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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# 1311558

DOCUMENT INFORMATION: (TITLE, NUMBER, REV, DATE)
K0000147032
Pipe Specification, Single Wall, LO2 Service

SENSITIVE BUT UNCLASSIFIED (SBU)

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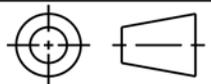
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**UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES.
INTERPRET DIMENSIONS AND
TOLERANCES PER ASME Y14.5M-1994.
TOLERANCES NO:**

FRACTIONS DECIMALS ANGLES

THIRD ANGLE PROJECTION



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			
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SOFTWARE	ENGINEER S. Larsen	CHECKER				
FILENAME	ENGINEER S. Hoyle	STRESS	SIZE CAGE CODE DWG NO REV A 22264 K0000147032-SPC -			
MATERIAL	ENGINEER E. Thompson					
HEAT TREATMENT	SUBMITTED T. Adams	SCALE None	UNIT WEIGHT —	SHEET 1	OF 20	
FINAL PROTECTIVE FINISH	APPROVED A. Littlefield					

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K0000147032-SPC, -.12, RELEASED, Verify Latest Revision in KDDMS

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Abbreviations, acronyms, and symbols

- ASME American Society of Mechanical Engineers
- GN₂ Gaseous Nitrogen
- GO₂ Gaseous Oxygen
- GSE Ground Support Equipment
- KSC Kennedy Space Center
- LO₂ Liquid Oxygen
- LN₂ Liquid Nitrogen
- KSC John F. Kennedy Space Center
- MDP Maximum Design Pressure
- NASA National Aeronautics and Space Administration
- NDE Non-Destructive Evaluation

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1. SCOPE

This specification provides technical information for the design, fabrication, and testing 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-STD-5005	Standard For the Design and Fabrication of Ground Support Equipment
NASA-STD-5008	Protective Coating of Carbon Steel, Stainless Steel, and Aluminum on Launch Structures, Facilities, and Ground Support Equipment

NASA/Kennedy Space Center

KSC-C-123	Surface Cleanliness of Fluid Systems, Specification For
KSC-GP-425	Fluid Fitting Engineering Standards
KSC-STD-E-0015	Marking of Ground Support Equipment, Standard For

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KSC-STD-SF-0004 Safety Standard for Ground Piping Systems Color Coding and Identification

KSC-STD-Z-0009 Design of Cryogenic Ground Support Equipment Standard For

KSC Drawings

TBD TBD

TBD TBD

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

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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 A312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
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 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 A967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts

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3. REQUIREMENTS

3.1 Definition

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

- a. **Field Monitor** – Pressure monitoring performed by individual from a dial indicator gage without electronic transmission.
- b. **shall:** - Used to indicate a requirement which must be implemented and its implementation verified;
- c. **should:** Used to indicate a goal which must be addressed by the design but is not formally verified;
- d. **Will:** Used to indicate a statement of fact and is not verified.
- e. **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.
- f. **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.
- g. **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.

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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, fabricated, examined, and tested as normal fluid service with severe cyclic conditions in accordance with ASME B31.3.

3.2.2 Temperature and Pressure

3.2.2.1 The assembled pipe shall be designed for -321 degrees F to +158 degrees F at 300 psig

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

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

3.2.2.4 The Maximum Design Pressure (MDP) for the pipe shall be 300 PSIG with atmospheric pressure applied to external surface of inner pipe.

3.2.2.5 A pressure cycle for the pipe shall be 0 psig to 300 psig and back to 0 psig.

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

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3.2.4 Pipe Assembly

- 3.2.4.1 Pipe assembly shall meet requirements in Table 1: Pipe Sizes.
- 3.2.4.2 The pipe shall be schedule 10 seamless pipe in accordance with ASTM A312 TP316/TP316L (dual grade).
- 3.2.4.3 All pipe primary welds shall accommodate 100% radiography
- 3.2.4.4 Pipe elbows shall be long radius per ASME/ANSI B16.9. Mitered tee and elbows are not permitted on inner pipe.

3.2.5 Joint Connections

- 3.2.5.1 Joints in the piping system shall be of the flanged design.
- 3.2.5.2 Flanges shall be per ANSI/ASME B16.5 and shall be ASTM A182 F316/F316L (dual graded) stainless steel. Flange styles and pressure classes are as indicated on KSC drawings. All serrations on raised face flanges shall be concentric and per ASME B16.5 paragraph 6.4.5.3.
- 3.2.5.3 All flanged joints shall be either weld neck or lap-joint design in accordance with ANSI/ASME B16.5. The use of slip-on flanges shall be avoided. Stainless steel flange material shall be in accordance with ASTM A182 and shall be of the same grade as the piping material to which it is attached. The bolt, washer and nut materials shall be in accordance with ASTM A193, A194, or A320, as applicable. A weld neck flange bolted to a lap joint flange should be used where necessary to allow correct bolt alignment between the two flanges.
- 3.2.5.4 Gasket material shall be glass-filled Teflon TFE 2.4 mm (3/32 in) thick. Dimensions for flat ring gaskets shall be per KSC drawing 76K04886 or ASME B16.5 for cryogenic piping
- 3.2.5.5 Socket weld joints shall not be used.
- 3.2.5.6 Slip flanges shall not be used.

3.2.6 Weld Fittings

- 3.2.6.1 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.

3.2.7 Reliability

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3.2.7.1 The pipe assemblies shall have a minimum 20 year design service life under the conditions specified herein

3.2.7.2 The pipe assemblies shall be designed for a minimum of 7,000 pressure cycles.

3.2.8 Thermal Life Cycle

3.2.8.1 The pipe assemblies shall have a designed thermal cycle life of a minimum of 7,000 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.

