APPLICATION	
NEXT ASSY	USED ON

REVISION HISTORY

PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

EAR 99 -- NO LICENSE REQUIRED

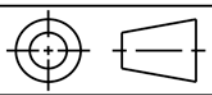
The information contained in the document is technical in content, but not technical data as defined by the International Traffic in Arms Regulations (ITAR) or the Export Administration Regulations (EAR), and therefore is EAR 99 NLR, no export license required. [General Prohibition Six (Embargo) applies to all items subject to the EAR, (i.e., items on the CCL and within EAR 99 NLR). You may not make an export or re-export contrary to the provisions of part 746 (Embargos and Other Special Controls) of the EAR and 22 CFR part 126.1 of the ITAR].

EDR # 1418133 NASA KSC Export Control Office (321-867-9209)

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) 03/21/2014

DRAFTSMAN	CHECKER
Carl Exline	David Roth
ENGINEER	CHECKER
Larry Kaylor	
ENGINEER	STRESS
Steve Kugelmann	

ENGINEER
Edward Thompson

SUBMITTED
Theodore Adams

APPROVED
Alan Littlefield

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

CSITU PIPE SPECIFICATION, VACUUM JACKETED, LH2 SERVICE

SIZE	CAGE CODE	DWG NO	REV
A	22264	K0000191097-SPC	-
SCALE None	UNIT WEIGHT —	SHEET 1 OF 23	

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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

TABLE OF CONTENTS

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

RECORD OF REVISIONS/CHANGES

REV LTR		DESCRIPTION	DATE
-		**Basic Issue**	**March 21, 2014**

SIZE	CAGE CODE	DWG NO	REV
A	22264	K0000191097-SPC	-
SCALE None	UNIT WEIGHT —	SHEET 4 OF 23	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

Abbreviations, acronyms, and symbols

ASME	American Society of Mechanical Engineers
DP	Design Pressure
GH_2	Gaseous Hydrogen
GN_2	Gaseous Nitrogen
GSE	Ground Support Equipment
KSC	Kennedy Space Center
LH_2	Liquid Hydrogen
LN_2	Liquid Nitrogen
MDP	Maximum Design Pressure
NASA	National Aeronautics and Space Administration
NDE	Non-Destructive Evaluation
NPS	Nominal Pipe Size
VJ	Vacuum Jacket
WPS	Weld Procedure Specification
WPQ	Welder/Welding Operator Procedure Qualifications

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

1. SCOPE

This specification provides technical requirements for the design, fabrication, and testing of vacuum jacketed cryogenic piping segments used in the transfer of liquid hydrogen (LH_2) 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 Specification

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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

KSC Drawings

79K14672	Vacuum Pump out ports

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 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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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 A380	Practice for Cleaning, Descaling, and Passivation of Stainless Steel parts, Equipment, and Systems
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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3. REQUIREMENTS

3.1 Definition

The assemblies are vacuum jacketed pipe used to deliver cryogenic propellant ($LH_{2)}$, 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. **Work Day –** Monday through Friday

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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 pipe 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 in service 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 VJ pipe 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 pipe 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 pipe shall be 120 PSIG at +158 degrees F,with 0 psia (full vacuum) applied to external surface of inner pipe (annular space).

3.2.2.7 The outer jacket piping and outer jacket expansion bellows shall have an annular space design pressure (as defined by ASME B31.3) of 35 psig at +158 degrees F.

3.2.2.8 The outer jacket piping and outer jacket expansion bellows 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 31.3.

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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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 commodity (LH2, LN2, GN2, GHe) per AIAA G-095

3.2.4 Heat Leak

3.2.4.1 The maximum steady state heat leak from 80 degrees F to LH_2 cryogenic temperature for the bayonet end connections shall be (determined by test or analysis at the maximum ambient temperature):

Bayonet Size (in)	Btu/hr
8x10	345
10x12	455

3.2.4.2 The maximum heat leak for the vacuum jacketed pipe, including spacers and materials in annular space 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/ft
8	2.5
10	3.0

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.2.5 Inner Pipe Assembly

3.2.5.1 Inner pipe shall be constructed of 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 A312 TP316.

3.2.5.2 Inner pipe shall be **schedule 10.**

3.2.5.3 The inner line shall be supported with spacers that center it within the outer jacket

3.2.5.3.1 Details of the design, location and material selection of spacers shall be submitted to the owner for approval prior to fabrication.

