K0000113586-SPC Flex Hose, Stainless Steel EDU Design Specification

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APPLICATION	
NEXT ASSY	USED ON

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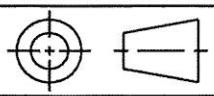
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
INTERPRET DIMENSIONS AND
TOLERANCES PER ASME Y14.5M-1994.
TOLERANCES NO:

FRACTIONS DECIMALS ANGLES

THIRD ANGLE PROJECTION



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SOFTWARE

FILENAME K0000113586-SPC

MATERIAL

HEAT TREATMENT

FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING (YY/MM/DD) 12/06/21

DRAFTSMAN J Jingle | CHECKER H Solanky

ENGINEER F Jankowski | CHECKER

ENGINEER V Ward | STRESS

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SUBMITTED T Aranyos

APPROVED S Green

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

FLEX HOSE, STAINLESS, HYDRAZINE AND MONOMETHYLHYDRAZINE SERVICE, SPECIFICATION FOR

SIZE	CAGE CODE	DWG NO	REV
A	22264	K0000113586-SPC	–

SCALE None | UNIT WEIGHT – | SHEET 1 OF 20

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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
GHe	Gaseous Helium
ITAR	International Traffic in Arms Regulations
KSC	John F. Kennedy Space Center
MEOP	Maximum Expected Operating Pressure
MIL	Military
MMH	Monomethylhydrazine
MP	Mega Pixel
MSFC	Marshall Space Flight Center
NAS	National Aerospace Standard
NASA	National Aeronautics and Space Administration
NDE	Non Destructive Evaluation
N_2H_4	Hydrazine
PPM	Parts Per Million
SAE	Society of Automotive Engineer
SOW	Statement of Work

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1. SCOPE

This specification establishes the requirements for the design, fabrication and acceptance of an Engineering Development Unit (EDU) Stainless Steel Braided Convoluted Flex hose to transfer Hydrazine (N_2H_4) and Monomethylhydrazine (MMH). This flex hose will serve as an Engineering Development Unit (EDU) aerospace "flight like simulation" component for use in conceptual system level integrated thermo-vacuum ground proof of concept testing simulating eventual intended operations on a hypergol satellite program to be used in GEO orbit.

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 shall be obtained from the procuring activity or as directed by the Contracting Officer.

2.1 Governmental

Military (MIL)

MIL-PRF-26536	Hydrazine (N_2H_4)
MIL-P-27401	Nitrogen (Type I/II Grade B)
MIL-PRF-27404	Monomethylhydrazine (MMH)
MIL-PRF-27407	Helium (Type I Grade A)

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

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2.2 Non-Governmental

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

NAS 410	NAS Certification & Qualification of Nondestructive Test Personnel

American Society of Mechanical Engineers (ASME)

ASME BPVC Section V Appendix IV	Nondestructive Evaluation
ASME BPVC Section VIII	Rules for Construction of Pressure Vessels

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 A240	Standard Specification for Chromium and Chromium – Nickle Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Application
ASTM A269	Standard Specification for Seamless and Welded Austenic Stainless Steel Tubing for General Service
ASTM A380	Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment and Systems
ASTM A580	Standard Specification for Stainless Steel Wire
ASTM A967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
ASTM D1193	De-mineralized Reagent Water, Type H
ASTM E1742/E1742M	Standard Practice for Radiographic Examination
ASTM E1417/1417M	Standard Practice for Liquid Penetrant Examination
ASTM G93-03	Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment used in Oxygen-Enriched Environments

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American Welding Society (AWS)

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

Expansion Joint Manufacturing Association

EJMA	Standards of the Expansion Joint Manufacturers Association, Inc.

International Standard Organization (ISO)

ISO 10380	Pipework – Corrugated Metal Hoses and Hose Assemblies

Society of Automotive Engineers (SAE)

SAE AS4326	Nut, Coupling (Stainless Steel)
SAE AS4327	Sleeve (Stainless Steel)
SAE AS4330	37 Degree Flare (Material Stainless Steel)

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3. REQUIREMENTS

3.1 Definition

The flex hose will be used in ground simulation of transfer Hydrazine and Monomethylhydrazine from one spacecraft to another in space and when pressurized with GHe.

