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MASTER

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R. M. Fuller
ORNL RDT Standards Coordinator

RDT M 3-2T

Supersedes
RDT M 3-2T, December 1974

RDT Standard

STAINLESS AND ALLOY STEEL
SEAMLESS TUBES (ASME SA-213
WITH ADDITIONAL REQUIREMENTS)

APRIL 1976

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FOREWORD

This standard supersedes the December 1974 issue of RDT M 3-2T and incorporates those changes to that issue of the standard that were approved in April 1976 for publication in this revision. These changes are identified by the following marginal notations:

C	Change
D	Deletion
N	Addition

Systeme International (SI) metric equivalents have been added following standard American units.

Editorial changes that were made during preparation of this revision are not identified.

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STAINLESS AND ALLOY STEEL SEAMLESS TUBES (ASME SA-213 WITH ADDITIONAL REQUIREMENTS)

1. SCOPE

This standard covers stainless and alloy steel tubes for nuclear and associated applications.

2. GENERAL REQUIREMENTS

Material shall conform to the requirements of ASME SA-213; to the requirements of the ASME Boiler and Pressure Vessel Code (ASME Code), Section III, Article NB-2000; and to the additional requirements of this standard.

Note: The provisions of NB-2510 for the exemption of certain materials from requirements for nondestructive examination because of size or application do not apply.

| N

3. BASIS OF PURCHASE

In addition to the requirements of Section 3 of ASME SA-213, the purchaser will specify the following as applicable:

1. Cold drawn tubing.
2. For ferritic materials, the fracture toughness requirements (see NB-2300 and 4.5).
3. Heat treatment temperature, time, and heating and cooling rates for test specimen materials for ferritic materials which will be heat treated during fabrication or installation (see NB-2211).
4. Application Supplements and Optional Provisions invoked (see Sections 5 and 6). The purchaser will invoke Application Supplements when the end use is as described in Section 5.

4. ADDITIONAL REQUIREMENTS

The following requirements are mandatory.

4.1 Heat Treatment. All grades of austenitic tubing shall be water quenched from the solution heat treatment temperatures or rapidly cooled by other means. Rapid cooling by other means is acceptable only when the cooling rate attained is sufficient to prevent reprecipitation of chromium carbides as demonstrated by freedom from intergranular attack when tested in accordance with ASTM A 262, Practice E. Specimens

for the intergranular corrosion test shall be taken from the same locations as specified for mechanical test specimens. The number of intergranular corrosion tests shall not be less than the number of tensile tests required.

4.2 Check Analysis. An analysis shall be made on samples taken from one tube from each heat in accordance with Section 8 of ASME SA-213. Analysis results shall meet the chemical composition requirements of Section 8 of ASME SA-213. | C

4.3 Repair by Welding. Repair by welding is not permitted. | D

4.4 Ultrasonic Examination. All tubes, regardless of size or intended application, shall be examined ultrasonically. Examination shall be performed in accordance with NB-2551 and the following additional requirements. | C

a. The depth of the calibration standard notches shall not exceed the larger of 0.004 in. (0.1 mm) or 3 percent of the nominal wall thickness.

b. The pitch of the feed helix for circumferential scanning shall be such that a clearly discernible response is obtained from the calibrated standard reference notches on at least three successive revolutions. | D

4.5 Fracture Toughness Tests. Materials which are 1/2 in. (13 mm) or greater in nominal section thickness and are excluded from the impact testing requirements of NB-2300 because of size shall be impact tested in accordance with NB-2332(a) and the following.

a. The requirements of NB-2321.2, NB-2322, NB-2340, NB-2350, and NB-2360 shall apply.

b. For thicknesses 5/8 in. (16 mm) or less each specimen shall exhibit at least 20 mils (0.5 mm) lateral expansion.

c. The lowest service temperature shall be as specified by the purchaser.

4.6 Retests. All required mechanical property and corrosion tests shall be repeated after any additional heat treatment at temperatures above 800°F (425°C). In the event tubes are re-heat treated, the certifications submitted as required in 4.10 shall include initial test data, re-heat treat data if other than treatment normally used by the manufacturer for the particular grade of material, and the final test data indicating acceptability.

4.7 Halide Contamination. Care shall be taken during all operations to minimize contact of austenitic materials with halide or halide bearing compounds, including die lubricants, masking tape, and marking

compounds. All processing compounds, degreasing agents, cleaning solutions, and foreign material shall be completely removed at any stage of processing prior to any elevated temperature treatment, and in any event immediately prior to packaging for shipment. Any pickling or descaling operation in a bath containing chlorides shall be followed immediately by a nitric acid pickle and rinsing with hot potable water which meets the requirements of Public Health Publication No. 956. Drinking water furnished by cities, counties, states, or other political subdivisions shall be assumed to meet these requirements.

