METRIC/INCH-POUNDS

KSC-SPEC-Z-0007E
October 20, 1994
Supersedes
KSC-SPEC-Z-0007D
July 1, 1991

TUBING, STEEL, CORROSION RESISTANT, TYPES 304 AND 316, SEAMLESS, ANNEALED, SPECIFICATION FOR

ENGINEERING DEVELOPMENT DIRECTORATE

National Aeronautics and
Space Administration

John F. Kennedy Space Center

KSC FORM 16-12 (REV. 7/92)

TRANSMITTAL SHEET

TO:	DATE
Distribution	October 20, 1994

MATERIAL TRANSMITTED

KSC-SPEC-Z-0007E, Tubing, Steel, Corrosion Resistant, Types 304 and 316, Seamless, Annealed, Specification for

This document supersedes all previous issues of the document.

FILING INSTRUCTIONS

Destroy KSC-SPEC-Z-0007D dated July 1, 1991, and replace with KSC-SPEC-Z-0007E dated October 20, 1994.

KSC-SPEC-Z-0007E
October 20, 1994
Supersedes
KSC-SPEC-Z-0007D
July 1, 1991

TUBING, STEEL, CORROSION RESISTANT, TYPES 304 AND 316, SEAMLESS, ANNEALED, SPECIFICATION FOR

Approved:

Walter T. Murphy
Director of Engineering Development

JOHN F. KENNEDY SPACE CENTER, NASA

TABLE OF CONTENTS

Section	Title	Page
1.	SCOPE	1
2.	APPLICABLE DOCUMENTS	1
2.1	Governmental	1
2.1.1	Specifications	1
2.1.2	Standards	2
2.1.3	Handbooks	2
2.1.4	Publications	2
2.2	Non-Governmental	2
3.	REQUIREMENTS	3
3.1	General Requirements	3
3.2	Supplementary Requirements	3
3.2.1	Method of Manufacture	3
3.2.2	Material	3
3.2.3	Passivation	4
3.2.4	Surface Condition	4
3.2.5	Surface Roughness	4
3.2.6	Discontinuities	4
3.2.7	Dimensions and Tolerances	5
3.2.7.1	Sizes	5
3.2.7.2	Tolerances	5
3.2.8	Corrosion Resistance	6
3.2.9	Identification of Product	6
3.2.9.1	Marking	6
3.2.9.2	Unique Designation	6
4.	QUALITY ASSURANCE PROVISIONS	7
4.1	Inspection Reports	7
4.2	Test Specimens	7
4.3	Corrosion Resistance	7
4.3.1	Acidified Copper Sulfate Test	7
4.3.1.1	Sampling	7
4.3.1.2	Preparation of Specimen	7

LIST OF TABLES

Table	Title	Page
1	Chemical Composition	4
2	Allowable Wall Thickness Discontinuities for Inch-Specified Tubing	5
3	Allowable Wall Thickness Discontinuities for Metric-Specified Tubing	5
4	Outside Diameter Tolerances for Inch-Specified Tubing	6
5	Outside Diameter Tolerances for Metric-Specified Tubing	6
6	Sampling Plan	7

TUBING, STEEL, CORROSION RESISTANT, TYPES 304 AND 316, SEAMLESS, ANNEALED, SPECIFICATION FOR

1. SCOPE

This specification defines the requirements for pressure tubing suitable for use with standard, 37-degree, flared tube fittings and buttwelding tube fittings in ground support equipment fluid systems at the John F. Kennedy Space Center (KSC), NASA.

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. 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 the event of difference between this specification or its accompanying drawings and the referenced document, this specification and its accompanying drawings shall govern to the extent of such difference.

2.1 Governmental.

2.1.1 Specifications.

John F. Kennedy Space Center (KSC), NASA

75M18787	Procurement Specification for Saturn V GSE Fluid Systems, Tube, Pipe, and Fittings

Military

MIL-T-8504	Tubing, Steel, Corrosion Resistant (304), Aerospace Vehicle Hydraulic Systems, Annealed, Seamless and Welded

Federal

QQ-P-35	Passivation Treatments for Corrosion-Resisting Steel

2.1.2 Standards.

Federal

FED-STD-183	Continuous Identification Marking of Iron and Steel Products

Military

MIL-STD-163	Steel Mill Products Prepared for Shipment and Storage
MIL-STD-753	Corrosion-Resistant Steel Parts: Sampling, Inspection and Testing for Surface Passivation

2.1.3 Handbooks.

Federal

GSA-FSS H 4-1	Federal Supply Code for Manufacturers

2.1.4 Publications.

John F. Kennedy Space Center (KSC), NASA

GP-425	Engineering Standards

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

2.2 Non-Governmental.

American Society for Testing and Materials (ASTM)

ASTM A262	Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A269	Seamless and Welded Austenitic Stainless Steel Tubing for General Service

ASTM E213	Ultrasonic Examination of Metal Pipe and Tubing
ASTM E426	Electromagnetic (Eddy-Current) Examination of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.)

