

NOTICE - WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER, AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

APPLICATION		REVISION HISTORY					
NEXT ASSY	USED ON	PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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

EDDR# 1311339

DOCUMENT INFORMATION: (TITLE, NUMBER, REV, DATE)
 K0000146597-SPC
 Pipe Specification, Vacuum Jacketed, LO2 Service

SENSITIVE BUT UNCLASSIFIED (SBU)
 INSTRUCTIONS: This item must be reviewed under the requirements for "Sensitive But Unclassified Information" as described in NPR 1600.1, Chapter 5.
<http://nodis-dms.gsfc.nasa.gov>

	Yes	No	SBU Reviewer's Signature	Date	Company / Org
Document contains SBU?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	 Heather White (affiliate) (4/25/2013)	04/25/2013	ESC

EXPORT CONTROL (EC)
 INSTRUCTIONS: Attach the document requiring an export determination. Contact the KSC ECO Help Desk (867-9209) for help in completing this form.
<http://exportcontrol.ksc.nasa.gov>

Contractor EC Reviewer's Name and Organization	Contractor EC Reviewer's Signature	Date
Heather White, ESC	 Heather White (affiliate) (4/25/2013)	04/25/2013

NASA ECO Reviewer's Name and Organization	NASA ECO Reviewer's Signature	Date

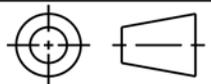
	EXPORT DETERMINATION (Check one box only)	
EAR 99	<input checked="" type="checkbox"/> NLR	The information contained in the document is technical in content, but is not technical data as defined by the ITAR or the EAR, and therefore is EAR 99 NLR (no export license required). (General Prohibition Six (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.)
EAR Controlled	<input type="checkbox"/>	This document is within the purview of the Export Administration Regulations (EAR), 15 CFR 750-774, and is export controlled. It may not be transferred to foreign nationals in the U.S. or abroad without specific approval of a knowledgeable NASA export control official, and/or unless an export license or license exemption is obtained/available from the Bureau of Industry and Security, United States Department of Commerce. Violations of these regulations are punishable by fine, imprisonment, or both.
ITAR Controlled	<input type="checkbox"/>	This document contains information which falls under the purview of the U.S. Munitions List (USML), as defined in the International Traffic in Arms Regulations (ITAR), 22 CFR 120-130, and is export controlled. It shall not be transferred to foreign nationals, in the U.S. or abroad, without specific approval of a knowledgeable NASA export control official, and/or unless an export license or license exemption is obtained/available from the United States Department of State. Violations of these regulations are punishable by fine, imprisonment, or both.

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	ORIGINAL DATE OF DRAWING (YY/MM/DD) 06/11/2013	JOHN F. KENNEDY SPACE CENTER, NASA KENNEDY SPACE CENTER, FLORIDA				
	DRAFTSMAN C. Exline					CHECKER W. Patrick
SOFTWARE	ENGINEER S. Larsen	CHECKER	ICPSU PIPE SPECIFICATION, VACUUM JACKETED, LO2 SERVICE			
FILENAME	ENGINEER S. Hoyle	STRESS				
MATERIAL	ENGINEER E. Thompson		SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
HEAT TREATMENT	SUBMITTED T. Adams		SCALE None	UNIT WEIGHT —	SHEET 1	OF 26
FINAL PROTECTIVE FINISH	APPROVED A. Littlefield					

