



Designation: B 743 – 00

Standard Specification for Seamless Copper Tube in Coils¹

This standard is issued under the fixed designation B 743; 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.

1. Scope.*

1.1 This specification establishes the requirements for seamless copper tube in coils, suitable for use in refrigeration and air conditioning or other uses, such as oil lines, gasoline lines, and so forth.

1.2 **Units**—The values stated in inch-pound units are standard. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.3 The tube shall be produced of the following coppers. Unless otherwise specified, tubes made from any one of these coppers may be supplied:

Copper Alloy UNS No.	Previously Used Designation	Type of Copper
C10200	OF	Oxygen-free without residual deoxidants ⁴
C10300	...	Oxygen-free, extra low phosphorus ⁴
C10800	...	Oxygen-free, low phosphorus ⁴
C12000	DLP	Phosphorized, low residual phosphorus
C12200	DHP	Phosphorized, high residual phosphorus

⁴ See Classification B 224.

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

1.5 The following safety hazards caveat pertains to the test method portion, Section 19, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing²
- B 170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes²
- B 193 Test Method for Resistivity of Electrical Conductor Materials³

¹ This specification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

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² Annual Book of ASTM Standards, Vol 02.01.

³ Annual Book of ASTM Standards, Vol 02.03.

B 224 Classification of Coppers²

B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube²

B 577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper²

B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast²

E 2 Methods of Preparation of Micrographs of Metals and Alloys (Including Recommended Practice for Photography as Applied to Metallography)⁴

E 3 Practice for Preparation of Metallographic Specimens⁵

E 8 Test Methods of Tension Testing of Metallic Materials⁶

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials⁵

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵

E 53 Test Methods for Determination of Copper in Unalloyed Copper by Gravimetry⁷

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁷

E 112 Test Methods for Determining Average Grain Size⁵

E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes⁸

E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁹

E 846 Terminology for Copper and Copper Alloys²

3. General Requirements

3.1 The following sections of Specification B 251 constitute a part of this specification:

3.1.1 Sampling,

3.1.2 Number of tests and retests,

3.1.3 Dimensions and permissible variations,

3.1.4 Test specimens, and

3.1.5 Significance of numerical limits.

3.2 In addition, when a section with a title identical to those referenced in 2.1 appears in this specification, it contains additional information which supplements those appearing in Specification B 251. In case of conflict, this specification shall prevail.

⁴ Discontinued. See 1982 Annual Book of ASTM Standards, Vol 03.01.

⁵ Annual Book of ASTM Standards, Vol 14.02.

⁶ Annual Book of ASTM Standards, Vol 03.01.

⁷ Annual Book of ASTM Standards, Vol 03.05.

⁸ Annual Book of ASTM Standards, Vol 03.03.

⁹ Annual Book of ASTM Standards, Vol 14.04.

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



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4. Terminology

4.1 *Definitions*—For the definitions of terms related to copper and copper alloys, refer to Terminology B 846.

4.1.1 *coil, n*—length of the product wound into a series of connected turns. The unqualified term “coil” as applied to tube usually refers to a bunched coil.

4.1.1.1 *bunched, adj*—coil in which the turns are bunched and held together such that the cross section of the bunched turns is approximately circular.

4.1.1.2 *level or traverse wound, adj*—coil in which the turns are wound into layers parallel to the axis of the coil such that successive turns in a given layer are next to one another (sometimes called “helical coil”).

4.1.1.3 *single layer flat, adj*—coil in which the product is spirally wound into a single disk-like layer (sometimes called “pan-cake coil” or “single layer spirally wound coil”).

4.1.1.4 *double layer flat, adj*—coil in which the product is spirally wound into two connected disk-like layers such that one layer is on top of the other (sometimes called “double layer pan-cake coil” or “double layer spirally wound coil”).

4.2 *Definitions of Terms Specific to This Standard:*

4.2.1 *unaided eye, n*—visual inspection, without the use of special equipment or enhancement excepting the use of corrective lenses.

