Designation: A 554 – 08

Standard Specification for Welded Stainless Steel Mechanical Tubing[1]

This standard is issued under the fixed designation A 554; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers welded stainless steel tubing for mechanical applications where appearance, mechanical properties, or corrosion resistance is needed. The grades covered are listed in Table 1.

1.2 This specification covers as-welded or cold-reduced mechanical tubing in sizes to 16 in. (406.4 mm) outside dimension, and in wall thicknesses 0.020 in. (0.51 mm) and over.

1.3 Tubes shall be furnished in one of the following shapes as specified by the purchaser: round, square, rectangular, or special.

1.4 Supplementary requirements of an optional nature are provided and when desired shall be so stated in the order.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron[3]

E 59 Practice for Sampling Steel and Iron for Determination of Chemical Composition[3]

2.2 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[4]

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[4]

2.3 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[4]

3. Ordering Information

3.1 Orders for material under this specification should include the following, as required, to describe the desired material adequately:

3.1.1 Quantity (feet, mass, or number of pieces),

3.1.2 Name of material (welded stainless steel mechanical tubing),

3.1.3 Form (round, square, rectangular, special, see 1.3),

3.1.4 Dimensions:

3.1.4.1 Round-outside diameter and wall thickness for all conditions (Section 8). Alternatively, for cold-reduced condition, outside diameter and inside diameter or inside diameter and wall dimensions may be specified,

3.1.4.2 Square and rectangular outside dimensions and wall thickness (see 9.1),

3.1.4.3 Special (to be specified),

3.1.5 Length (mill lengths, cut lengths, or multiple lengths (see 8.3)),

3.1.6 Grade (Table 1),

3.1.7 Condition (see 6.1),

3.1.8 Inside diameter bead condition (see 6.2),

3.1.9 Surface finish (see Section 11),

3.1.10 Report of chemical analysis, if required (Section 7),

3.1.11 Individual supplementary requirements, if required,

3.1.12 End use,

3.1.13 Specification designation,

3.1.14 Special requirements,

3.1.15 Special marking (Section 14), and

3.1.16 Special packing (Section 15).

4. Process

4.1 The steel may be made by any process.

4.2 If a specific type of melting is required by the purchaser, it shall be stated on the purchase order.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.10 on Stainless and Alloy Steel Tubular Products.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.

***A Summary of Changes section appears at the end of this standard.**

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TABLE 1 Chemical Requirements

Grade	Composition, %									
	Carbon, max	Manganese, max	Phosphorus, max	Sulfur, max	Silicon, max	Nickel	Chromium	Molybdenum	Titanium	Columbium + Tantalum
					Austenitic					
MT-301	0.15	2.00	0.040	0.030	1.00	6.0–8.0	16.0–18.0	...	...	...
MT-302	0.15	2.00	0.040	0.030	1.00	8.0–10.0	17.0–19.0	...	...	...
MT-304	0.08	2.00	0.040	0.030	1.00	8.0–11.0	18.0–20.0	...	...	...
MT-304L	0.035[A]	2.00	0.040	0.030	1.00	8.0–13.0	18.0–20.0	...	...	...
MT-305	0.12	2.00	0.040	0.030	1.00	10.0–13.0	17.0–19.0	...	...	...
MT-309S	0.08	2.00	0.040	0.030	1.00	12.0–15.0	22.0–24.0	...	...	...
MT-309S-Cb	0.08	2.00	0.040	0.030	1.00	12.0–15.0	22.0–24.0	...	...	[B]
MT-310S	0.08	2.00	0.040	0.030	1.00	19.0–22.0	24.0–26.0	...	...	...
MT-316	0.08	2.00	0.040	0.030	1.00	10.0–14.0	16.0–18.0	2.0–3.0	...	...
MT-316L	0.035[A]	2.00	0.040	0.030	1.00	10.0–15.0	16.0–18.0	2.0–3.0	...	...
MT-317	0.08	2.00	0.040	0.030	1.00	11.0–14.0	18.0–20.0	3.0–4.0	...	...
MT-321	0.08	2.00	0.040	0.030	1.00	9.0–13.0	17.0–20.0	...	[C]	...
MT-330	0.15	2.00	0.040	0.030	1.00	33.0–36.0	14.0–16.0	...	...	...
MT-347	0.08	2.00	0.040	0.030	1.00	9.0–13.0	17.0–20.0	...	...	[B]
					Ferritic					
MT-429	0.12	1.00	0.040	0.030	1.00	0.50 max	14.0–16.0	...	...	...
MT-430	0.12	1.00	0.040	0.030	1.00	0.50 max	16.0–18.0	...	...	...
MT-430-Ti	0.10	1.00	0.040	0.030	1.00	0.075 max	16.0–19.5	...	5 × C min, 0.75 max	...