American National Standards Institute (ANSI)

ANSI B46.1	Surface Texture (Surface Roughness, Waviness, and Lay)

(Application for copies should be sent to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

3. REQUIREMENTS

3.1 General Requirements. - The tubing covered by this specification shall comply with the mechanical properties specified in MIL-T-8504 and the additional requirements specified herein.

3.2 Supplementary Requirements.

3.2.1 Method of Manufacture. - Tubing shall be manufactured by the seamless, cold-drawing process and shall be fully annealed.

3.2.2 Material. - Tubing material shall be types 304 or 316 corrosion-resistant steel in accordance with ASTM A269. Chemical composition of types 304 and 316 corrosion-resistant steel shall be in accordance with the requirements of table 1.

Table 1. Chemical Composition

Element	Type 304 Limits (percent)	Type 316 Limits (percent)
Carbon	0.08 (max)	0.08 (max)
Manganese	2.00 (max)	2.00 (max)
Phosphorus	0.03 (max)	0.03 (max)
Sulfur	0.030 (max)	0.030 (max)
Silicon	1.00 (max)	1.00 (max)
Chromium	18.00 - 20.00	16.00 - 18.00
Nickel	8.00 - 12.00	11.00 - 14.00
Molybdenum	0.50 (max)	2.00 - 3.00
Copper	0.50 (max)	0.50 (max)

3.2.3 Passivation. - Tubing shall be passivated in accordance with QQ-P-35. Tubing surfaces shall be passive to tests in compliance with methods 102 or 103 of MIL-STD-753.

3.2.4 Surface Condition. - Both inside and outside surfaces shall be smooth, have a gray metallic appearance, and be free from surface films, scale, flakes, or loose or adherent particles of foreign matter. All chemical residues shall have been removed by rinsing in flowing water, followed by thorough drying. A bright annealed surface is also acceptable.

3.2.5 Surface Roughness. - Surface roughness shall not exceed an arithmetical average roughness height rating (RHR) of 70 on inside surfaces or 40 on outside surfaces, as defined by ANSI B46.1. Tubes of 50.8 millimeters (mm) (2 inches) outside diameter and above shall not exceed an arithmetical average RHR of 125 on inside and outside surfaces.

3.2.6 Discontinuities. - The maximum permissible depth of discontinuities for wall thicknesses is 7 percent of the minimum wall thickness, unless otherwise specified in table 2 for tubing specified in inch and in table 3 for tubing specified in metric.

Table 2. Allowable Wall Thickness Discontinuities for Inch-Specified Tubing

Minimum Wall Thickness (inch)	Maximum Permissible Depth of Discontinuities (inch)
0.020 and under	10 percent of minimum wall thickness
0.021 through 0.030	0.002
0.031 through 0.040	0.0025
0.041 through 0.050	0.003
0.051 through 0.066	0.004
0.067 through 0.085	0.006

Table 3. Allowable Wall Thickness Discontinuities for Metric-Specified Tubing

Minimum Wall Thickness (mm)	Maximum Permissible Depth of Discontinuities (mm)
0.51 and under	10 percent of minimum wall thickness
0.52 through 0.78	0.05
0.79 through 1.03	0.064
1.04 through 1.29	0.08
1.30 through 1.69	0.10
1.70 through 2.16	0.15

3.2.7 Dimensions and Tolerances.

3.2.7.1 Sizes. - Tubing shall be furnished with the diameters and wall thicknesses specified in the contract or purchase order.

3.2.7.2 Tolerances. - The finished outside tube diameter shall be round within the outside diameter tolerances specified in table 4 for tubing specified in inch and table 5 for tubing specified in metric. Wall thickness tolerances shall be +10/-0 percent of the specified nominal wall thickness.

Table 4. Outside Diameter Tolerances for Inch-Specified Tubing

Size Range, Outside Diameter (inch)	Tolerance (inch)
0.000 to 0.187, exclusive	+0.003 -0.000
0.187 to 0.500, exclusive	+0.004 -0.000
0.500 to 1.500, exclusive	+0.005 -0.000
1.500 to 2.000, exclusive	+0.010 -0.000
2.000 to 3.000, exclusive	+0.015 -0.010
3.000 to 5.000, exclusive	+0.015 -0.015

Table 5. Outside Diameter Tolerances for Metric-Specified Tubing

Size Range, Outside Diameter (mm)	Tolerance (mm)
0.000 to 4.75, exclusive	+0.08 -0.00
4.75 to 12.70, exclusive	+0.10 -0.00
12.70 to 38.10, exclusive	+0.13 -0.00
38.10 to 50.80, exclusive	+0.25 -0.00
50.80 to 76.20, exclusive	+0.38 -0.25
76.20 to 127.00, exclusive	+0.38 -0.38

3.2.8 Corrosion Resistance. - Upon examination, tubing shall exhibit no evidence of cracks due to intergranular attack on interior or exterior surfaces after exposure to a boiling acidified copper sulfate solution at the conditions specified in 4.3.1.