5. Ordering Information

5.1 Orders for materials under this specification shall include the following information:

5.1.1 ASTM designation and year of issue,

5.1.2 Copper UNS No. (for example, C12200), if required (see 1.4 and 7.1),

5.1.3 Temper (see Section 8).

5.1.4 Dimensions, diameter, and wall thickness. Dimensional tolerances, if other than those included in this specification, are required,

5.1.5 Length (see 16.1),

5.1.6 Type of coil (see 4.1),

5.1.7 Total quantity of each item,

5.2 The following options are available and shall be specified at the time of placing the order, when required:

5.2.1 Embrittlement test (see 13.3.1),

5.2.2 Refrigeration or air-conditioning grade (see 17.3),

5.2.3 If coil ends are to be sealed (see 13.4.1.1),

5.2.4 Eddy-current test (see 13.1.1),

5.2.5 Expansion test (see 12.1.1),

5.2.6 Electrical resistivity requirement (see 10.1),

5.2.7 Certification (see Section 23),

5.2.8 Mill test report.

6. Materials and Manufacture

6.1 *Material:*

6.1.1 The material of manufacture shall be cast billet, bar, tube, and so forth of Copper Alloys Nos. C10200, C10300, C10800, C12000, or C12200 and of such purity and soundness as to be suitable for processing in to the product prescribed herein.

6.2 *Manufacture:*

6.2.1 The tube shall be manufactured by such hot and cold working processes needed to produce a homogenous, uniform wrought structure in the finished product.

6.2.1.1 It shall be cold-drawn to the finish size and wall thickness.

6.2.1.2 When the cold-drawn temper is required, the final drawing operation shall be such as to meet the specified temper.

6.2.1.3 When the annealed temper is required, the tube shall be annealed after the final cold draw.

7. Chemical Composition

7.1 The material shall conform to the compositional requirements listed in Table 1 for the copper specified in the ordering information.

8. Temper

8.1 *H (Drawn) Temper*—The temper of drawn tube shall be designated as H58 (drawn, general purpose).

8.2 *O (Annealed) Temper*—The temper of annealed tube shall be designated as 050 (light anneal) and 060 (soft anneal) (see Table 2). Tempers are defined in Practice B 601.

9. Grain Size of Annealed Tempers

9.1 Samples of annealed temper tubes shall be examined at a magnification of 75 diameters. The microstructure shall show complete recrystallization and shall have an average grain size within the limits specified in Table 3, when tested in accordance with Test Method E 112.

10. Physical Property Requirements

10.1 *Electrical Resistivity*—When specified in the contract or purchase-order, tube ordered for electrical conductor application produced from Copper UNS No. C10200, C10300, or C12000 shall have an electrical mass resistivity, $\Omega \cdot \text{g}/\text{m}^2$, not to exceed the limits in Table 4 for the specified copper and temper when tested in accordance with Test Method B 193.

11. Mechanical Property Requirements

11.1 *Tensile and Yield Strength*—The product shall conform to the requirements in Table 2 for the specified temper.

11.2 *Rockwell Hardness:*

11.2.1 For product of the H58 temper and Rockwell hardness values are given for reference purposes only.

11.2.2 For product of the O (annealed) temper, the product

TABLE 1 Chemical Requirements

Element	Composition, %				
	Copper Alloy UNS No.				
	C10200 ^A	C10300	C10800	C12000	C12200
Copper, ^B min	99.95	...	...	99.90	99.9
Copper + phosphorus, min	...	99.95	99.95	...	...
Phosphorus	...	0.001–0.005	0.005–0.012	0.004–0.012	0.015–0.040

^AOxygen in C10200 shall be 10 ppm max.

^BSilver counting as copper.

