APPLICATION	
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REVISION HISTORY

PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

NASA KSC Export Control Office (ECO)
Export/SBU Determination Record

EDDR# 1311342

DOCUMENT INFORMATION: (TITLE, NUMBER, REV, DATE)
K0000146600-SPC
Flexible Hose Specification, Vacuum Jacketed, LH2 Service

SENSITIVE BUT UNCLASSIFIED (SBU)

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	Yes	No	SBU Reviewer's Signature	Date	Company / Org
Document contains SBU?	☐	☒	Heather White (affiliate) (4/25/2013)	04/25/2013	ESC

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KSC FORM 7-657V2 NS (REV. 09/11) PREVIOUS EDITIONS ARE OBSOLETE

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. 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

MATERIAL

HEAT TREATMENT

FINAL PROTECTIVE FINISH

ORIGINAL DATE OF DRAWING (YY/MM/DD) 06/11/2013

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ICPSU FLEXIBLE HOSE SPECIFICATION, VACUUM JACKETED, LH2 SERVICE

SIZE	CAGE CODE	DWG NO	REV
A	22264	K0000146600-SPC	-
SCALE None	UNIT WEIGHT —	SHEET 1 OF 26	

KSC FORM 21-2C NS (REV 06/04) PREVIOUS EDITIONS ARE OBSOLETE

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RECORD OF REVISIONS/CHANGES

REV LTR	CHANGE NO.	DESCRIPTION	DATE
Basic		**Initial Release**	

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SCALE None		UNIT WEIGHT —	SHEET 5 OF 26

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Abbreviations, acronyms, and symbols

ASME	American Society of Mechanical Engineers
DP	Design Pressure
GN_2	Gaseous Nitrogen
GSE	Ground Support Equipment
KSC	Kennedy Space Center
LH_2	Liquid Hydrogen
LN_2	Liquid Nitrogen
NASA	National Aeronautics and Space Administration
NDE	Non-Destructive Evaluation
NPS	Nominal Pipe Size
VJ	Vacuum Jacket

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1. SCOPE

This specification provides technical requirements for the design, fabrication, and testing of vacuum jacketed flexible hose assemblies used in the transfer of liquid hydrogen (LH2) and liquid nitrogen (LN2).

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 documents shall be specified in an attachment to the Solicitation/Statement of Work/Contract.

In case of conflict between referenced document and this specification, this specification shall take precedence

2.1 Governmental

National Aeronautics and Space Administration (NASA)

NASA-SPEC-5004	Welding of Aerospace Ground Support Equipment and Related Nonconventional Facilities

NASA/Kennedy Space Center

KSC-C-123	Surface Cleanliness of Fluid Systems, Specification For

Military Specifications

MIL-PRF-27407C	Propellant Pressurizing Agent, Helium
MIL-PRF-27401F	Propellant Pressurizing Agent, Nitrogen

KSC Drawings

79K14672	Vacuum Pump out ports

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2.2 STANDARDS

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

2.3 Non-Governmental

American National Standard Institute (ANSI)

ANSI/AIAA G-095	Guide to Safety of Hydrogen and Hydrogen Systems

The American Society of Mechanical Engineers

ASME B31.3	Process Piping
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory-Made Wrought Buttwelding Fittings

American Society of Nondestructive Testing (ASNT)

ASNT-TC-1A	Recommended Practice, Personnel Qualification and Certification in Nondestructive Testing

American Society of Testing and Materials

ASTM A182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service
ASTM A193	Standard specification for alloy-steel and stainless steel bolting for high temperature or high pressure service and other special purpose applications.
ASTM A194	Standard specification for carbon and alloy steel nuts for bolts for high pressure or high temperature service, or both

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ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A320	Standard specification for alloy-steel and stainless steel bolting materials for low temperature service
ASTM A403	Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
ASTM B575	Standard Specification for Low-Carbon Nickel-Chromium-Molybdenum, Low-Carbon Nickel-Chromium-Molybdenum-Copper, Low-Carbon Nickel-Chromium-Molybdenum-Tantalum, and Low-Carbon Nickel-Chromium-Molybdenum-Tungsten Alloy Plate, Sheet, and Strip
ASTM A580	Standard Specification for Stainless Steel Wire
ASTM A967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts

National Bureau of Standards

NBS Monograph 29	Thermal Expansion of Technical Solids at Low Temperatures. A Compilation from the literature

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3. REQUIREMENTS

3.1 Definition

The assemblies are vacuum jacketed flexible hose(s) used to deliver cryogenics commodity (LH_2, GH_2, LN_2) as part of the Ground Support Equipment (GSE).