3.2 Characteristics

3.2.1 Performance Characteristics

3.2.1.1 The service shall be for N_2H_4 per MIL-PRF-26536 and MMH per MIL-PRF-27404 and GHe per MIL-PRF-27407.

3.2.1.2 Maximum expected operating pressure (MEOP) of 450 pounds per square inch absolute (psia) maximum.

3.2.1.3 The design fluid flow rate is as follows for the following specific media:

3.2.1.3.1 MMH MIL-PRF-27404 0.19 to 1.9 gallons / minute

3.2.1.3.2 N_2H_4 MIL-PRF-26536 0.16 to 1.6 gallons / minute

3.2.1.3.3 GHe MIL-PRF-27407 Type I Grade A 0.0055 pounds / second

3.2.1.4 Design temperature range 5 to 55 degrees Celsius.

3.2.1.5 The flex hose shall be designed for a minimum acceptance leak test "proof" - safety factor of 1.5 x MEOP.

3.2.1.6 The flex hose shall be designed for a minimum burst safety factor of 5 x MEOP.

3.2.1.7 The flex hose shall be designed for a minimum number of 65 spool cycles / bending as defined per section 4.6.

3.2.1.8 The flex hose shall be designed for a minimum of 300 pressure cycles as defined per section 4.7.

3.2.1.9 Lateral loads of +2 / -2 G force (gravitational load) - Not Applicable for EDUs

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3.2.1.10 Axial loads of +6 / -2 G force (gravitational load) - Not Applicable for EDUs

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

3.2.1.12 Random Vibration Flight-Level – Not Applicable for EDUs

3.2.1.13 Acoustic Impingement Flight-Level - Not Applicable for EDUs

3.2.1.14 Mechanical Shock Flight-Level - Not Applicable for EDUs

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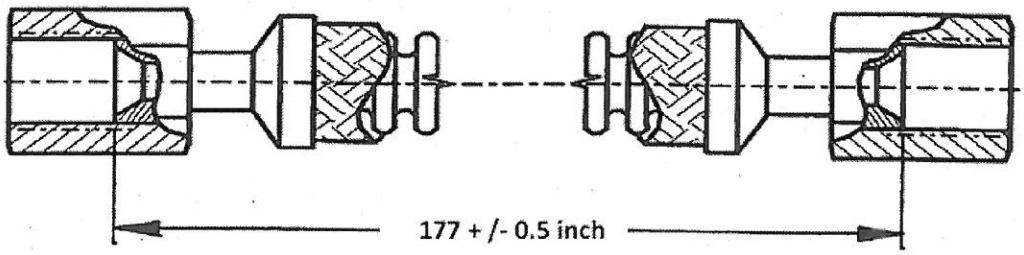
3.2.2 Physical Characteristics (Reference Figure 1)

3.2.2.1 The flex hose shall be ¼ inch nominal internal diameter and a maximum (braid) outside diameter of ½ inch or less.

3.2.2.2 Flex hose shall be 177 inches + /- 0.50 inches from flare face surface to flare face surface with no pressure applied.

3.2.2.3 Flare shall be 37 degree tube fitting per AS4330.

3.2.2.4 Dynamic bend radius 3 inches or less.

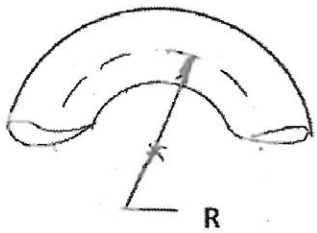


Flex Hose Design Data:

Nominal Diameter: 0.25 inch (see definition)

Braid Outside Diameter: 0.50 inches or less

Dynamic Bend Radius: 3 inches or less



3 inch Dynamic Bend Radius
To Centerline of Hose

Figure 1

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3.2.3 Materials

3.2.3.1 Bellows Convolutions – Stainless Steel per ASTM A269 or alternate contractor Stainless steel selection submitted with bids and approved by NASA Contracting Officer Technical Representative.

3.2.3.2 Braid – Stainless Steel per ASTM A580 or alternate contractor Stainless steel selection submitted with bids and approved by NASA Contracting Officer Technical Representative.

3.2.3.3 Braid Bands – Stainless Steel per ASTM A240 or alternate contractor Stainless steel selection submitted with bids and approved by NASA Contracting Officer Technical Representative.

3.2.3.4 Flare Tube Fitting – Stainless Steel per ASTM A580 or alternate contractor Stainless steel selection submitted with bids and approved by NASA Contracting Officer Technical Representative.