3.2.9 Identification of Product.

3.2.9.1 Marking. - Tubing shall be marked in accordance with Federal Standard 183. The designation "KSC-SPEC-Z-0007E," the material type (type 304 or type 316), and the tube size and wall thickness shall also be marked on all tubing.

3.2.9.2 Unique Designation. - The full name (or the applicable Federal supply code for the manufacturer, as specified in GSA-FSS H 4-1) of the producer who assigned the heat number for the material procured under this specification shall be part of the assigned heat number, and shall be stated as a prefix to the heat number after the indicator designation "HT." The producer's code number shall be separated from the heat number by a hyphen.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection Reports. - Legible copies (capable of being reproduced) of reports of test results shall be supplied with each delivery of pressure tubing. 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 Test Specimens. - Prior to inspections or tests, a Government representative shall select test specimens or samples of tubing (see table 6). Test specimens, labeled for identification with the items specified in the contract, shall be provided. Each axial flare test specimen and 5 percent of the tensile and surface condition test specimens shall be forwarded with the shipment. When the number is less than 5, all the specimens shall be forwarded. All other test specimens shall be forwarded with the shipment in a package marked "Test Specimens" with one copy of the supplier's test report. An examination of the tubing for roundness as specified in 3.2.7.2 shall be accomplished on the samples selected for dimensions and tolerances (3.2.7).

Table 6. Sampling Plan

Lot Size	Sample Size	Acceptance No.
1 to 110	5	0
111 to 500	7	0
501 to 800	10	0
801 to 1,200	15	0
Over 1,200	25	0

4.3 Corrosion Resistance.

4.3.1 Acidified Copper Sulfate Test. - To test the corrosion resistance of the sample, an acidified copper sulfate test shall be performed in accordance with ASTM A262, Practice E.

4.3.1.1 Sampling. - Two full-ring specimens [25.4 mm (1 inch) or more in length] shall be cut from each sample tubing selected from each lot.

4.3.1.2 Preparation of Specimen. - Specimens of the as-received tubing (full sections whenever practicable) shall be treated for 48 hours in a boiling copper sulfate, sulfuric acid solution in accordance with ASTM A262, Practice E.

4.3.1.3 Examination. - After exposure, full-section specimens shall be flattened between parallel plates by a gradually applied load normal to the axis of the tubing until the distance between the pressure plates is not greater than four times the wall thickness. Strip-section specimens shall be bent cold 180 degrees around a suitable mandrel of a diameter equal to 3 times the outside diameter of the tubing. The folded areas shall be examined at 20X magnification. The tubing shall exhibit no evidence of cracks due to intergranular attack in accordance with ASTM A262, Practice E.

4.3.2 Alternate Corrosion-Resistance Test. - At the option of the tubing manufacturer, the following alternate corrosion-resistance quality assurance test may be performed in lieu of the requirements of 4.3.1.

4.3.2.1 Sampling. - Specimens shall be cut from sample tubing from each lot selected in accordance with 4.2, unless otherwise specified.

4.3.2.2 Examination. - Tubing specimens shall be tested and examined for carburization of the interior and exterior surfaces and for susceptibility to intergranular attack in accordance with ASTM A262, Practice A.

4.3.2.3 Interpretation of Results. - Tubing lots represented by specimens that are classified as having an acceptable etch structure shall be considered to have acceptable corrosion resistance. Lots represented by a specimen with an etch structure classified as nonacceptable must be subjected to the Acidified Copper Sulfate Test specified in 4.3.1.

4.4 Flaring. - The remaining tubing specimens prepared in accordance with 4.3.1.2 shall be flared. The end of each specimen to be flared without spinning shall be cut square, with the cut end smooth and free from burrs but the corners not rounded. The specimen shall, at room temperature, be forced axially by steady pressure over a hardened and polished tapered steel pin to produce the tubing flare configuration specified by KC154 (or metric equivalent) of GP-425. Both the tube and pin shall be clean and dry during the flaring operation. The surfaces of the flare shall be examined at 20X magnification for compliance with 3.2.6 of this specification. The manufacturer shall use the best available commercial practice to measure surface discontinuities.