3.2.9 Environmental Conditions

3.2.9.1 Pipe, joints, components and seals exposed to the atmosphere shall be made of corrosion resistant materials to be corrosion resistant to marine environment and saltwater spray.

3.2.10 Listed Components Usage

3.2.10.1 Piping components shall be listed components in accordance with ASME B31.3.

3.2.11 Unqualified Components

3.2.11.1 Unlisted components shall be qualified in accordance to ASME B31.3 paragraph 302.2.3.

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3.3 Construction

3.3.1 Welder Qualification

3.3.1.1 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.

3.3.2 Non Destructive Evaluation (NDE) Examiners

3.3.2.1 Weld examiners shall be qualified in accordance with ASME B31.3 paragraph 342.

3.3.3 Non Destructive Evaluation (NDE)

3.3.3.1 All welding inspections shall be performed by certified weld examiners in accordance with NASA-SPEC-5004 and ASNT-TC-1A

3.3.3.2 NDE for severe cyclic welds shall be performed per ASME B31.3.

3.3.3.3 All welds shall be 100% visually examined by certified welding examiner per ASME B31.3. Pass/fail criteria shall be per ASME B31.3.

3.3.3.4 All pipe welds shall be 100% radiograph examined per NASA-SPEC-5004 and ASME B31.3. Pass/Fail criteria shall be per ASME B31.3.

3.3.4 Welding

3.3.4.1 All Pipe welds shall be full penetration welds for severe cyclic conditions in accordance with NASA-SPEC-5004 and ASME B31.3 Chapter V. Backing rings are not permitted.

3.3.4.2 Attachments to the pipe shall be in accordance with ASTM A240 with a full-seal weld to prevent moisture intrusion

3.3.4.3 Remove scale, burrs and break sharp edges

3.3.5 Low Temperature Toughness

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

3.3.6 Passivation

3.3.6.1 Weld heat affected areas shall be passivated per ASTM A380 and ASTM A967.

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3.3.7 Paint

- 3.3.7.1 Coat all exterior surfaces of pipe using an inhibited polyamide epoxy primer and aliphatic polyurethane topcoat perNASA-STD-5008B. Other coatings such as polysiloxane and silicone ablative may be substituted as top coats. Hastelloy bellows shall not be coated.
- 3.3.7.2 Coating shall be applied after completion of all acceptance testing.

3.3.8 Cleaning

- 3.3.8.1 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.

3.3.9 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 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
- Service
- Year Built
- Temperature Range

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

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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

3.3.14 Security

N/A

3.3.15 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. Isometric drawing “tbd” shall take precedence over individual flex hose drawingsA

3.9 Qualification

N/A

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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.

4.2 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
- Liquid Oxygen to MIL-PRF-25508G, Type II, Grade A

4.2.1 Required Testing Chronology

The testing in sections 4.2.2 to 4.2.6 shall be performed sequentially.

4.2.2 Cold Shock

4.2.2.1 The pipe assembly shall undergo cold shock testing after the pressure/leak testing is completed.

4.2.2.2 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.

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4.2.3 Pressure/Leak Testing

- 4.2.3.1.1 The leak pressure test shall be conducted via hydrostatic testing at a minimum of 150% of the design pressure.
- 4.2.3.1.2 The pressure shall be maintained for a minimum of 10 minutes. The pipe undergoing test shall exhibit no leakage while undergoing leak testing and show no permanent deformation or damage as result of the leak testing.
- 4.2.3.1.3 Leak testing shall be performed at ambient temperature.

4.3 Mass Spectrometer Leak Testing

- 4.3.1.1 The pipe shall undergo leak testing after the cold shock testing is completed and prior to the application of any coatings.
- 4.3.1.2 One of the following two testing procedures shall be used.
- 4.3.1.2.1 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.
- 4.3.1.2.2 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.
- 4.3.1.3 For flanged pipe joints use the following leak criteria;
- 4.3.1.3.1 With joint pressurized to MDP with 100% helium, the helium leakage indication shall be below 1×10^{-4} std-cc/sec. To accomplish this test, a helium leak detector set capable of sensitivity to 1×10^{-6} std-cc/sec shall be used.
- 4.3.1.3.2 As an option with joint pressurized to MDP with 10% helium/90% nitrogen, the helium leakage indication shall be below 1×10^{-5} std-cc/sec. To accomplish this test, a helium leak detector set capable of sensitivity to 1×10^{-7} std-cc/sec shall be used.

4.4 Dimensional Verification

- 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.

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4.5 Responsibility For Verification / Inspection

- 4.5.1.1 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.
- 4.5.1.2 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 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 Packaged per KSC-C-123

5.1.1.1 All pipe assemblies shall be packaged per KSC-C-123. Packing design shall be approved by NASA prior to use.

5.1.2 Pipe Pressure

5.1.2.1 Cleanliness shall be maintained.

5.1.2.2 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.

5.1.2.3 Establish a minimum dew point of minus 65F (24 ppm) using 2 micron filtered MIL-PRF-27401F, Type II, 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

5.1.2.4 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.

5.1.2.5 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.

5.1.3 Recordings

5.1.3.1 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 pipe section within a hard sided container (at a minimum wood construction), using standard commercial practice, ensuring each 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.

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6. NOTES

6.1 Intended Use

This document is intended to establish the requirements for fabrication and testing of LO₂ 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

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APPENDIX A - PIPE ASSEMBLY PART SPECIFICATIONS

Table 1: Pipe Sizes

QTY (Units)	Fluid	Spool Number	Function	Type	Size pipe (Schedule 10)	Location	Drawing Number
1	LO2	5165	Liquid Oxygen Bleed	Pipe Spool	1-1/2"	ICPSU	K0000065264
1	LO2	5170	Liquid Oxygen Bleed	Pipe Spool	1-1/2"	ICPSU	K0000065265

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