3.2.3.5 Sleeve - Stainless Steel AS4327

3.2.3.6 Coupling Nut – Stainless Steel AS4326

3.3 Design and Fabrication

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

3.3.2 Welding procedures per AWSD17.1/D17.2M section 5.4.1, shall be submitted to NASA Contracting Officer Technical Representative 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.

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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 Weld interface of convoluted bellows, braid, and braid band to tube end to be submitted to NASA Contracting Officer Technical Representative for approval.

3.3.11 Weld traceability maps shall be utilized for each flex hose.

3.3.12 Braid shall be free of any broken wires.

3.3.13 Braid tension to achieve desired flexibility must be designed, and / or tested, specified on the shop drawings, and recorded for fabrication repeatability.

3.3.14 Hose Joining

3.3.14.1 If the hose cannot be constructed of one continuous length of sheet metal or tubing, the joint shall be either butt-welded or edge welded. Reference Figure 1of ISO 10380.

3.3.14.2 All hose weld joints or hose to end fitting joints shall be designed stronger than the hose itself and not designed with stress concentration points.

3.3.15 Socket weld joints shall not be used.

3.3.16 Inner convolute to end connection fittings shall be per ISO 10380 or ASME VIII Div 1 Figure 26-13 joint type.

3.3.17 Weld design for joining inner line convolutions to stub ends shall be butt weld to accommodate 100% radiography. Butt weld is a proven design; however, alternate weld design/construction, such as machined overlap full groove weld to equivalent backing plate type design, may be considered by vendor with bid submit. If alternate weld design/construction is provided in lieu of butt weld, detailed definition of the alternate weld design/construction shall be submitted by the vendor as a specification alternative (including alternative method of weld examination), and must be submitted with bid package subject to approval by NASA Contracting Officer Technical Representative.

3.3.18 The flex hose shall be designed for a maximum torsional rotation on a flat extended surface of 24 inch-pounds without exceeding 0.25 of the ultimate tensile stress before permanent deformation occurs of the material.

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3.3.18.1 Vendor shall complete a flex hose torsion analysis as part of the flexhose design deliverables using the methods described in the 9th Edition of EJMA Design Standard Paragraph 4.13.4 or alternative reference standard of vendor selection to be submitted for NASA Contracting Officer Technical Representative approval.

3.3.19 The flex hose shall have an allowable leakage of less than 1×10^{-9} standard cubic centimeter/second (cc/sec) gaseous helium (GHe) when pressurized to 675 psia for 30 minutes and to be inspected with a mass spectrometer rated to 1×10^{-10} standard cc/sec GHe or better.

3.4 Cleaning and Drying

3.4.1 Flex hoses shall be cleaned per ASTM G93-03 level 300A.

3.4.2 Based on the media (recommended de-mineralized water) utilized for functional verification tests, the flex hose shall be dried and tested to a dew point of less than 5 PPM. It is recommended that the units be purge 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 flex hose shall have an operational life of 5 years and a storage life of 2 years.

3.5.2 The flex hose shall be designed for a minimum of 65 fluid transfer cycles.

3.5.3 The flex hose shall be fatigue tested to not less than 300 cycles (dynamic bend radius cycles).

3.5.4 The flex hose shall be torque tested. (Reference section 4.8)

3.5.4.1 Applied torque of 72 inch-pounds for 2 torque cycles.

3.5.4.2 Applied torque of 20 inch-pounds for 300 torque cycles.

3.6 Sustainability

3.6.1 N/A

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3.7 Transportability

The flex hose 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.

3.8 Name Plates and Product Marking

The flex hose shall have a nameplate / tag permanently and legibly marked for identification, wired to the flex hose with 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: Hydrazine and Monomethylhydrazine
- 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

N/A

3.11 Documentation

Documentation shall be furnished per the requirements of the SOW.

3.12 Personnel and Training

N/A

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 flex hose meets the design specification requirements necessary to ensure operational suitability in their anticipated environments.

Acceptance testing is required for each flex hose designed and fabricated in accordance with this specification. After successful acceptance testing, any changes to the flex hose 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 Flex hose 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 flex hose 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	4.3	X	X
Bend Radius Test	4.4	X	X
Proof / Leak Test	4.5	X	X
Spool Full Cycle / Bending Test (Vendor Test Article)	4.6.2	X	
Pressure Cycle / Bending Test (Vendor Test Article)	4.7.2	X	
Torque Angular Displacement Test (Vendor Test Article)	4.8.1	X	
Torque Cycle Test (Vendor Test Article)	4.8.2	X	
Burst Test * (Vendor Test Article only)	4.9	X	
Post Test Visual Inspection	4.10	X	X

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

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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.