[A] For small diameter or thin walls, or both, where many drawing passes are required, a carbon content of 0.040 % max is necessary in grades MT-304L and MT-316L. Small outside diameter tubes are defined as those less than 0.500 in. (12.7 mm) in outside diameter and light wall tubes as those less than 0.049 in. (1.24 mm) in average wall thickness.

[B] The columbium plus tantalum content shall be not less than ten times the carbon content and not more than 1.00 %.

[C] The titanium content shall be not less than five times the carbon content and not more than 0.60 %.

4.3 The primary melting may incorporate separate degassing or refining and may be followed by secondary melting, such as electroslag remelting or vacuum-arc remelting. If secondary melting is employed, the heat shall be defined as all of the ingots remelted from a single primary heat.

4.4 Steel may be cast in ingots or may be strand cast. When steel of different grades are sequentially strand cast, identification of the resultant transition material is required. The producer shall remove the transition material by an established procedure that positively separates the grades.

5. Materials and Manufacture

5.1 The tubes shall be made from flat-rolled steel by an automatic welding process without the addition of filler metal.

6. Condition

6.1 The tubes shall be furnished in any of the following conditions as specified:

6.1.1 As welded,

6.1.2 Welded and annealed,

6.1.3 Cold reduced,

6.1.4 Cold reduced and annealed.

6.2 The inside diameter bead shall be furnished in any of the following conditions as specified:

6.2.1 Bead not removed,

6.2.2 Bead controlled to 0.005 in. (0.13 mm) or 15 % of the specified wall thickness, whichever is greater, and

6.2.3 Bead removed.

6.3 Square and rectangular welded stainless tubing is supplied as cold worked unless otherwise specified.

7. Heat Analysis

7.1 An analysis of each heat of steel shall be made by the steel manufacturer to determine the percentages of the elements specified. If secondary melting processes are employed, the heat analysis shall be obtained from one remelted ingot or the product of one remelted ingot of each primary melt. The chemical composition thus determined, or that determined from a product analysis made by the tubular product manufacturer, shall conform to requirements specified. When requested in the order or contract, a report of this analysis shall be furnished to the purchaser. (See Test Methods E 30 and Practice E 59.)

8. Permissible Variations in Dimensions—Round Tubing

8.1 For all conditions except tubing with bead removed, Table 2 shall apply.

8.2 For tubing with bead removed, Table 3 shall apply.

8.3 *Lengths*—Tubing is normally furnished in mill lengths 5 ft (1.5 m) and over. Definite cut lengths are furnished when specified, to the length tolerances shown in Table 4. For tubing ordered in multiple lengths, it is common practice to allow a definite amount over for each multiple for the purchaser's cutting operation. Thus cutting allowance should be specified in the purchase order.

8.4 *Straightness Tolerance*—The straightness tolerance shall be 0.030 in. (0.76 mm) maximum in any 3-ft (0.9-m) length of tubing. The straightness tolerance on shorter lengths and on special requirements shall be agreed upon between the purchaser and producer.

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TABLE 2 Diameter, Wall,[A] and Ovality Tolerances (All Conditions Except Tubing with Bead Removed)

NOTE 1—Ovality is the difference between maximum and minimum outside diameters measured at any one cross section. There is no additional tolerance for ovality on tubes having a specified wall thickness of more than 3 % of the outside diameter.