**TABLE 2 Mechanical Property Requirements of Drawn-Temper and Annealed-Temper Tube**

Temper Designation	Wall Thickness, in. (mm)	Rockwell Hardness		Tensile Strength Min, ksi ^A (Mpa)	Yield Strength ^B Min, ksi ^A (Mpa)	Elongation in 2 in., min %
		Scale	Value			
H58	Less than 0.020	N/A	N/A	36 (250)	30 (205)	N/A
O50	0.020 and over	30T ^C	30 min	36 (250)	30 (205)	N/A
	Less than 0.015	N/A	N/A	30 (205)	9 (62)	40
	0.015 to 0.035 (0.381 to 0.889)	15T ^C	65 max	30 (205)	9 (62)	40
O60	Over .035 (0.889)	F ^C	55 max	30 (205)	9 (62)	40
	Less than 0.015	N/A	N/A	30 (205)	6 (40)	40
	0.015 to 0.035 (0.381 to 0.889)	15T ^C	60 max	30 (205)	6 (40)	40
	Over 0.35 (0.889)	F ^C	50 max	30 (205)	6 (40)	40

^Aksi = 1000 psi.^BYield strength to be determined at 0.5 % extension under load.^CRockwell hardness values apply to tubes having an inside diameter of $\frac{5}{16}$ in. (7.92 mm) or over, and Rockwell hardness test shall be made on the inside surface of the tube. When suitable equipment is not available for determining the specific Rockwell hardness, other Rockwell scales and values may be specified subject to agreement between the purchaser and supplier.**TABLE 3 Grain Size of Annealed Tempers**

Temper	Average Grain Size, mm
O60	0.040 min
O50	0.040 max

TABLE 4 Copper UNS No.

NOTE 1—Refer to Appendix X1 for the International Annealed Copper Standard (IACS) electrical conductivity equivalents.

Temper	C10200	C10300	C12000
O50, O60	0.153 28	0.156 14	0.170 31
H58	0.15737	0.159 40	0.174 18

shall conform to the Rockwell hardness values contained in Table 2.

12. Performance Requirements

12.1 Expansion Requirement:

12.1.1 When specified in the contract or purchase order, specimens of the annealed product shall be capable of being expanded in accordance with Test Method B 153 with an expansion of the outside diameter in the following percentage:

Outside Diameter, in. (mm)	Expansion of Outside Diameter, %
0.750 (19.1) and under	40
Over 0.750 (19.1)	30

12.1.2 The expanded tube shall show no cracking or rupture visible to the unaided eye.

13. Other Requirements

13.1 Nondestructive Examination for Defects:

13.1.1 Upon agreement between the manufacturer and the purchaser, each tube shall be subjected to an eddy-current test.

13.1.2 Tubes shall be tested normally in the drawn temper; however, they may be tested in the annealed temper at the option of the manufacturer.

13.1.3 Testing shall follow the procedures of Practice E 243 except for the determination of “end effect.”

NOTE 1—End effect is that length of the tube, which travels through the coil until the testing unit, has stabilized and is able to detect flaws. The

magnitude of the spike, generated when an end passes through the test coils is such that it disrupts testing momentarily.

13.1.4 Unless otherwise agreed upon between the manufacturer, or supplier, and the purchaser, the manufacturer shall have the option of calibrating the test equipment using either notches or drilled holes. If agreement cannot be reached, drilled holes shall be used.

13.1.4.1 Notch-depth standards rounded to the nearest 0.001 in. (0.025 mm) shall be 22 % of the nominal bottom-wall thickness.

13.1.4.2 Drilled-hole standards shall be 0.025 in. (0.635 mm) diameter for tubes up to and including $\frac{3}{4}$ in. (19.05 mm) specified diameter and 0.31 in. (0.785 mm) diameter for tubes over $\frac{3}{4}$ in. (19.05 mm) specified diameter.

13.1.5 Tubes that do not actuate the signaling device on the eddy-current tester shall be considered in conformance with the requirements of this test.

13.1.6 Tubes, rejected for irrelevant signals because of moisture, soil, and like effects, may be reconditioned and retested.