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

a. **Annulus** – Space between inner and outer piping walls

b. **Calendar Day** – Consecutive days on a calendar.

c. **Field Monitor** – Pressure monitoring performed by individual from a dial indicator gage without electronic transmission.

d. **Pressure Cap** – A pressure retaining cap which may be used for pressurizing pipe spool to 150% design pressure. Pressure cap may also be used as shipping cover.

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

f. **should:** Used to indicate a goal which must be addressed by the design but is not formally verified;

g. **Will:** Used to indicate a statement of fact and is not verified.

h. **TBR –** to be resolved / reviewed, involves data / processes to be designed / developed by contractor and provided to NASA at 45 percent and 90 percent design reviews for approval.

i. **TBD –** to be determined, involves data / processes in work at present by NASA, to be updated by NASA and incorporated to specification prior to contract award.

j. **TBS –** to be supplied, involves data / process to be supplied by the contractor to NASA as part of deliverables of this specification, but are not required for approval by NASA.

k. **Work Day –** Monday through Friday.

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3.2 General

3.2.1 Fluid Service

3.2.1.1 The service shall be for Liquid Hydrogen (LH_2), Gaseous Hydrogen (GH_2), Gaseous Helium (GHe), Liquid Nitrogen (LN_2) or Gaseous Nitrogen (GN_2)

3.2.1.2 All flexible hose assembly components shall be designed and fabricated as normal fluid service in accordance with ASME B31.3.

3.2.1.3 Examination processes and Pass/Fail criteria shall be in accordance with severe cyclic service requirements in ASM E B31.3.

3.2.2 Temperature and Pressure

3.2.2.1 The lowest ambient temperature expected in service shall be +20F.

3.2.2.2 The nominal ambient temperature for ground operations shall be +80 degrees F

3.2.2.3 The maximum ambient temperature in service shall be +105 degrees F.

3.2.2.4 The assembled flexible hose shall be designed for -423 degrees F to +158 degrees F at 120 psig.

3.2.2.5 The Design Pressure (DP) for the inner flexible hose shall be 135 PSIG with atmospheric pressure applied to external surface of inner pipe.

3.2.2.6 The Design Pressure (DP) for the inner flexible hose shall be 120 PSIG with 0 psia (full vacuum) applied to external surface of inner line (annular space).

3.2.2.7 The outer jacket flexible hose shall have an annular space design pressure (as defined by ASME B31.3) of 35 psig @ 158 degrees F.

3.2.2.8 The outer jacket shall be designed for external pressure of 20 psig (above ambient) with 0 psia (full vacuum) annular space pressure.

3.2.3 Material Properties

3.2.3.1 All materials used as pressure components shall meet the requirements of ASME B31.3.

3.2.3.2 Thermal properties of materials at cryogenic temperatures shall be as described from the National Bureau of Standards - Thermal Expansion of Technical Solids at Low Temperatures. A Compilation from the literature, NBS Monograph 29

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3.2.3.3 All materials for construction are specified in this specification. However, the contractor may use materials not specifically called out in this specification provided that chemical and mechanical analysis for the material are submitted to the owner for approval prior to start of fabrication. All materials including those in the vacuum annulus space shall be compatible with the fluid service (LH2, LN2, GN2, GHe) per AIAA G-095.

3.2.4 Heat Leak

3.2.4.1 The maximum heat leak for the vacuum jacketed flexible hose, including spacers but not end fittings, at LH_2 cryogenic conditions and an ambient temperature of 80 degrees F shall be (determined by test or analysis at the maximum ambient temperature):

Nominal ID of Inner Line (in)	Btu/hr/foot
3x5	3.24
4x6	4.22

3.2.5 Bend Radius

3.2.5.1 The bend radius shall be as specified in **Table 1**.

Minimum Center-Line Bend Radius		
VJ Flex Hose Size (inner x outer wall - NPS)	**Dynamic Flexing (inches)**	**Static Bend (inches)**
3”x5”	28	12.8
4”x6”	32	14.8