NOTE 2—For sizes up to and including 5-in. (127.0-mm) outside diameter, an ovality tolerance of twice the tabular outside diameter tolerance spread shown is applied one half plus and one half minus to tubes having a specified wall thickness of 3 % or less of the specified outside diameter. The average of the maximum and minimum outside diameter readings should fall within the outside diameter tolerances as shown in this table.

NOTE 3—For sizes over 5-in. (127.0-mm) to and including 16-in. (406.4-mm) outside diameter, when the specified wall thickness is 3 % or less of the outside diameter, the ovality shall not exceed 1.5 % of the specified outside diameter.

OD Size, in. (mm)	Wall Thickness		OD, ±	
	in.	mm	in.	mm
Under ½ (12.7)	0.020 to 0.049	0.51 to 1.24	0.004	0.10
½ to 1 (12.7 to 25.4)	0.020 to 0.065	0.51 to 1.65	0.005	0.13
½ to 1 (12.7 to 25.4)	over 0.065 to 0.134	over 1.65 to 3.40	0.010	0.25
Over 1 to 1 ½ (25.4 to 38.1), incl	0.025 to 0.065	0.64 to 1.65	0.008	0.20
Over 1 to 1 ½ (25.4 to 38.1), incl	over 0.065 to 0.134	over 1.65 to 3.40	0.010	0.25
Over 1 ½ to 2 (38.1 to 50.8), incl	0.025 to 0.049	0.64 to 1.24	0.010	0.25
Over 1 ½ to 2 (38.1 to 50.8), incl	over 0.049 to 0.083	over 1.24 to 2.11	0.011	0.28
Over 1 ½ to 2 (38.1 to 50.8), incl	over 0.083 to 0.149	over 2.11 to 3.78	0.012	0.30
Over 2 to 2 ½ (50.8 to 63.5), incl	0.032 to 0.065	0.81 to 1.65	0.012	0.30
Over 2 to 2 ½ (50.8 to 63.5), incl	over 0.065 to 0.109	over 1.65 to 2.77	0.013	0.33
Over 2 to 2 ½ (50.8 to 63.5), incl	over 0.109 to 0.165	over 2.77 to 4.19	0.014	0.36
Over 2 ½ to 3 ½ (63.5 to 88.9), incl	0.032 to 0.165	0.81 to 4.19	0.014	0.36
Over 2 ½ to 3 ½ (63.5 to 88.9), incl	over 0.165	over 4.19	0.020	0.51
Over 3 ½ to 5 (88.9 to 127.0), incl	0.035 to 0.165	0.89 to 4.19	0.020	0.51
Over 3 ½ to 5 (88.9 to 127.0), incl	over 0.165	over 4.19	0.025	0.64
Over 5 to 7 ½ (127.0 to 190.5), incl	0.049 to 0.250	1.24 to 6.35	0.025	0.64
Over 5 to 7 ½ (127.0 to 190.5), incl	over 0.250	over 6.35	0.030	0.76
Over 7 ½ to 16 (190.5 to 406.4), incl	all	all	0.00125 in./in. or mm/mm of circumference	

[A] Wall tolerance ±10 % of specified wall thickness.

TABLE 3 Diameter, Wall,[A] and Ovality Tolerances for Tubing with Bead Removed

NOTE 1—Ovality is the difference between maximum and minimum outside diameters measured at any one cross section. There is no additional tolerance for ovality on tubes having a specified wall thickness of more than 3 % of the outside diameter.

NOTE 2—An ovality allowance of twice the outside diameter tolerance, shown in this table, is applied one half plus and one half minus to the outside diameter, for tubes having a specified wall thickness of 3 % or less of the specified outside diameter. The average of the maximum and minimum outside diameter readings should fall within the outside diameter tolerances of this table.

NOTE 3—Tubing may be specified to only two of the three following dimensions—outside diameter, inside diameter, or wall.