4.8 Marking.

4.8.1 Unless otherwise specified, each tube shall be marked in constantly recurring symbols at intervals not greater than 3 ft (900 mm) throughout its length.

4.8.2 RDT M 3-2 shall be included in the identification required by ASME SA-213 and NB-2150.

Note: Any Application Supplement or Optional Provision invoked shall be added in parentheses. Example:
RDT M 3-2(A)(1).

4.8.3 Marking materials containing chlorine or other halides, and low melting point elements, such as sulfur, lead, zinc, copper, and mercury in other than trace amounts, shall not be used for identification of austenitic stainless steels.

4.9. Hydrostatic Test. Each tube subsequent to final drawing and heat treating shall be subjected to the internal hydrostatic test.

4.10 Certification. A Certified Materials Test Report shall be furnished. In addition to the requirements of NB-2130, the report shall include certification to the requirements of RDT M 3-2.

4.11 Quality Assurance. Material manufacturers and suppliers shall have a Quality System Program or Identification and Verification Program, as applicable, which meets the requirements of NA-3700. Alternatively, for materials which NB-2610(b) exempts from these requirements a quality verification program which meets the requirements of RDT F 2-4 is acceptable.

N

5. APPLICATION SUPPLEMENTS

The following requirements shall apply only when specified by the purchaser.

A. Tubes intended for use in Class 1 vessel nozzles shall be examined on all external and all accessible internal surfaces by the liquid penetrant method in accordance with NB-2556. For materials less

than 3/16 in. (5 mm) thick, acceptance standards shall be as specified under Optional Provision 3.

B. Austenitic materials intended for use at temperatures over 800°F (425°C) in ASME Code applications shall have a minimum carbon content of 0.04 percent or greater, as specified by the purchaser.

C. Tubes intended for heat exchangers or similar applications shall be examined by the liquid penetrant method in accordance with Article 6, ASME Code Section V. No indications shall be permitted.

D. Grade T22 materials intended for use at temperatures over 700°F (380°C) in ASME Code applications shall have a minimum carbon content of 0.07 percent, or greater when specified by the purchaser.

E. Ferritic materials which will be used in ASME Code, Section III, reactor vessel applications where neutron fluence will be greater than 10^{18} nvt (E_n or 1 Mev or above) shall satisfy the following provisions.

(1) Charpy V-Notch (C_v) Impact Transition Curve. Optional Provision 8 shall be mandatory.

(2) Steel Manufacturing Process. Steel shall be made by the basic electric furnace process. Molten steel shall be vacuum treated prior to or during the pouring of the ingot to remove objectionable gases, particularly hydrogen.

(3) Phosphorus, Sulfur, and Copper Limitations. For ladle analysis, the phosphorus content shall be 0.012 percent maximum, the sulfur content shall be 0.015 percent maximum, and the copper content shall be 0.10 percent maximum. For check analysis, phosphorus and sulfur content shall not exceed 0.015 and 0.018 percent, respectively, and the copper content shall not exceed 0.10 percent.

(4) Grain Size. The McQuaid Ehn grain size of the material as determined in accordance with ASTM E 112 shall be Number 5 or finer.

6. OPTIONAL PROVISIONS

The following provisions shall apply only when specified and to the extent specified by the purchaser.

1. Cobalt Content Limitations. The cobalt content as determined by check analysis performed on each heat of material shall be 0.10 percent maximum.

2. Extra Low Carbon Grades (Austenitic Steel).

(a) Carbon Content. The carbon content as determined by ladle and check analyses for the applicable type or grade of austenitic stainless steel covered by the referencing standard shall be 0.030 percent

maximum. In all other respects, the requirements of the referencing standard shall apply for the type or grade whose carbon content is to be limited.

(b) Boiling Nitric Acid Test. The following shall apply where the boiling nitric acid test of Practice C, ASTM A 262, is specified. Duplicate specimens shall be taken from the material on the same frequency basis required for check analysis in the referencing standard, unless another frequency is specified by the purchaser. Specimens shall be prepared as required, sensitized by heating to 1250°F (675°C) with one hour hold at temperature, and water quenched. The average corrosion rate for each specimen shall not exceed 0.0020 in. (0.050 mm) per month for the full five periods. Corrosion rates shall be reported for each period together with the average rate for five periods for both specimens.