Table 1: Minimum Flexible Hose Center-Line Bend Radius

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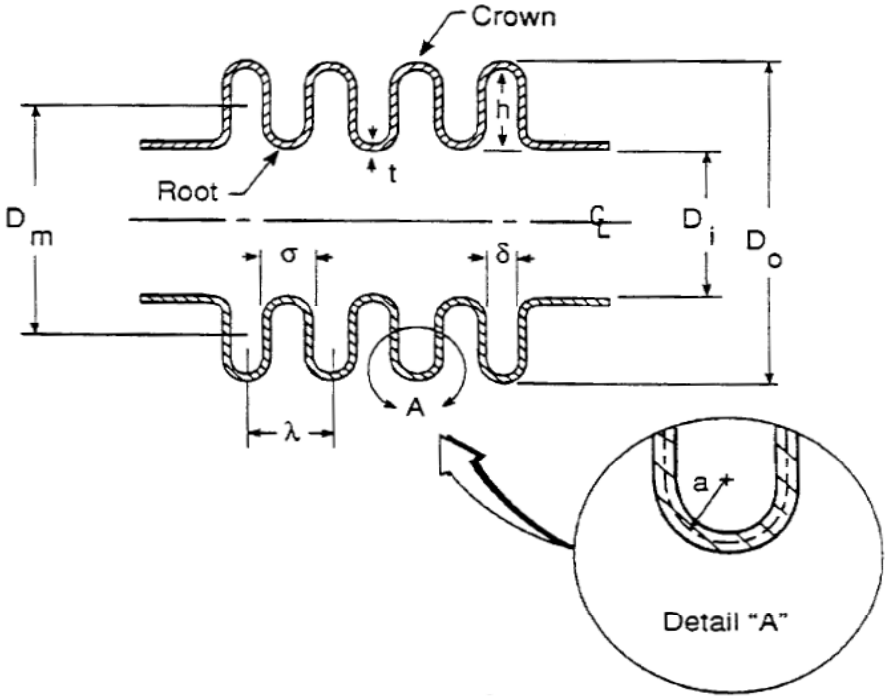
3.2.6 Convolutes

3.2.6.1 Reference **Figure 1** for values listed

3.2.6.2 Convolutes shall meet dimensions shown in **Table 2**.

Figure 1: Convolutes Diagram



Inside Convolute (δ) $\delta = \lambda - \sigma$
Inside Convolute Spacing (λ) $\lambda = 1 / (Nc/12)$
Root Convolute Inside Width (σ) $\sigma = \lambda/2 + t\,Np$

Bellows Inner Diameter, Di (inches)	Wall Thickness, t (inches)	Number of Plys Np	Mean Inside Convolute Height h (inches)	Number of Convolutions Nc
3	0.016-0.024	1	0.329-0.481	24-49.92
4	0.016-0.024	1	0.329-0.481	24-49.92

Table 2: Convolute dimensional information

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3.2.7 Inner Flexible hose

3.2.7.1 Inner pipe shall be constructed of A312 TP304, TP316, dual grade A 312 TP304/304L, or dual grade A312 TP316/TP316L. For these dual grade steels, the design shall be based on the allowable stresses tabulated in ASME B31.3 for the straight grade. A312 TP304L or TP316L pipe shall not be used

3.2.7.2 Inner pipe shall be schedule 10.

3.2.7.3 Inner flexible hose shall be closed pitch annular convolutions using stainless steel ASTM A240 304, 316, or dual grade 304/304L, or dual grade 316/316L. When using stainless steel materials that meet ASTM requirements for two grades, the design may be based on the allowable stresses tabulated in ASME B31.3, Table A-1 for the straight grade

3.2.7.4 Compression length shall be designed to include braid tension required for full engagement of convolutes with vacuum in outer annulus, inner hose at minimum design temperature, and 0 psig in inner hose.

3.2.7.5 Length of hose shall be controlled by the inner line braid. The inner line braid shall be installed so that the inner line convoluted section is compressed a sufficient amount to maintain the inner line braid in tension and prevent any reduction in length of the line when the vacuum annulus is evacuated

3.2.7.6 The inner line shall be supported with spacers that center it within the outer jacket. The design, location, and material of the spacers are left to the vendor to decide.

3.2.7.6.1 Details of the design and material selection shall be submitted to the owner for approval prior to fabrication.

3.2.7.7 Spacers shall allow for motion of the convolutes. Spacers shall not be located within 3/4" of a circumferential hose weld

3.2.7.8 If a multi-layer insulation (MLI) system is utilized to meet heat leak requirements, the MLI shall consist of alternating layers of aluminized Mylar or aluminum foil and a microfiber insulating sheet.