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

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

TABLE OF CONTENTS

1. SCOPE.....6

2. APPLICABLE DOCUMENTS6

2.1 Governmental6

2.2 STANDARDS7

2.3 Non-Governmental7

3. REQUIREMENTS9

3.1 Definition.....9

3.2 General10

3.2.1 Fluid Service.....10

3.2.2 Temperature and Pressure10

3.2.3 Material Properties10

3.2.4 Heat Leak11

3.2.5 Inner Pipe Assembly12

3.2.6 Outer Pipe Assembly12

3.2.7 VJ Joint Connections.....13

3.2.8 Instrumentation/Auxiliary Ports14

3.2.9 Weld Fittings14

3.2.10 Thermal Life Cycle14

3.2.11 Listed / Unlisted Components Usage15

3.3 Construction16

3.3.1 General16

3.3.2 Welder Qualification16

3.3.3 Non Destructive Evaluation (NDE) Examiners16

3.3.4 Non Destructive Evaluation (NDE).....16

3.3.5 Welding17

3.3.6 Low Temperature Toughness17

3.3.7 Passivation.....17

3.3.8 Paint.....17

3.3.9 Cleaning.....17

3.3.10 Name Plates and Product Marking17

3.3.11 Workmanship18

3.3.12 Interchangeability18

3.3.13 Safety18

3.3.14 Human-Factors Engineering.....18

3.3.15 Security.....18

3.3.16 Government-Furnished Property19

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 2	OF 26

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.4	Documentation	19
3.5	Logistics	19
3.6	Personnel and Training.....	19
3.7	Major-Component Characteristics	19
3.8	Precedence.....	19
3.9	Qualification.....	19
3.10	Samples	19
4.	VERIFICATION	19
4.1	Responsibility for Inspection.....	19
4.2	Special Tests and Inspections	20
4.2.1	Pipe Spool Measurements	20
4.3	Verification Inspections	20
4.3.1	Required Testing Chronology	20
4.3.2	Cold Shock	20
4.3.3	Pressure/Leak Testing	21
4.3.4	Mass Spectrometer Leak Testing	21
4.3.5	Vacuum Retention Test	21
4.3.6	Dimensional Verification	22
4.3.7	Responsibility For Verification / Inspection	22
5.	PREPARATION FOR DELIVERY.....	23
5.1	Preservation	23
5.1.1	Protective pressure cap.....	23
5.1.2	Packaged per KSC-C-123	23
5.1.3	Vacuum in Annulus.....	23
5.1.4	Inner Line Pressure.....	23
5.1.5	Recordings.....	24
5.2	Packing	24
6.	NOTES	24
6.1	Intended Use.....	24
APPENDIX A - PIPE ASSEMBLY PART SPECIFICATIONS		25

LIST OF TABLES

Table 1: Vacuum Jacket Pipe Sizes.....	25
Table 2: Expansion Joint Design and Operating Requirements.....	25
Table 3: Auxiliary Port Pipe Size and Termination	26

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 3	OF 26

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

RECORD OF REVISIONS/CHANGES

REV LTR	CHANGE NO.	DESCRIPTION	DATE
Basic		Initial Release	

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 4	OF 26

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

Abbreviations, acronyms, and symbols

- ASME American Society of Mechanical Engineers
- DP Design Pressure
- GN₂ Gaseous Nitrogen
- GO₂ Gaseous Oxygen
- GSE Ground Support Equipment
- KSC Kennedy Space Center
- LO₂ Liquid Oxygen
- LN₂ Liquid Nitrogen
- NASA National Aeronautics and Space Administration
- NDE Non-Destructive Evaluation
- NPS Nominal Pipe Size
- VJ Vacuum Jacket

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 5 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

1. SCOPE

This specification provides technical information for the design, fabrication, and testing of vacuum jacketed cryogenic piping segments used in the transfer of liquid oxygen (LO₂) 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

KSC Drawings

79K14672 Vacuum Pump out ports

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 6	OF 26

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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

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 Butt welding 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
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

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 7 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

ASTM A320 Standard specification for alloy-steel and stainless steel bolting materials for low temperature service

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

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

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 8	OF 26

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 (LO₂), 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

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 9 OF 26	

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 Oxygen (LO₂), Gaseous Oxygen (GO₂), Gaseous Helium (GHe), Liquid Nitrogen (LN₂) or Gaseous Nitrogen (GN₂)
- 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 for ground operations shall be +80 degrees F
- 3.2.2.3 The maximum ambient temperature for ground operations shall be +105 degrees F
- 3.2.2.4 The assembled VJ pipe shall be designed for -321 degrees F to +158 degrees F at 285 psig
- 3.2.2.5 The Design Pressure (DP) for the inner pipe shall be 300 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 285 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
- 3.2.2.9 Water hammer considerations per B31.3 paragraph 301.5.1 shall be applied

3.2.3 Material Properties

- 3.2.3.1 All materials used as pressure components shall meet the requirements of ASME 31.3.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 10 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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

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.

