9.1 The accumulator shall be burst tested to a pressure of 1250 psig (2.5 times 500 psia) (both directions in turn, across the bellows). Verify the leakage meets the requirement of line item 4.1.5.1.3. This test shall be performed after all acceptance testing is complete.

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5. PREPARATION FOR DELIVERY

5.1 Preservation

Packaging procedures and materials should be adequate to preserve the cleanliness level of the components during shipping and handling.

5.2 Protection of Accumulator

Fluid and Gas ports shall be sealed with AS4350 plug, straight thread and AS9956 O-ring, virgin PTFE.

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6. PACKING FOR SHIPMENT

Safe delivery in packaging is defined as delivery of a shipment to its destination with minimal damage to the package and no damage to the contents.

6.1 Packaging Procedure

The vendor shall prepare a step by step procedure for packaging the shipping unit in compliance with NPR 6000.1, Class IV Level B. This procedure shall be approved by NASA Contracting Officer prior to shipment of any unit.

6.2 Marking for Shipment

The vendor shall provide outside package marking essential to the identification of the item in detail, including appropriate identification of the product on both packages and shipping containers and all markings necessary for safe delivery and for storage.

7. NOTES

7.1 Intended Use

This document is intended to establish the requirements for fabrication and testing of an accumulator designed for GHe on the gas side, and N_2O_4, N_2H_4, and MHH on the liquid side.

7.2 Definitions

For the purpose of this document, the following definitions shall apply.

a. **Acceptance Tests** - A test (or series of tests) conducted on each fabricated item to verify that it performs in accordance with expectations and requirements, that it is designed and produced with adequate workmanship and quality, and that it is acceptable for delivery to the customer. Acceptance testing often includes testing for certification and to detect latent manufacturing and workmanship problems.

b. **Pressure Cycle** - Defined as pressurization from atmospheric pressure to specified pressure and back down to atmospheric.

c. **Maximum Expected Operating Pressure (MEOP)** – The maximum pressure which the pressurized hardware is expected to experience during its service life, in association with its applicable operating environments..

d. **Service / Operating Life** - The specified operating time / cycles that an item can accrue before replacement or refurbishment without risk of degradation of performance beyond acceptable limits.

e. **Shall** - Used to indicate a requirement which must be implemented and its implementation verified.

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f. **Proof Test** – A pressurized acceptance test to verify that the materials, manufacturing processes and workmanship meet design specification and that the hardware is suitable for flight.

g. **Burst Test –** A pressurized test to demonstrate that the actual burst pressure of the vessel meets design specification safety factors before failure. Testing such as burst test must be performed after all acceptance testing is complete.

h. **Bellows Ullage** – Fluids remaining in bellows when bellows is compressed to lower stop.

Custodian:

NASA - John F. Kennedy Space Center
Kennedy Space Center, Florida 32899

Preparing Activity:

John F. Kennedy Space Center