3.2.7.9 Each vacuum jacket annulus space shall be equipped with a chemical gettering system consisting of desiccant, molecular sieve, and hydrogen converter.

3.2.7.10 Inner flexible hose primary welds should accommodate 100% radiography.

3.2.7.10.1 If inner flexible hose primary weld cannot accommodate 100% radiography, the inner flexible hose primary welds shall accommodate dye penetrant testing.

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3.2.8 Outer Flexible hose

3.2.8.1 Outer pipe shall be constructed of A312 TP304, TP316, dual grade A 312 TP304/304L, or dual grade A312 TP316/TP316L. For these dual grade steels, the design shall be based on the allowable stresses tabulated in ASME B31.3 for the straight grade. A312 TP304L or TP316L pipe shall not be used

3.2.8.2 Outer pipe shall be schedule 10.

3.2.8.3 The outer vacuum jacket shall be closed pitch annular convolution using ASTM B575 N06022 (Hastelloy C22).

3.2.8.4 The outer line convolutions shall be covered with braided wire reinforcement per ASTM A580 316/316L (dual grade) stainless steel.

3.2.8.5 Compression length shall be designed to include braid tension required for full engagement of convolutes with vacuum in outer annulus, inner hose at minimum design temperature, and 0 psig in inner hose.

3.2.8.6 The outer flexible hose welds shall accommodate 100% dye penetrant examination per ASME B31.3.

3.2.8.7 **Vacuum Valve**

3.2.8.7.1 Each section of vacuum jacketed flexible hose shall be equipped with a vacuum valve assembly that contains an evacuation port and a relief valve in accordance with 79K14672-3. Vacuum valve height dimension shown on deliverables list drawings are for reference only.

3.2.9 VJ Joint Connections

3.2.9.1 Male bayonet shall be welded to flexible hose pipe stub.

3.2.9.2 Male Bayonet with flange connections will be Government Furnished Equipment (GFE)

3.2.9.3 Fastener bolt, washer and nut materials will be Government Furnished Equipment (GFE)

3.2.9.4 Male Bayonet shipping covers will be Government Furnished Equipment (GFE)

3.2.9.5 Butt welded joint designs shall meet the requirements of ASME B16.9.

3.2.9.6 Butt welded end designs shall meet the requirements of ASME B16.25

3.2.9.7 Gasket size, material, type and part number shall be specified and provided to owner.

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3.2.10 Weld Fittings

3.2.10.1 Fittings shall be as per ASME B16.9 and ASTM A403 class WP-S (seamless) or WP-WX (welded with 100% x-ray) and shall be WP316/WP316L (dual graded) and shall be of schedule to match flexible hose segment.

3.2.11 Thermal Life Cycle

3.2.11.1 The pipe assemblies shall have a designed thermal and pressure cycle life of a minimum of 3,000 cycles. A thermal cycle is defined as the pipe assembly starting at ambient temperature, then being taken down to minus 423 degrees F, held at that temperature for a minimum of 15 minutes, and then allowed to return to ambient temperature. A pressure cycle for the assembled VJ pipe shall be 0 psig to 120 psig and back to 0 psig. These requirements are design requirements only and do not require verification by test.

3.2.12 Listed / Unlisted Components Usage

3.2.12.1 The flexible hose assembly shall be qualified in accordance with ASME B31.3 paragraph 304.7.2 (c) or (d). Paragraph 304.7.2(e) of ASME B31.3 shall not be utilized to qualify the flexible hose.

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3.3 Construction

3.3.1 General

3.3.1.1 All work on vacuum jacketed flexible hose assemblies which exposes the annular area between the inner and outer line shall be performed in a controlled environment which will minimize the exposure to moist air, oil, grease or other contaminants. A dry GN_2 purge shall be maintained whenever possible, after annulus closure. The annulus area of the vacuum jacketed lines shall be maintained clean at all times. Application of tape, grease pencil, and chalk marks shall be avoided. Exposed surface areas shall be thoroughly degreased before the annulus is closed.

3.3.2 Welder Qualification

3.3.2.1 All welding shall be performed by qualified welders per weld procedure specifications for each weld in accordance with NASA-SPEC-5004 and ASME B31.3. Weld traceability maps of welder and procedure number at each joint are required for each flexible hose.