4.5 Surface Condition. - A 0.3-meter (m) (1-foot) section shall be selected from each lot of tubing and split lengthwise. One-half of the section shall be immersed in an aqueous solution of 15-percent nitric acid and 3-percent hydrofluoric acid by volume at 38 to 49 degrees Celsius (°C) [100 to 120 degrees Fahrenheit (°F)] for 15 minutes. After immersion, the specimen shall be washed and dried. The two

halves shall then be compared as to the appearance of the inner and outer surfaces. Difference in color and appearance, other than minor changes in shade and texture, shall be cause for rejection.

4.6 Loose Material. - The remaining portion of tubing selected for testing of surface condition shall be tested for the presence of grit, metallic flakes, or other detrimental materials. Wads of firmly compacted clean white cloth or fibrous material shall be forced through the bore of each of two sample tubes selected from each lot, and any soiled areas examined at 10X magnification. The material forced through the bore of each sample shall be wetted in acetone or an equivalent solvent. The presence of surface films, oxidation particulate, scale, flakes, or loose or adherent particles as a result of carburization, nitriding, or the presence of oxygen during heat treatment or other manufacturing processes shall be cause for rejection of the entire lot.

4.7 Surface Roughness. - A 0.3-m (1-foot) section of tubing shall be selected from each lot of tubing and split lengthwise. The inner and outer surfaces of both halves shall be examined for surface waviness and lay in accordance with ANSI B46.1. The failure of any tubing to meet the requirements of 3.2.5 shall be cause for rejection.

4.8 Nondestructive Electromagnetic (Eddy Current) Test. - Each length of the tube shall be tested in accordance with ASTM E426. A single length of tubing shall be used to create a calibrated defect. A longitudinal buttress that is "U" shaped or "V" notched with an included angle of 60 degrees, plus or minus 1 degree (as specified in ASTM E213), and is 0.79 mm (0.031 inch) or less in width shall be machined in an axial plane (parallel to the tube axis on the outside surface of the tube) to have a depth in accordance with 3.2.6 and of sufficient length in relation to test methods so as to cause a reject, thus establishing the calibration defect standard. Measurement of surface discontinuities may also be calibrated to a depth of 7 percent of the minimum wall thickness or 0.10 mm (0.004 inch), whichever is greater. Discontinuities producing a measurement equal to or greater than the calibrated defect shall be cause for rejection of the tube length.

5. PREPARATION FOR DELIVERY

Tubing shall be preserved, packaged, packed, and marked for shipment in accordance with the applicable requirements of MIL-STD-163 Level C, as a minimum, unless Level Commercial is specified and/or approved by the procurement agency. The ends of each tube shall be sealed with plastic caps to prevent contamination.

6. NOTES

6.1 Intended Use. - The tubing specified in this specification is intended for use with standard, 37-degree, flared tube fittings and buttwelded tube fittings in fluid systems of space vehicle ground support equipment.

CAUTION

> Types 304 and 316 corrosion-resistant steel are susceptible to corrosion when used in fabrication processes involving welding or brazing or when exposed to temperatures above 427 °C (800 °F).

6.2 Ordering Data. - Procurement documents for corrosion-resistant steel tubing shall specify the following:

a. Title, number, and date of this specification

b. Nominal outside diameter and minimum wall thickness required

c. Material type required (type 304 preferred or type 316)

d. Quantity required

e. Lengths required

f. Special marking required (see 3.2.9)

g. Legible, reproducible inspection reports required

6.3 Supersession Data. - This specification supersedes 3.2 of John F. Kennedy Space Center procurement specification 75M18787.

6.4 Cross-Reference to Superseded Designations. - Tubing as described herein is a direct substitute for all choices of tubing given in 3.2 of 75M18787. Type 304 stainless steel is the preferable material.

NOTICE: The Government drawings, specifications, and/or data are prepared for the official use by, or on the 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 then the Government project for which they were prepared and/or provided by the Government, or an 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

Preparing Activity:

John F. Kennedy Space Center
Mechanical Engineering Division
Engineering Development Directorate

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, nor to request waivers or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER KSC-SPEC-Z-0007E	2. DOCUMENT DATE October 20, 1994

3. DOCUMENT TITLE
Tubing, Steel, Corrosion Resistant, Types 304 and 316, Seamless, Annealed, Specification For

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)*	7. DATE SUBMITTED

8. PREPARING ACTIVITY

a. NAME	d. TELEPHONE *(Include Area Code)*
Director of Engineering Development	(407) 867-2565

b. ADDRESS *(Include Zip Code)*
National Aeronautics and Space Administration, Mail Code: DE
Kennedy Space Center, FL 32899