13.1.7 Tubes that are reconditioned and retested (see 13.1.6) shall be considered in conformance with the requirements of this specification, if they do not cause output signals beyond the acceptable limits.

13.1.8 Eddy-current discontinuities will be identified on coils in excess of 200 ft (61 m) in length for subsequent removal by the purchaser.

13.1.9 At the customer’s discretion, the permissible number of identified eddy current discontinuities may be specified.

13.2 Cuprous Oxide Requirement—Samples of Copper UNS No. C10200, C10300, and C12000 shall be significantly free of cuprous oxide as determined by Procedure A of Test Methods B 577. In case of dispute, a referee method in accordance with Procedure C shall be used.

13.3 Embrittlement—Samples of Copper UNS Nos. C10200, C10300, C10800, C12000, and C12200 shall be capable of passing the embrittlement test of Procedure B of Test Methods B 577. The actual performance of this test is not mandatory under the terms of this specification unless specified in the ordering information. In case of a dispute, a referee



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method in accordance with Procedure C shall be used.

13.4 Cleanliness Requirement:

13.4.1 When refrigeration or air conditioning grade is specified, the tube shall be capable of meeting the following cleanliness requirement described in 13.4.1.1.

13.4.1.1 The inside of the tube, with closed ends, shall be sufficiently clean such that when the interior of the tube is washed with a suitable solvent, such as re-distilled chloroform or redistilled trichloroethylene, the residue remaining upon evaporation of the solvent shall not exceed 0.0035 g/ft² (0.038 g/m²) of interior surface. See 19.3 for the test method.

13.4.1.2 The term “capable of” in the context of this requirement shall mean that the testing and reporting of individual lots need not be performed by the producer of the product, if capability of the manufacturing process to meet this requirement has previously been established; however, should subsequent testing by either the producer or purchaser establish that the product does not meet this requirements, the product shall be subject to either rejection, or recall or both.

14. Expansion Test

14.1 The annealed material shall be capable of being expanded in accordance with Test Method B 153 with an expansion of the outside diameter in the following percentage:

Outside Diameter, in. (mm)	Expansion of Outside Diameter, %
0.750 (19.1) and under	40
Over 0.750 (19.1)	30

14.2 The expanded tube shall show no cracking or rupture visible to the unaided eye. The term “unaided eye” as used herein permits the use of corrective spectacles necessary to obtain normal vision.

15. Nondestructive Testing

15.1 Upon agreement between the manufacturer and the purchaser, tube shall be subjected to an eddy-current test.

15.2 The tube shall be passed through an eddy-current test unit adjusted to provide information on the suitability of the tube for the intended application. Testing shall follow the procedures of Practice E 243 except for the determination of “end effect.”

15.3 Unless otherwise agreed upon between the manufacturer and the purchaser, the manufacturer shall have the option of calibrating the test equipment using either notches or drilled holes. Notch depth standards rounded to the nearest 0.001 in. (0.025 mm) shall be 22 % of the nominal wall thickness. Drilled hole standards shall be 0.025 in. (0.635 mm) diameter for tubes up to and including ¾-in. specified diameter. Alternatively, when a manufacturer uses speed insensitive equipment that can select a maximum unbalance signal, a maximum unbalance signal of 0.3 % may be used.

15.4 Unless otherwise specified, eddy-current discontinuities, as detected, will be identified on coils in excess of 200 ft (6096 cm) in length for subsequent removal by the purchaser.

15.5 At the customer’s discretion, the permissible number of identified eddy-current discontinuities may be specified.

16. Dimensions and Permissible Variations

16.1 For coil lengths, see Table 5 of this specification. If

TABLE 5 Methods of Test

Test	ASTM Designation
Chemical analysis ^A	B 170, E 53, E 62
Tension	E 8
Rockwell hardness	E 18
Grain size	E 2, E 3, E 112
Expansion (pin test)	B 153

^A Reference to Specification B 170 is to the suggested chemical methods in the annex thereof. When Committee E-1 has tested and published methods for assaying the low level impurities in copper, the annex in Specification B 170 will be eliminated.

coils are produced to a specified nominal weight, no coil shall weigh less than 40 % of the nominal weight, and no more than 20 % of the coils in a lot shall weigh less than 70 % of the nominal weight unless otherwise agreed between supplier and purchaser.