3.3.3 Non Destructive Evaluation (NDE) Examiners

3.3.3.1 Weld examiners shall be qualified in accordance with NASA-SPEC-5004, ASME B31.3 paragraph 342 and ASNT-TC-1A Level III.

3.3.4 Non Destructive Evaluation (NDE)

3.3.4.1 All welding inspections shall be performed in accordance with NASA-SPEC-5004 and ASME B31.3 by qualified weld examiners.

3.3.4.2 Weld examination pass/fail criteria shall be per ASME B31.3 severe cyclic service.

3.3.4.3 All welds shall be 100% examined per NASA-SPEC-5004 and ASME B31.3 as follows:

3.3.4.3.1 All welds shall be visually examined.

3.3.4.3.2 All welds located on outer jacket shall be dye penetrant examined

3.3.4.3.3 All welds located on outer flexible hose shall be dye penetrant examined

3.3.4.3.4 All welds located on inner flexible hose shall be radiographed. Radiograph exception per 3.3.4.3.

3.3.4.3.5 All longitudinal seam welds shall be radiographed.

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3.3.4.4 If welds located on inner flexible hose cannot be radiographed due to the inherent design of the flexible hose, all welds shall be 100% dye penetrant tested. Pass/Fail criteria shall be per ASME B31.3 for severe cyclic service. Dye penetrant shall be removed from the annular space in order to meet the vacuum retention requirements of this specification.

3.3.4.5 Dye penetrant will be removed from the annular space in order to meet the vacuum retention requirements of this specification.

3.3.4.6 Seams on convoluted sections shall be 100% radiographed prior to the forming process. Pass/fail criteria shall be per ASME B31.3 for severe cyclic criteria.

3.3.5 Welding

3.3.5.1 All welds should be full penetration welds in accordance with NASA-SPEC-5004 and ASME B31.3. If full penetration welds are not possible due to the inherent design, single sided fillet welds may be used.

3.3.5.2 Backing rings shall not be used.

3.3.5.3 Brazed and brazed welded joints shall not be used.

3.3.5.4 Remove scale, burrs and break sharp edges

3.3.5.5 Pull braids tight to ensure contact with all convolutes after bellows compression and prior to welding braid in ferrule.

3.3.6 Low Temperature Toughness

3.3.6.1 All welds and materials shall meet the requirements for low temperature toughness (impact test) in accordance with ASME B31.3, paragraph 323.2.2.

3.3.7 Passivation

3.3.7.1 Welds and heat affected areas shall be passivated per ASTM A967. Passivation chemicals/fluid/materials shall be removed from the annular space in order to meet the vacuum retention requirements of this specification.

3.3.8 Cleaning

3.3.8.1 The inner surfaces of all flexible hose assemblies and components shall be cleaned to KSC-C-123, level 300. All cleaning processes and cleanliness level inspections shall be as specified in KSC-C-123.

3.3.9 Name Plates and Product Marking

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Electrochemical Etch (Type II), Engrave (Type VII), or Laser Engrave (Type VIII) flexible hose/part using 0.125 inch minimum characters per provisions in MIL-STD-792. At a minimum, the data indicated below shall be included:

- manufacturing vendor's name
- Contract Number
- KSC Drawing Number
- KSC Spool number
- Serial Number
- Design Pressure
- Test pressure
- Test date
- Service
- Year Built
- Temperature Range
- Weight

3.3.10 Workmanship

Hardware shall be fabricated and finished so appearance, fit, and adherence to specified dimensions and tolerances are observed and in a manner that ensures reliable operations in accordance with the requirements specified herein. Particular attention shall be given to the neatness and thoroughness of construction and to the freedom of parts from burrs and sharp edges that might damage associated equipment or cause injury to personnel. Any item failing the acceptance criteria shall be repaired or replaced and reexamined by the same acceptance criteria as required for the original work.

3.3.11 Interchangeability

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

3.3.12 Safety

N/A

3.3.13 Human-Factors Engineering

N/A

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3.3.14 Security

N/A

3.3.15 Government-Furnished Property

Bayonets, bayonet covers, bayonet cover fastener hardware

3.4 Documentation

N/A

3.5 Logistics

N/A

3.6 Personnel and Training

N/A

3.7 Major-Component Characteristics

N/A

3.8 Precedence

In case of conflict between referenced document and this specification, this specification shall take precedence.