3.2.3.4 Note that the inner pipe and outer pipe are specified herein and contain a corrosion allowance of 1/16 inch for both the inner pipe and outer pipe.

3.2.4 Heat Leak

3.2.4.1 The maximum steady state heat leak from 80 degrees F to LO₂ cryogenic temperature for the bayonet end connections shall be (determined by test or analysis at the maximum ambient temperature):

<u>Bayonet Size (in)</u>	<u>Btu/hr</u>
3x5	70.1
4x6	94.3

3.2.4.2 The maximum heat leak for the field welded transitions end connections at LO₂ cryogenic conditions & an ambient temperature of 80 degrees F shall be (determined by test or analysis at the maximum ambient temperature):

<u>Transition Size (in)</u>	<u>Each Joint (Btu/hr)</u>
3x5	16.88
4x6	24.66

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 11	OF 26

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 A312 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
- 3.2.5.2 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 22 layers each of alternating Aluminum Foil and glass fiber paper with a thickness of 3.3 mil or greater (CryoTherm 233 or equivalent).
- 3.2.5.8 Aluminized Mylar shall not to be used.
- 3.2.5.9 Each vacuum jacket annulus space shall be equipped with a chemical gettering system consisting of desiccant, molecular sieve, and hydrogen converter.
- 3.2.5.10 All inner pipe primary welds, as defined per ASME B31.3, shall accommodate 100% radiography
- 3.2.5.11 Inner pipe fittings shall be in accordance with ASME B16.9.
- 3.2.5.12 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 the straight grade. A312 TP304L or TP316L pipe shall not be used

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 12 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.2.6.2 Outer pipe shall be schedule 10.

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 Expansion bellows shall meet requirements in Table 2: Expansion Joint Design and Operating Requirements

3.2.6.6 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.

3.2.6.7 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)

3.2.6.8 Expansion bellows shall be designed with removable clam-shell style protective covers. Protective covers shall be fabricated from 316/316L stainless steel.

3.2.6.9 **Vacuum Valve**

3.2.6.9.1 Each section of vacuum jacketed pipe shall be equipped with a vacuum valve assembly in accordance with 79K14672-3. Any vacuum valve height dimension shown on deliverables list drawings are for reference only.

3.2.6.9.2 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 or be the same grade as the piping material to which it is attached.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 13 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

- 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 Flange fastener Bolt studs, washer and nut materials shall be in accordance with ASTM A193, A194, or A320.
- 3.2.7.8 Socket weld joints shall not be used.
- 3.2.7.9 Butt welded joint designs shall meet the requirements of ASME B16.9.
- 3.2.7.10 Butt welded end designs shall meet the requirements of ASME B16.25
- 3.2.7.11 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.
- 3.2.7.12 A field transition joint shall secure the annular vacuum within the individual pipe assembly. A field joint cover shall be designed and fabricated to provide a vacuum jacket around the inner pipe field joint. The cover shall include a field joint shall include a chemical gettering system. The field joint shall be designed to minimize the heat leak from the inner pipe.
- 3.2.7.13 Bayonet connections will be close-tolerance bayonets.