3.2.5.4 Spacers shall withstand 3,000 lbf minimum compressive load with no performance degradation.

3.2.5.5 Spacers will be designed to minimize heat leakage using materials that will minimize off-gassing.

3.2.5.6 Spacer locations shall be Government Furnished Information.

3.2.5.7 The inner pipe shall be wrapped with alternating layers of Aluminized Mylar or Aluminum Foil and glass fiber paper with a thickness of 3.3 mil or greater (CryoTherm 233 or equivalent).

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

3.2.5.9 All inner pipe primary welds, as defined per ASME B31.3, shall accommodate 100% radiography.

3.2.5.10 Inner pipe fittings shall be in accordance with ASME B16.9.

3.2.5.11 Inner pipe elbows shall be long radius per ASME B16.9. Mitered tee and elbows are not permitted on inner pipe.

3.2.6 Outer Pipe Assembly

3.2.6.1 Outer pipe shall be constructed of dual grade A312 TP316/TP316L. For dual grade steels, the design shall be based on the allowable stresses tabulated in ASME B31.3 for A312 TP316.

3.2.6.2 Outer pipe shall be schedule 10.

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.2.6.3 All outer pipe circumferential welds shall accommodate 100% dye penetrant examination per ASME B31.3.

3.2.6.4 **Expansion Bellows**

3.2.6.5 All outer jacket metallic bellows and expansion joints shall be designed, fabricated and examined in accordance with ASME B31.3 section 304.7.4, F304.7.4, 345.3.3 and Appendix X**.**

3.2.6.6 Expansion bellows shall only be used on outer jacket and shall be annular convolution single ply construction using ASTM B575 alloy N06022 (Hastelloy C22 or equivalent)

3.2.6.7 Expansion bellows shall be designed with removable clam-shell style protective covers. Protective covers shall be fabricated from dual grade A312 TP316/TP316L.

3.2.6.8 **Vacuum Valve**

3.2.6.8.1 Each section of vacuum jacketed pipe shall be equipped with a GFE vacuum valve assembly in accordance with 79K14672-3.

3.2.6.8.2 Vacuum pump-out valves shall not be located near cold area of the jacket pipe to avoid a loss of vacuum due to freezing the O-rings.

3.2.7 VJ Joint Connections

3.2.7.1 Female Bayonets shall be designed in accordance with ASME B31.3 Paragraphs 302.2.3, 304 and qualified by Paragraph 304.7.2(c) or (d) either individually or as part of the pipe spool assembly. Paragraph 304.7.2(e) may not be utilized to qualify the component.

3.2.7.2 Female bayonets shall be supplied with a slip-on style bolted flange.

3.2.7.3 Bolt hole dimensions on flanges shall meet the requirements of ASME 16.5 for a class 150 flange of a diameter matching the jacketed pipe dimensions.

3.2.7.4 Flanges shall be constructed from ASTM A182 F316/F316L (dual graded) stainless steel.

3.2.7.5 All serrations on raised face flanges shall be concentric and per ASME B16.5 paragraph 6.4.5.3.

3.2.7.6 Flanges shall be forged type only. Fabricated and flared type is not permitted.

3.2.7.7 Socket weld joints shall not be used.

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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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

3.2.7.10 The Inner pipes of vacuum jacketed pipe sections which are joined by a field welded transition joint shall be fabricated with a minimum 3 inches of extra length beyond joint design for field butt weld installation.

3.2.7.11 A field joint cover shall be designed and fabricated to provide a vacuum jacket around the inner pipe at the field joint. The cover shall include a chemical gettering system. The field joint shall be designed to minimize the heat leak from the inner pipe.

3.2.7.12 Bayonet connections will be close-tolerance bayonets.

3.2.8 Instrumentation/Auxiliary Ports

3.2.8.1 All instrumentation/auxiliary ports, including vacuum jacket terminations, shall comply to the requirements of ASME B31.3

3.2.9 Weld Fittings

3.2.9.1 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 pipe segment.