4.2 Testing Medium

4.2.1 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.

4.2.2 De-mineralized water in lieu of N_2H_4 or MMH may be used for testing.

4.3 Dimensional Verification

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

4.3.2 The flex hose assembly dimensions shall be verified to be in accordance with vendor fabrication drawings prior to beginning acceptance testing.

4.4 Bend Radius Verification

4.4.1 Verify bend radius of flex hose is 3 inches (dynamic) or less over the length of the hose.

4.5 Proof / Leak Test

4.5.1 The flex hose shall be proof tested at 1.5 times MEOP (675 psia) for 30 minutes.

4.5.2 The flex hose shall have a leak rate of $<1 \times 10^{-9}$ standard cc/sec GHe or better, when pressurized to 675 psia, and verified by a mass spectrometer rated to 1×10^{-10} standard cc/sec GHe or better.

4.5.3 Flex hose length measurement shall be performed prior to and upon completion of the first proof test (test pressure released). The permanent elongation shall not exceed 1% of the test length per ISO 10380 5.3.1.4

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4.6 Spool Cycle Test

4.6.1 Definition of one spool cycle

4.6.1.1 Wind the flex hose completely onto a 5.5 inch diameter spool and then unwind the flex hose to the straight position. A pressure of 50 +/- 5 psia shall be maintained in the flex hose.

4.6.2 Spool Full Cycle Tests (Vendor Test Article)

4.6.2.1 Perform 65 spool cycle tests (defined in section 4.6.1). At completion of 65 cycles, perform proof/leak test per section 4.5. The test frequency shall be between 5 cycles per minute and 10 cycles per minute.

4.7 Pressure Cycle Test

4.7.1 Definition of one pressure cycle

4.7.1.1 One pressure cycle shall increase the pressure from 0 psig to 450 psig and then decrease back to 0 psig.

4.7.2 Pressure Cycle Tests (Vendor Test Article)

4.7.2.1 Perform 300 pressure cycle tests (defined in section 4.7.1). Perform proof /leak test per section 4.5, prior to and upon completion of test.

4.8 Torque Test

4.8.1 Torque Maximum Angular Displacement (Vendor Test Article)

4.8.1.1 Perform a stress versus angular displacement torque (strain-rotation) test with the flex hose in the extended position (no bends) and one end restrained. Apply a torque of 72 inch-pounds one time in a clockwise and counterclockwise direction. Record maximum angle displacement and torque. Permanent deformation shall be cause for rejection.

4.8.2 Torque Cycle Test (Vendor Test Article)

4.8.2.1 Perform a torque cycle test with flex hose in the extended position (no bends) and one end restrained. Apply a torque of 20 inch-pounds for 150 cycles in a clockwise direction and 150 cycles in a counterclockwise direction. Perform proof / leak test per section 4.5 upon completion of test.

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4.9 Burst Test (Vendor Test Article)

4.9.1 The flex hose shall be burst tested to a pressure of 2250 psia (5 x 450 psia). Verify the leakage meets the requirement of line item section 4.5.2. Verify no broken braid wires or rupture of any of the components. This test shall be performed after all acceptance testing is complete.

4.10 Post Test Visual Inspection

4.10.1 Upon completion of testing and prior to delivery, verify no broken braid wires. One or more broken braid wires will result in rejection of flex hose assembly.

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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 flex hose per ASTM G93-03 section 12.1.3.

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. The flex hose can be coiled for shipping with a minimum bend radius of 18 inches.

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 Technical Representative prior to shipment of any shipping 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 a flex hose designed for the transfer of N_2H_4 and MMH.

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 testing for certification and to detect latent manufacturing and workmanship problems.

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b. **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.

c. **Dynamic Bend Radius** – A measurement of flex hose bend radius while moving hose through range of motion and internal pressure applied as specified in section 4.6.1.

d. **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.

e. **Nominal Diameter** - Hose bellows convolution inside diameter equal to ¼ inch tube outside diameter.

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

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

h. **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.

i. **Shall** - Used to indicate a requirement which denotes a mandatory action.

j. **Should** – Used to indicate a requirement which denotes a good practice and is recommended, but not required.

Custodian:

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

Preparing Activity:

John F. Kennedy Space Center