17. Workmanship, Finish and Appearance

17.1 The product shall be free of defects of a nature that interfere with normal commercial applications, except as noted in 13.1.8.

17.2 The product shall be well cleaned and free of dirt.

17.3 Product of refrigeration and air conditioning grade shall meet the cleanliness requirement of 13.4.

18. Specimen Preparation

18.1 Chemical Analysis:

18.1.1 Sample preparation shall be in accordance with Practice E 255.

18.1.2 Analytical specimen preparation shall be the responsibility of the reporting laboratory.

18.2 Electrical Resistivity:

18.2.1 The test specimen shall be full size and shall be the full cross section of the material it represents, when possible.

18.2.2 When the test specimen is taken from material in bulk, care must be taken that the properties are not appreciably altered in the preparation.

NOTE 2—Plastic deformation tends to work-harden a material and raise its resistivity, while heating tends to anneal the material with a subsequent reduction in resistivity.

18.3 *Microscopical Examination*—Samples preparation shall be in accordance with Test Method B 577.

18.4 *Embrittlement Test*—Samples preparation shall be in accordance with Test Method B 577.

18.5 *Grain-Size*—The test specimen shall be prepared in accordance with Test Method E 3 and shall approximate a radial longitudinal-section of the tube.

18.6 *Expansion Test Specimen*—Test specimens shall conform to the requirements of the specimen preparation section of Test Method B 153.

18.7 *Cleanliness Test Specimen*—A section of straight tube, or a section of a straightened tube from the outside end of a coil, not less than 5 ft (1.5 m), shall be selected.

19. Test Methods

19.1 In the case of disagreement, the properties enumerated in this specification shall be determined in accordance with the ASTM test methods listed in Table 6.



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TABLE 6 Methods of Test

Test	ASTM Designation
Grain size	E 112
Expansion (pin test)	B 153
Eddy current	E 243
Chemical analysis	
Copper	E 53
Phosphorus	E 62

19.2 Tension Test:

19.2.1 Tension-test specimens shall be of the full-section of the tube and shall conform to the requirements of specimens for tube section, of Test Method E 8, unless the limitations of the testing machine preclude the use of such a specimen. Test specimens conforming to type No. 1, Fig. 9, of Test Methods E 8, may be used when a full-section specimen cannot be tested.

19.2.2 Whenever different tension-test results are obtained from both full-size and machined test specimens, the results obtained from full-size test specimens shall be used to determine conformance to the requirements of this specification.

19.2.3 Tension-test results on products produced under this specification are not seriously affected by variations in speed of testing. A considerable range of testing speed is permissible; however, the rate of stressing to the yield strength should not exceed 100 ksi/min (690 MPa/min.) Above the yield strength, the movement per minute of the testing-machine head under load should not exceed 0.5 in./in. (0.5 mm/mm) of gage length (or distance between grips for full section specimens).

19.3 Cleanliness Test:

19.3.1 A section of a straightened tube from the outside end of a coil, not less than 5 ft (1.5 m), shall be selected. One end of the tube shall be closed, and the tube shall be filled with solvent to $\frac{1}{8}$ of capacity. The opposite end shall be closed and the tube shall be rolled back and forth on horizontal supports to thoroughly wash the inside surface. The closure shall be removed and the solvent shall be poured into a suitable weighed-container. The solvent in the container shall be evaporated to dryness on a low-temperature hot plate or sand bath. Overheating of the container shall be avoided to prevent charring of the residue. The container then shall be dried in an oven at 212 to 230°F (100 to 110°C) for 10 min, cooled in a desiccator, and weighed. A blank determination shall be run with the same volume of solvent and the gain in weight for the blank shall be subtracted from the weight of the residue sample. The corrected weight shall then be calculated in grams of residue per internal area of the tube in square feet.