3.2.10 Thermal Life Cycle

3.2.10.1 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.

3.2.11 Listed / Unlisted Components Usage

3.2.11.1 Piping components shall be listed components in accordance with ASME B31.3. Unlisted components may be used provide they are qualified in accordance to 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 unlisted components.

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.3 Construction

3.3.1 General

3.3.1.1 All work on vacuum jacketed lines 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 pipe.

3.3.3 Non Destructive Evaluation (NDE) Examiners

3.3.3.1 Weld examiners shall be qualified in accordance with NASA-SPEC-5004.

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 pipe jacket shall be dye penetrant examined

3.3.4.3.3 All welds located on inner pipe shall be radiographed.

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

3.3.4.5 Seams on outer expansion bellows shall be 100% radiographed prior to the forming process. Pass/fail criteria shall be per ASME B31.3 for severe cyclic criteria.

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.3.5 Welding

3.3.5.1 All inner circumferential welds shall be full penetration welds for severe cyclic conditions in accordance with NASA-SPEC-5004 and ASME B31.3.

3.3.5.2 Backing rings are not permitted.

3.3.5.3 Brazing and soldering is not permitted.

3.3.5.4 Attachments to the vacuum jacket shall be in accordance with ASTM A240 with a full-seal weld.

3.3.5.5 Remove scale, burrs and break sharp edges.

3.3.6 Low Temperature Toughness

3.3.6.1 All welds 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 Paint

3.3.8.1 Coat all exterior surfaces of jacket using an inhibited polyamide epoxy primer and aliphatic polyurethane topcoat per NASA-STD-5008B. Other coatings such as polysiloxane and silicone ablative may be substituted as top coats. Hastelloy bellows and any jacket surface which is to be inside field joint vacuum annulus shall not be coated.

3.3.8.2 Coating shall be applied after completion of all acceptance testing and before final marking/labeling.

3.3.9 Cleaning

3.3.9.1 The inner surfaces of all pipe 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.

3.3.10 Name Plates and Product Marking

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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

indicated below shall be included:

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

3.3.11 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 exceeding the acceptance criteria shall be repaired or replaced and reexamined by the same acceptance criteria as required for the original work.

3.3.12 Interchangeability

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

3.3.13 Safety

N/A

3.3.14 Human-Factors Engineering

N/A

3.3.15 Security

N/A

3.3.16 Government-Furnished Property

N/A

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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.

3.9 Qualification

N/A

3.10 Samples

N/A

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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

4.2 Special Tests and Inspections

4.2.1 Pipe Spool Measurements

4.2.1.1 Measure and record the weight of pipe spool +/- 5 pounds.

4.2.1.2 Measure and record the length of the pipe spool under the following conditions:

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

4.2.1.3 Vendor shall provide to the owner expansion bellows 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

4.3.1.1 The testing in sections 4.3.2 to 4.3.5 shall be performed sequentially.

4.3.2 Cold Shock

4.3.2.1 The completed vacuum jacketed pipe 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 pressure.

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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 per ASME B31.3.

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 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 MDP with 100% helium and holding at MDP 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 MDP with 10% helium/90% nitrogen and holding at MDP 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

4.3.5 Vacuum Retention Test

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

4.3.5.2 The vacuum level within 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.

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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.

4.4 Dimensional Verification

4.4.1 Pipe Assemblies

4.4.1.1 Pipe assemblies shall be dimensionally verified to be in accordance with the vendor's fabrication drawings prior to packaging for shipment. Dimensional verification shall occur after testing is conducted in accordance with section 4.3.

4.5 Responsibility For Verification / Inspection

4.5.1 Verification/Inspection

4.5.1.1 The vendor shall be responsible for the performance of all verification (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 the government. The government 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.

4.5.1.2 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.

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

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

4.5.1.5 Government reserves the right to have access to the Vendor's facility at any time during the design, fabrication and code testing. Government 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 the government (or its designated contractor representative) to make the necessary travel arrangements.

4.5.1.6 Review of analysis data and procedures by government 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.

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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 schedule stainless steel protective pressure caps to prevent damage or contamination during storage, transportation and handling.