OD Size, in. (mm)	OD, ±		ID, ±	
	in.	mm	in.	mm
Up to 3⁄32 (2.4), excl	0.001	0.03	0.001	0.03
3⁄32 to 3⁄16 (2.4 to 4.8), excl	0.0015	0.038	0.0015	0.038
3⁄16 to ½ (4.8 to 12.7), excl	0.003	0.08	0.005	0.13
½ to 1 (12.7 to 25.4), excl	0.004	0.10	0.006	0.15
1 to 1½ (25.4 to 38.1), excl	0.005	0.13	0.007	0.18
1 ½ to 2 (38.1 to 50.8), excl	0.006	0.15	0.008	0.20
2 to 2 ½ (50.8 to 63.5), excl	0.007	0.18	0.010	0.25
2 ½ to 3 ½ (63.5 to 88.9), excl	0.010	0.25	0.014	0.36
3 ½ to 5 (88.9 to 127.0), incl	0.015	0.38	0.020	0.51
Over 5 to 16 (127.0 to 406.4), incl	0.00125 in./in. or mm/mm of circumference		0.0013 in./in. or mm/mm of circumference	

[A] Wall tolerance is ±10 % of specified wall thickness.

TABLE 4 Length Variations—Cut Length Tubes

Length, ft (m)	Outside Diameter, in. (mm)	Permissible Variations in Length, in.		
		Over[A]		Under
		in.	mm	
4 (1.2) and under	up to 2 (50.8), incl	1⁄16	1.6	0
	over 2 to 4 (50.8 to 101.6), incl	3⁄32	2.4	0
	over 4 (101.6)	⅛	3.2	0
Over 4 to 10 (1.2 to 3.0), incl	up to 2 (50.8), incl	3⁄32	2.4	0
	over 2 (50.8)	⅛	3.2	0
Over 10 to 24 (3.0 to 7.3), incl	all sizes	3⁄16	4.8	0

[A] For all diameters in lengths over 24 ft (7.3 m), an additional over tolerance of ⅛ in. (3.2 mm) for each 10 ft (3.0 m) or fraction thereof shall be permissible, up to a tolerance of ½ in. (12.7 mm), max.

9. Permissible Variations in Dimensions—Square and Rectangular Tubing

9.1 For this tubing, variations in dimensions from those specified shall not exceed the amounts prescribed in Table 5. For lengths, see 8.3. For the measurement of corner radii in Table 5, refer to Fig. 1.

10. Workmanship, Finish, and Appearance

10.1 Finished tubes shall have smooth ends free of burrs. They shall be free of injurious defects and shall have a workmanlike finish. Surface imperfections such as handling marks, straightening marks, light mandrel and die marks, shallow pits, and scale patterns will not be considered as serious defects, provided the imperfections are removable within 10 % of the specified wall or 0.002 in. (0.05 mm),

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TABLE 5 Square and Rectangular Tubing

Outside Dimension Tolerances		
Largest Specified Outside Dimension Across Flats, in. (mm)	Wall Thickness, in. (mm)	±, in. (mm), across Flats, Convexity or Concavity, incl
To 1 ¼ (31.8), incl	all	0.015 (0.38)
Over 1 ¼ to 2 ½ (31.8 to 63.5), incl	all	0.020 (0.51)
Over 2 ½ to 5 ½ (63.5 to 139.7), incl	all	0.030 (0.76)
Over 5 ½ to 8 (139.7 to 203.2), incl	all	0.060 (1.52)

Wall Thickness Tolerance
± 10 % of specified wall thickness

Maximum Radii of Corners
See Fig. 1

Wall Thickness, in. (mm)	Radii of Corners, max, in. (mm)
Over 0.020 to 0.049 (0.51 to 1.24), incl	3/32 (2.4)
Over 0.049 to 0.065 (1.24 to 1.65), incl	1/8 (3.2)
Over 0.065 to 0.083 (1.65 to 2.11), incl	9/64 (3.6)
Over 0.083 to 0.095 (2.11 to 2.42), incl	3/16 (4.8)
Over 0.095 to 0.109 (2.42 to 2.77), incl	13/64 (5.2)
Over 0.109 to 0.134 (2.77 to 3.40), incl	7/32 (5.6)
Over 0.134 to 0.156 (3.40 to 3.96), incl	1/4 (6.4)
Over 0.156 to 0.200 (3.96 to 5.08), incl	3/8 (9.5)
Over 0.200 to 0.250 (5.08 to 6.35), incl	1/2 (12.7)
Over 0.250 to 0.375 (6.35 to 9.53), incl	3/4 (19.1)