3.2.8 Instrumentation/Auxiliary Ports

- 3.2.8.1 Instrumentation/auxiliary ports shall meet requirements in Table 3: Auxiliary Port Pipe Size and Termination.
- 3.2.8.2 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

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 14	OF 26

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.2.10.1 The pipe assemblies shall have a designed thermal 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 321 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 285 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.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 15	OF 26

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 GN₂ 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, 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 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.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 16 OF 26	

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 300A. 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) pipe/part using 0.125 inch minimum characters per provisions in MIL-STD-792 and the General Requirements (Paragraph

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 17	OF 26

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.1) and Quality Assurance provisions (Paragraph 4) of KSC-STD-E-0015.

At a minimum, the data 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 failing 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

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 18	OF 26

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

3.3.16 Government-Furnished Property

N/A

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.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 19	OF 26

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 4.3.6 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 LN₂ by tilting the line at least 15 degrees and introducing the LN₂ 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 LN₂ is forced out the high end. The LN₂ supply shall then be maintained to keep LN₂ 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.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 20 OF 26	

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, or be conducted via pneumatic testing at a minimum of 110% 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 pipe 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 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 outer vacuum jacket shall be evacuated to a minimum of 10 micrometers of Hg pressure at ambient temperature.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 21 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

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 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 4.1

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.

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.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 22 OF 26	

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 pipe spools shall be furnished with 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 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 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). Weld neck flanges shall be added to each inner pipe not terminated by an existing flange. Additional length of inner pipe material will be necessary to allow removal of flange for installation into next level of 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 GN₂ 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 fabricated component level 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.

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 23 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

5.1.5 Recordings

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 LO₂ vacuum jacketed pipe.

NOTICE. The Government drawings, specifications, and/or data are prepared for the official use by, or on behalf of, the United States Government. The Government neither warrants these Government drawings, specifications, or other data, nor assumes any responsibility or obligation, for their use for purposes other than the Government project for which they were prepared and/or provided by the Government, or any activity directly related thereto. The fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded, by implication or otherwise, as licensing in any manner the holder or any other person or corporation nor conveying the right or permission to manufacture, use, or sell any patented invention that may relate thereto.

Custodian:

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

Preparing Activity:

John F. Kennedy Space Center

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 24 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

APPENDIX A - PIPE ASSEMBLY PART SPECIFICATIONS

Table 1: Vacuum Jacket Pipe Sizes

QTY (Units)	Fluid	Spool Number	Function	Type	Size inner X outer pipe (Schedule 10)	Location	Drawing Number
1	LO2	4180	Fill/Drain	VJ Pipe Spool	3x5	ICPSU	K0000065256
1	LO2	4185	Fill/Drain	VJ Pipe Spool	3x5	ICPSU	K0000065257
9	LO2	NA	Male Bayonet	VJ Pipe Spool	3x5	ICPSU	Vendor drawing
2	LO2	NA	Female Bayonet	VJ Pipe Spool	3x5	ICPSU	Vendor drawing

Table 2: Expansion Joint Design and Operating Requirements

Used On	Spool No.	Nominal Pipe Size	Bellows Compression (in)	Bellows Convolute Length (In)	Overall Length with Weld Stubs (in)
K0000065256, K0000065257	4180 4185	5 NPS	0.38	4	10
K0000065257	4185	5 NPS	0.13	4	Field Joint AR
K0000065257	4185	5 NPS	0.21	4	7

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT _	SHEET 25 OF 26	

REVISION HISTORY					
PART NO.	ZONE	REV	DESCRIPTION	DATE	APPROVAL

Table 3: Auxiliary Port Pipe Size and Termination

Dwg No.	Spool No.	Aux Port Inner Pipe (IPS)	Aux Port Outer Pipe (IPS)	Aux Port Termination Part No.	Mfg Cage Code	Description
K0000065257	4185	1.5	2 NPS Sch 10	AAB1002-04-5-1.5-10	06581	.1/4 in female boss to 1.5 in Sch 10 pipe, Butt weld

SIZE A	CAGE CODE 22264	DWG NO K0000146597-SPC	REV -
SCALE None	UNIT WEIGHT —	SHEET 26 OF 26	