5.1.2 Packaged per KSC-C-123

5.1.2.1 All pipe assemblies shall be packaged per KSC-C-123. Packing design shall be approved by the government 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 pipe 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 65 degrees F (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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

5.1.5.1 All pipe 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 pipe 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 pipe section within a hard sided container (at a minimum wood construction), using standard commercial practice, ensuring each vacuum jacketed pipe section is protected against damage during shipment. Entire pipe section length must also be protected against damage using isolation / separation means between segments during shipment. Pipes can be shipped on saddle supports with hold-downs, or equivalent means. Shipping containers shall conform to freight classification rules and applicable container specifications. These shipping containers shall be capable of being picked-up by fork lift or lifting straps.

6. NOTES

6.1 Intended Use

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

Custodian:

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

Preparing Activity:

John F. Kennedy Space Center

K0000191097-SPC (CSITU PIPE SPECIFICATION, VACUUM JACKETED, LH2 SERVICE)

Document Number:	K0000191097-SPC
Version:	-
Name:	CSITU PIPE SPECIFICATION, VACUUM JACKETED, LH2 SERVICE
Type:	Specification (KSC)
Container:	SLS ML CSITU Product
State:	Released
Modified By:	William Patrick
Modified On:	Wed, Mar 26, 2014 15:02:01 EDT
Change Requests:	K-CR-10441

Maturity History

Version	State	Promoted By	Promoted On
-.4	Released	wcadmin-(Site)	Mon, Apr 7, 2014 08:37:06 EDT
-.4	Completed	William Patrick	Thu, Mar 27, 2014 08:55:59 EDT
-.4	Under Review	wcadmin-(Site)	Wed, Mar 26, 2014 15:03:40 EDT
-.3	In Work	wcadmin-(Site)	Wed, Mar 26, 2014 14:21:50 EDT
-.3	Under Review	wcadmin-(Site)	Mon, Mar 24, 2014 17:17:06 EDT
-.1	In Work	Carl exline	Wed, Aug 28, 2013 07:22:39 EDT

KDDMS Routing History

CN/CT Number	Task	Assignee	Role	Events	Comment	Started	Completed
D-CN-10541	KSC Documentation Release Audit Change Notice	Nicholas Delgado	Change Admin III	Complete	released per KDP-P-2718	Thu, Apr 3, 2014 15:33:34 EDT	Mon, Apr 7, 2014 08:37:06 EDT
K-CT-10468	KSC Complete Signature Required Assignment	Brett Lannie	Assignee		routed for signature approval per KDP-P-2718	Thu, Mar 27, 2014 15:35:00 EDT	Thu, Mar 27, 2014 15:40:14 EDT
K-CT-10468	KSC Signature Required	Alan Littlefield	Signatory	Complete	approve	Thu, Mar 27, 2014 15:40:14 EDT	Thu, Apr 3, 2014 15:33:34 EDT
K-CT-10468	KSC Signature Required	Theodore Adams	Signatory	Complete		Thu, Mar 27, 2014 15:40:14 EDT	Wed, Apr 2, 2014 18:23:47 EDT
K-CT-10468	KSC Signature Required	Larry Kaylor	Signatory	Complete		Thu, Mar 27, 2014 15:40:14 EDT	Mon, Mar 31, 2014 16:35:52 EDT
K-CT-10468	KSC Signature Required	Carl exline	Signatory	Complete		Thu, Mar 27, 2014 15:40:14 EDT	Mon, Mar 31, 2014 07:53:54 EDT
K-CT-10468	KSC Signature Required	Stephen Kugelmann	Signatory	Complete	Approved	Thu, Mar 27, 2014 15:40:14 EDT	Fri, Mar 28, 2014 15:44:55 EDT
K-CT-10468	KSC Signature Required	Edward Thompson	Signatory	Complete		Thu, Mar 27, 2014 15:40:14 EDT	Fri, Mar 28, 2014 07:36:37 EDT
K-CT-10468	KSC Signature Required	David Roth	Signatory	Complete		Thu, Mar 27, 2014 15:40:14 EDT	Thu, Mar 27, 2014 15:57:59 EDT