Twist Tolerances	
Largest Size, in. (mm)	Twist in 3 ft, max, in. (mm/m)
Under ½ (12.7)	0.050 (1.4)
½ to 1½ (12.7 to 38.1), incl	0.075 (2.1)
Over 1 ½ to 2 ½ (38.1 to 63.5), incl	0.095 (2.6)
Over 2 ½ to 4 (63.5 to 101.6), incl	0.125 (3.5)
Over 4 to 6 (101.6 to 152.4) incl	0.250 (6.9)
Over 6 (152.4)	0.375 (10.4)

Squareness of Sides
$\pm B = C \times 0.006$

where:
B = tolerance for out-of-square, and
C = length of longest side.

The straightness tolerance is 0.075 in. in 3 ft or 2.1 mm in 1 m using a 3-ft (1-m) straightedge and feeler gage.

whichever is greater. The removal of surface imperfections is not required, unless special finishes are specified.

11. Surface Finish

11.1 Tubes shall be free of scale.

11.2 If special surface conditioning is required, they shall be stated in the order.

12. Rejection

12.1 Tubing that fails to meet the requirements of this specification shall be set aside and the manufacturer notified.

13. Coating

13.1 Stainless steel tubing is commonly shipped without protective coating. If special protection is needed, details shall be specified in the order.

Maximum radii of corners (Table 5)
For the purpose of this standard, the corner radius is defined as the Effective Corner Radius (ECR), which is equal to half the difference between the 'profile width' and the 'width of the flat'.

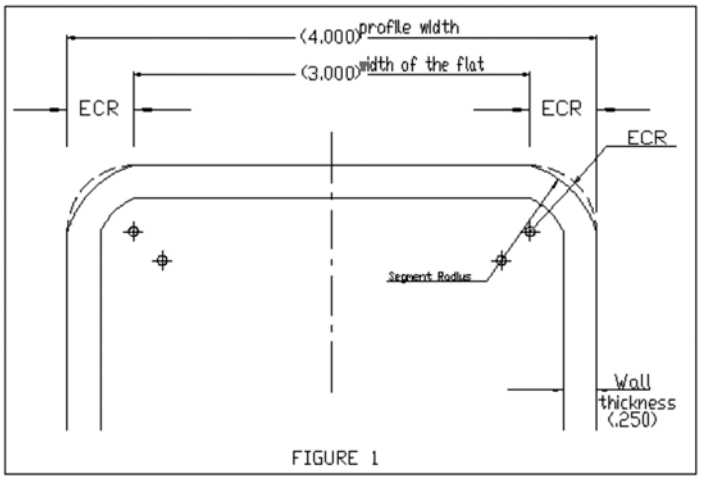

FIGURE 1

$$ECR = \frac{(\text{Tube Width}) - (\text{Width of Flat})}{2}$$

For this 4" wide shape with a wall thickness of .25" the Effective Corner Radius = ECR
ECR = (4" - 3") / 2 = .5"

FIG. 1 Measurement of Corner Radii

14. Product Marking

14.1 *Civilian Procurement*—Each box, bundle or lift, and piece (when individual pieces are shipped) shall be identified by a tag or stencil with the manufacturer's name or brand, specified size, purchaser's order number, this specification number, and grade. Bar coding is acceptable as a supplementary identification method. Bar coding should be consistent with the Automotive Industry Action Group (AIAG) standard prepared by the Primary Metals Subcommittee of the AIAG Bar Code Project Team.

14.2 *Government Procurement*—When specified in the contract or order, and for direct procurement by or direct shipment to the government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for Military agencies and in accordance with Fed. Std. No. 123 for civil agencies.

15. Packaging

15.1 *Civilian Procurement*—On tubing of 0.065-in. (1.65-mm) wall and lighter, the manufacturer will, at his option, box, crate, carton, package in secure lifts or bundles to ensure safe delivery. Tubing heavier than 0.065-in. wall will normally be shipped loose, bundled, or in secured lifts. Special packaging requiring extra operations other than those normally used by the manufacturer must be specified in the order.