19.3.2 The quantity of the solvent used will vary with the size of the tube being examined. The quantity of solvent used for the blank run shall be the same as that used for cleaning the tube sample.

19.3.3 The sample must be prepared in such a manner as to prevent the inclusion in the residue of copper chips or dust resulting from the cutting of the sample.

20. Significance of Numerical Limits

20.1 For purpose of determining compliance with the specified limits for requirements of the properties listed in Table 7,

TABLE 7 Rounding Units

Property	Rounded Unit for Observed or Calculated Value
Chemical composition hardness	nearest unit in the last righthand place of figures of the specified limit
Tensile strength	nearest ksi (nearest 5 MPa)
Expansion	nearest 1 %
Grain size:	
Up to 0.055 mm, incl	nearest multiple of 0.005 mm
Over 0.055 to 0.160 mm, incl	nearest 0.01 mm

an observed value or calculated value shall be rounded as indicated in accordance with the rounding method of Practice E 29.

21. Inspection

21.1 The manufacturer shall inspect and make the necessary tests to verify that the product furnished conforms to the requirements of this specification.

21.2 If, in addition, the purchaser elects to perform his own inspection, the manufacturer shall afford the inspector all reasonable facilities, without charge, to satisfy him that the tubes are being furnished in accordance with this specification.

22. Rejection and Rehearing

22.1 Products that fail to conform to the requirements of this specification may be rejected. Rejection shall be reported to the manufacturer or supplier promptly. In addition, written notification of rejection shall follow. In case of dissatisfaction with the results of the test, the manufacturer or supplier may make claim for a rehearing.

23. Certification

23.1 When specified on the purchase order, the manufacturer shall furnish to the purchaser a certificate stating that each lot has been sampled, tested, and inspected in accordance with this specification and has met the requirements.

24. Mill Test Report

24.1 When specified on the purchase order, the manufacturer shall furnish to the purchaser a test report showing results of the tests required by the specification.

25. Packaging and Package Marking

25.1 The material shall be separated by size, composition, and temper, and prepared for shipment in such a manner as to ensure acceptance by common carrier for transportation.

25.2 Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, temper, size, gross and net weight, total length or piece count, or both, and name of supplier. The specification number shall be shown, when specified.

26. Keywords

26.1 coils; copper tubes; seamless



APPENDIX

(Nonmandatory Information)

X1. INTERNATIONAL ANNEALED COPPER STANDARD (ELECTRICAL CONDUCTIVITY EQUIVALENTS)

TABLE X1.1 Electrical Conductivity Equivalents

Electrical Resistivity, $\Omega \cdot \text{gm}/\text{m}^2$	Conductivity, %	Electrical Resistivity, $\Omega \cdot \text{gm}/\text{m}^2$	Conductivity, %
0.151 76	101.00	0.159 40	96.16
0.153 28	100.00	0.170 31	90
0.156 14	98.16	0.174 18	88
0.157 37	97.40	. . .	...

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue of B 743 - 95 that may impact this standard.

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| <p>(1) General rewrite of the specification to conform with the Committee B05 Outline of Form. Included in the rewrite is the further utilization of Specification B 251.</p> <p>(2) The electrical resistivity requirement was added to the Physical Property section.</p> <p>(3) Appendix X1 on Metrics was deleted.</p> | <p>(4) Appendix X1 on Conductivity was added.</p> <p>(5) The Mechanical Properties table was rearranged, and the yield strength of O60 temper was lowered.</p> <p>(6) The Mechanical Properties section was changed to clarify the Rockwell hardness requirement.</p> <p>(7) The Ordering Information section was amended.</p> |
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