4. VERIFICATION

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or order, the vendor shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the vendor may use his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

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4.2 Special Tests and Inspections

4.2.1.1 Flexible Hose Measurements

4.2.1.1.1 Measure and record the weight of flexible hose +/- 5 pounds.

4.2.1.1.2 Measure and record the length of the flexible hose under the following conditions:

4.2.1.1.2.1 Ambient pressure and temperature with the annulus evacuated below 50 um Hg

4.2.1.1.2.2 Measure the length of the hose in the straight position

4.2.1.1.3 Vendor shall provide to the owner convolute dimensions including but not limited to pitch, material thickness, convolute height, minimum inside dimension between bottom of convolutes.

4.3 Verification Inspections

Testing commodities shall conform to specifications as follows:

- Gaseous helium to MIL-PRF-27407C, Type I, Grade A
- Gaseous nitrogen to MIL-PRF-27401F, Type I, Grade B
- Liquid nitrogen to MIL-PRF-27401F, Type II, Grade B

4.3.1 Required Testing Chronology

The testing in sections 4.3.2 to 4.3.6 shall be performed sequentially.

4.3.2 Cold Shock

4.3.2.1 The completed vacuum jacketed flexible hose will have the vacuum annulus evacuated to a minimum of 10 microns of Hg pressure.

4.3.2.2 The assembly shall be cold shocked with LN_2 by tilting the line at least 15 degrees and introducing the LN_2 into the assembly at the low end, allowing the boil off gas to vent from the high end. The chilldown and tilting of the assembly shall continue until a steady stream of LN_2 is forced out the high end. The LN_2 supply shall then be maintained to keep LN_2 within 6 inches, at the farthest point, from the end of the spool, and allowing the assembly to cold-soak for 1 hour

4.3.2.3 The vacuum readings shall be recorded before, during, and after the cold shock test. The vacuum reading after the cold-shock test shall be taken when the assembly returns to ambient temperature. Post cold shock vacuum reading shall be less than 50 microns of Hg

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pressure

4.3.3 Pressure/Leak Testing

4.3.3.1 The leak pressure test shall be conducted via hydrostatic testing at a minimum of 150% of the design pressure.

4.3.3.2 The pressure shall be maintained for a minimum of 10 minutes. The vacuum readings shall be recorded prior to test and after the pressure has been reduced to DP and at end of test where pressure is less than 10 psig. The vacuum jacketed flexible hose undergoing test shall exhibit no leakage while undergoing leak testing and show no permanent deformation or damage as result of the leak testing.

4.3.3.3 Leak test of the outer jacket (by pressurizing the annular space) is not required.

4.3.3.4 Leak testing shall be performed at ambient temperature

4.3.4 Mass Spectrometer Leak Testing

4.3.4.1 The vacuum jacket annulus shall be evacuated to a minimum of 10 microns of Hg pressure.

4.3.4.2 One of the following two testing procedures shall be used. Do not introduce helium into the vacuum annulus for any testing.

4.3.4.2.1 With inner line pressurized to DP with 100% helium and holding at DP for 1 minute minimum, the mass spectrometer leakage indication shall be below 10^{-7} std-cc/sec. To accomplish this test, a mass spectrometer set capable of sensitivity to 10^{-9} std-cc/sec shall be used.

4.3.4.2.2 As an option with inner line pressurized to DP with 10% helium/90% nitrogen and holding at DP for 1 minute minimum, the mass spectrometer leakage indication shall be below 10^{-9} std-cc/sec. To accomplish this test, a mass spectrometer set capable of sensitivity to 10^{-10} std-cc/sec shall be used.

4.3.4.3 The outer jacket shall be tested with all jacket welds surrounded by a 100% GHe atmosphere

4.3.4.3.1 GHe leakage shall be less than 10^{-7} std-cc/sec using a Helium Mass Spectrometer Leak Detector set to a minimum sensitivity of 10^{-9} scc/s

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4.3.5 Vacuum Retention Test

4.3.5.1 Each section of the vacuum jacketed flexible hose outer vacuum jacket shall be evacuated to a minimum of 10 micrometers of Hg pressure at ambient temperature.

4.3.5.2 The vacuum level with in each section of the outer vacuum jacket shall be measured and recorded every twenty-four (24) hours for a period of at least seven (7) days.

4.3.5.2.1 The final pressure at the end of the test period within each section of the vacuum jacket must stabilize at or below 50 microns of Hg pressure to be acceptable.