15.2 *Government Procurement*—When specified in the contract or order, and for direct procurement by or direct shipment to the government when Level A is specified, preservation, packaging, and packing shall be in accordance with the Level A requirements of MIL-STD-163.

16. Keywords

16.1 austenitic stainless steel; mechanical tubing; stainless steel tube; steel tube; welded steel tube

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SUPPLEMENTARY REQUIREMENTS

These requirements shall not be considered unless specified in the order and the necessary tests made at the mill. Mechanical tests shall be performed in accordance with the applicable sections of Test Methods and Definitions A 370.

S1. Hardness Test

S1.1 Round annealed tubes shall conform to the requirements as to the hardness limits prescribed in Table S1.1.

NOTE S1—There are tubing diameters, walls, or combinations which limit the applicability of particular hardness values.

S1.2 When specified, the hardness test shall be performed on a specimen from one tube from each 2500 ft (760 m) or fraction thereof from each heat of steel.

S2. Tension Test

S2.1 The tubes shall conform to the requirements as to tensile properties prescribed in Table S2.1. When cold-reduced tempers are ordered, the manufacturer shall be consulted.

S2.2 When the tension test is specified, one test shall be performed on a specimen from one tube of each lot of 2500 ft (760 m) or fraction thereof from each heat of steel, prior to cutting to length.

S2.3 The yield strength corresponding to a permanent offset of 0.2 % of the gage length of the specimen or to a total extension of 0.5 % of the gage length under load shall be determined.

S3. Nondestructive Test

S3.1 Various types of nondestructive test are available. When any such test is required, the test to be used and the inspection limits shall be specified in the order.

S4. Test Reports

S4.1 Mill test reports will be furnished when specified in the order.

S4.2 When specified on the purchase order, or when a specific type of melting has been specified, the type of melting used to produce the material shall be included with the test report.

TABLE S1.1 Hardness Requirements (Round Annealed Condition)

Grade	Hardness	
	Brinell, max	Rockwell B, max
All austenitic	192	90
MT 429 and MT 430	190	90
MT-430-Ti	190	90

TABLE S2.1 Tensile Requirements (Round Annealed Condition)

Grade	Tensile Strength, min		Yield Strength, min		Elongation[A] in 2 in. or 50 mm, min, %
	ksi	MPa	ksi	MPa	
MT 429 and MT 430	60	414	35	241	20
MT-430-Ti	60	414	30	207	20
MT 304 L & MT 316 L	70	483	25	172	35
All other austenitic steels	75	517	30	207	35

[A] For longitudinal strip tests, the width of the gage section shall be 1 in. (25.4 mm) and a deduction of 1.75 percentage points for austenitic grades and 1.0 percentage points for MT 429 and MT 430 shall be permitted from the basic minimum elongation for each 1/32-in. (0.79-mm) decrease in wall thickness below 5/16 in. (7.94 mm).

S5. Certification for Government Orders

S5.1 A producer's or supplier's certification shall be furnished to the government that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. This certificate shall include a report of heat analysis (product analysis when requested in the purchase order), and, when specified in the purchase order or contract, a report of test results shall be furnished.

S6. Rejection Provisions for Government Orders

S6.1 Each length of tubing received from the manufacturer may be inspected by the purchaser and, if it does not meet the requirements of the specification based on the inspection and test method as outlined in the specification, the tube may be rejected and the manufacturer shall be notified. Disposition of rejected tubing shall be a matter of agreement between the manufacturer and the purchaser.

S6.2 Material that fails in any of the forming operations or in the process of installation and is found to be defective shall be set aside, and the manufacturer shall be notified for mutual evaluation of the material's suitability. Disposition of such material shall be a matter for agreement.

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SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this specification since the last issue, A 554 – 03, that may impact the use of this specification. (Approved March 1, 2008)

(*1*) Moved material "condition" from Section 9 to Section 6. (*2*) Added new Fig. 1.

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