3. Liquid Penetrant Examination. Liquid penetrant examination shall be performed on all external tube surfaces in accordance with NB-2546 except that for tube wall thicknesses of less than 3/16 in. (5 mm), indications of all sizes shall be considered relevant and the following indications are unacceptable:

- a. Any cracks.
- b. Linear indications.
- c. Rounded indications with dimensions exceeding 1/32 in. (0.8 mm). Rounded indications separated by 1/16 in. (1.5 mm) or less edge to edge shall be evaluated as a single indication.
- d. Rounded indications separated by less than the larger of 4T or 1/2 in. (13 mm).
- e. Ten or more indications in any 6 in.² (38 cm²) of surface with the major dimension of this area not to exceed 6 in. (150 mm) with the area taken in the most unfavorable locations relative to the indications being evaluated.

4. Eddy Current Examination. Eddy current examination shall be in accordance with NB-2554 with the additional requirement that the depth of the calibration standard notches shall not be greater than the larger of 0.004 in. (0.1 mm) or 3 percent of the nominal wall thickness.

5. Intergranular Corrosion Test for Solution Heat-Treated and Water-Quenched Materials (Chromium-Nickel Steels). An intergranular corrosion test shall be performed in accordance with ASTM A 262, Practice E. Material up to 2 in. (50 mm) thick shall be capable of passing the test in the as-quenched condition. For materials greater than 2 in. (50 mm) thick, the applicability of the test shall be a matter of negotiation between the materials manufacturer and purchaser.

6. Liquid Penetrant Examination (Internal Surfaces). Liquid penetrant examination shall be performed on specimens from tube lots as provided in (a). Liquid penetrant examination of the internal surfaces of specimens shall be in accordance with Article 6, Section V. All indications shall be explored for depth by grinding, filing, or machining and reexamined to confirm removal of the source of indications. If shot, grit, or vapor blasting has been approved by the purchaser and employed internally in tube processing, the surfaces to be penetrant examined shall be prepared by machining, grinding, or pickling.

(a) Procedure for Internal Surface Examination. Five percent of the tubes in each lot shall be selected at random. A piece not less than 12 in. (300 mm) long shall be cut from one end only of each selected tube, sectioned longitudinally and liquid penetrant examined as described above. If all 12-in. (300 mm) sections are acceptable (see (b) for acceptance criteria), the remainder of the tube represented by the worst 12-in. (300 mm) sample in each lot shall be sectioned longitudinally and examined in the same way as the 12-in. (300 mm) sample. For a lot of 20 tubes or less, one tube shall be sectioned longitudinally and examined.

(b) Acceptance Criteria. When the removal of any indication reduces the wall thickness locally by 0.004 in. (0.1 mm) or more, the entire lot of tubes represented by any of the sectioned 12-in. (300 mm) lengths or by the sectioned full-length tube shall be rejected.

7. Ultrasonic Examination. Ultrasonic examination shall be in accordance with NB-2552 and the following additional requirements.

(a) Scanning shall be in both circumferential and both axial directions.

(b) The depth of the calibration notches shall not exceed the larger of 0.002 in. (0.05 mm) or 3 percent of the nominal wall thickness.

(c) The length of the calibration notches shall not exceed 1/4 in. (6 mm).

(d) The width of the calibration notch shall be the minimum practical but not wider than the greater of 0.008 in. (0.2 mm) or twice the depth.

8. Charpy V-Notch Transition Curve (Ferritic Steels).

(a) Sufficient C_V specimens shall be taken from the material to establish a temperature-impact energy transition curve. Test specimen location and orientation shall be as specified in NB-2322.

(b) The test temperature range shall be sufficiently wide to establish the upper and lower shelf ft-lb energies, with sufficient

testing at intermediate temperatures to permit plotting a reasonably smooth curve.

(c) The test temperature, lateral expansion, absorbed energy, percent shear fracture, and location and orientation of specimens shall be reported.

7. REFERENCED DOCUMENTS

RDT F 2-4T	Quality Verification Program Requirements	N
ASME SA-213 and ASTM A 213-71	Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater; and Heat-Exchanger Tubes	
ASME Boiler and Pressure Vessel Code, Section III, Nuclear Power Plant Components		
ASME Boiler and Pressure Vessel Code, Section V, Nondestructive Examination		
ASTM A 262	Recommended Practices for Detecting Susceptibility to Intergranular Attack in Stainless Steels	
ASTM E 112	Estimating Average Grain Size of Metals	
Public Health Service Publication No. 956, Drinking Water Standard		