4.3.6 Dimensional Verification

4.3.6.1 Flexible hose assemblies shall be dimensionally verified to be in accordance with the vendor's fabrication drawings prior to packaging for shipment.

4.3.7 Responsibility For Verification / Inspection

4.3.7.1 The vendor shall be responsible for the performance of all verification (~~analysis~~, test, demo or inspection) requirements as specified herein. Except as otherwise specified, the vendor may use his own facilities or any commercial laboratory acceptable to NASA. NASA reserves the right to witness or perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.3.7.2 The Vendor shall formulate acceptance test procedures for all components and will provide the facility and instrumentation to perform all relevant tests to ensure compliance with this specification. The acceptance test procedures shall include but not be limited to all of the testing procedures specifically outlined in this document.

4.3.7.3 All items purchased or manufactured by a subcontractor used in the Vendor's work shall be clearly identified and tabulated.

4.3.7.4 All material and components shall be traceable to original vendor via material certification records.

4.3.7.5 NASA reserves the right to have access to the Vendor's facility at any time during the design, fabrication and code testing. NASA shall have the right to witness any manufacturing or testing procedures upon request. When requested, the Vendor shall provide a minimum of 7 work days' notice in advance of any test date to allow for NASA (or its designated contractor representative) to make the necessary travel arrangements.

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4.3.7.6 Review of analysis data and procedures by NASA shall not release the Vendor from its responsibility to correct errors, oversights and omissions to ensure conformance to the requirements in this document and ASME code requirements.

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5. PREPARATION FOR DELIVERY

5.1 Preservation

5.1.1 Protective pressure cap

5.1.1.1 The VJ flexible hoses shall be furnished with stainless steel protective pressure cap to prevent damage or contamination during storage, transportation and handling.

5.1.2 Packaged per KSC-C-123

5.1.2.1 All flexible hose assemblies shall be packaged per KSC-C-123. Packing design shall be approved by NASA prior to use.

5.1.3 Vacuum in Annulus

5.1.3.1 Vacuum levels at delivery to the owner shall be 50 microns of HG pressure or less

5.1.3.2 Annulus shall be sealed and maintained at vacuum levels from acceptance tests.

5.1.3.3 All flexible hose assembly vacuum levels shall be checked and recorded prior to shipment for validation at KSC receiving site prior to acceptance.

5.1.4 Inner Line Pressure

5.1.4.1 Cleanliness shall be maintained.

5.1.4.2 Seal inner pipe ends and ports with pressure retaining flanges equipped with pressure gage and gas charging tee (1 set per pipe assembly). All flanges shall meet the component requirements in Section 3.

5.1.4.3 Establish a minimum dew point of minus 65F (24 ppm) using 2 micron filtered MIL-PRF-27401F, Type I, Grade B GN_2 in accordance with Test Method III (A.3.3) of KSC-C-123 then establish a 5 +/-2 psig GN2 blanket pressure

5.1.4.4 Capability shall be provided to field monitor blanket pressure, isolate pressure gage and re-establish any lost blanket pressure. All components and fittings shall be cleaned to KSC-C-123, Level 300 or better

5.1.4.5 Leak check shall be performed on pressure ports using MSFC-SPEC-384 Type 1 or 2 leak check fluid. Verify no bubble formation for one minute minimum.

5.1.5 Recordings

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5.1.5.1 All flexible hose assembly vacuum levels shall be checked and recorded prior to shipment for validation at KSC receiving site prior to acceptance.

5.1.5.2 All flexible hose assembly GN2 blanket pressures shall be checked and recorded prior to shipment for validation at KSC receiving site prior to acceptance.

5.2 Packing

The vendor shall package each vacuum jacketed flexible hose section within a hard sided container (at a minimum wood construction) using standard commercial practice, ensuring each vacuum jacketed flexible hose section is protected against damage during shipment. Entire flexible hose section length must also be protected against damage using isolation / separation means between segments during shipment. Boxes shall be strong enough to support being picked up using a forklift and/or using lifting straps. The boxes should be capable of being stacked. Flexible hoses may be shipped on saddle supports with hold-downs, or equivalent means. More than one flexible hose may be contained in a box. The boxes do not need to be weatherproof. Shipping containers shall conform to freight classification rules and applicable container specifications.

6. NOTES

6.1 Intended Use

This document is intended to establish the requirements for fabrication and testing of LH_2 vacuum jacketed flexible hose.

Custodian:

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

Preparing Activity:

John F. Kennedy Space Center