RDT E 6-20T

Supersedes
RDT E 6-20T, December 1971

RDT Standard

AUSTENITIC STAINLESS STEEL HEXAGONAL DUCT TUBES FOR CORE COMPONENTS AND ASSEMBLIES

MAY 1976

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Oak Ridge, Tennessee 37830

Printed in the United States of America
USERDA Technical Information Center, Oak Ridge, Tennessee

FOREWORD

This standard supersedes the December 1971 issue of RDT E 6-20T and incorporates those changes to that issue of the standard that were approved and published as Amendment 1 and those changes that were approved for publication in this revision. The changes are identified by the following marginal notations:

A1	Amendment 1, March 1973
C	Change approved May 1976
D	Deletion approved May 1976
N	Addition approved May 1976

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

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AUSTENITIC STAINLESS STEEL HEXAGONAL DUCT TUBES FOR CORE COMPONENTS AND ASSEMBLIES

1. SCOPE

This standard establishes the requirements for austenitic stainless steel seamless hexagonal duct tubes for fuel, control rod, and other core component assemblies.

1.1 Application. This standard applies to annealed or cold worked seamless duct tubes of 3 to 6 inch (76 to 152 mm) outside dimension and having up to 0.250 inch (6.35 mm) wall thickness.

1.2 Definitions.

1.2.1 Billet. An ingot or section of an ingot that has been hot worked by forging, rolling, or extrusion. | A1

1.2.2 Control Rod Duct. A tubular structure which positions and supports an array of absorber pins in the reactor core and consists of a duct tube and end fittings all joined to form an integral assembly.

1.2.3 Duct Tube. The hexagonal tube portion of the fuel duct or control rod duct with load pads, exclusive of hard surfacing, which encloses the fuel pin or absorber pin array and provides the channel for the primary coolant.

1.2.4 Duct Tube Blank. A seamless tube of circular cross section from which the duct tubes are formed.

1.2.5 Fuel Duct. A tubular structure which positions and supports an array of driver fuel pins in the reactor core and consists of a duct tube and end fittings all joined to form an integral assembly.

1.2.5 Heat. A single, homogeneous melt.

1.2.7 Ingot. A casting intended for subsequent working such as forging, rolling, extrusion, or drawing.

1.2.8 Lot. The product of one heat of material annealed under identical annealing parameters. | C

1.2.9 Repair. Utilization of operations that are not a part of the normal fabrication procedure to restore an item to an acceptable condition. | D

1.2.10 Rework. Utilization of operations that are part of the normal fabrication procedure to restore an item to an acceptable condition.

1.2.11 Temper Point. That point in the tube fabrication to process immediately following a final anneal and preceding a final cold working operation. Dimensions are established at this point that will assure the desired cold work in the final pass.

| D

2. APPLICABLE DOCUMENTS

The following documents are a part of this standard to the extent specified in Sections 3 through 5. The issue of a document in effect on the date of the invitation to bid, including any amendments or other published changes also in effect on that date, shall apply unless otherwise specified. Where this standard appears to conflict with the requirements of a reference document, such conflict shall be brought to the attention of the purchaser for resolution.

2.1 RDT Standards.

RDT F 2-2 Quality Assurance Program Requirements

RDT F 3-6T Nondestructive Examination

RDT F 3-15T Requirements for Inspection of Dimensional Characteristics

| N

RDT F 5-1T Cleaning and Cleanliness Requirements for Nuclear Components

RDT F 7-2T Packaging, Packing, and Marking of Components for Shipment and Storage

RDT F 11-3T Analytical Chemistry Methods for Metallic Core Components

| N

2.2 Military Specifications.

MIL-H-6875 Heat Treatment of Steels

2.3 American National Standards (ANSI).

ANSI B46.1 Surface Texture

2.4 American Society of Mechanical Engineers (ASME) Publications.

Boiler and Pressure Vessel Code

Section III Nuclear Power Plant Components

2.5 American Society for Testing and Materials (ASTM) Publications.

ASTM A 262 Susceptibility to Intergranular Attack in Stainless Steels

| A1

ASTM A 370 Mechanical Testing of Steel Products

ASTM A 450	Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes
ASTM E 3	Metallographic Specimens
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 21	Elevated Temperature Tension Tests of Metallic Materials
ASTM E 29	Indicating Which Places of Figures Are to Be Considered Significant in Specified Limiting Values
ASTM E 45	Inclusion Content of Steel
ASTM E 92	Vickers Hardness of Metallic Materials
ASTM E 112	Average Grain Size of Metals
ASTM E 113	Ultrasonic Testing by the Resonance Method

D

2.6 Drawings. Drawings shall be as specified in the Ordering Data.

2.7 Other Documents. Other documents shall be as specified in the Ordering Data.

3. TECHNICAL REQUIREMENTS

3.1 Material Requirements.

3.1.1 Chemical Composition. Finished ducts tubes of Type 316 stainless steel shall conform to the chemical composition requirements of Table 1. Finished duct tubes of other material types (304, 321, 348) shall be as specified in the Ordering Data. Ingots shall be analyzed and the analysis results shall be reported for information prior to use for fabrication.

3.1.2 Grain Size. The average grain size of duct material from any lot following final anneal and prior to cold working shall be 4 to 7 as determined by ASTM E 112, reference Plate II and shall exhibit no evidence of duplex structure.

C

3.1.3 Corrosion Resistance. Finished duct tubes shall not show susceptibility to intergranular attack when tested in accordance with ASTM A 262, Practice E. Evidence of cracking or intergranular attack shall be cause for rejection.

A1

3.2 Mechanical Properties.

3.2.1 Tensile Properties. Longitudinal properties of duct tubes in the 20 percent cold worked condition shall meet the requirements of Table 2. Longitudinal properties of duct tubes in the

Table 1. Alloy Composition Limits for Type 316 Stainless Steel

Element	Percentage
Chromium	17.0 to 18.0
Nickel	13.0 to 14.0
Carbon	0.040 to 0.060
Molybdenum	2.00 to 3.00
Manganese	1.50 to 2.00
Nitrogen	0.010 max.
Aluminum	0.050 max.
Arsenic	0.030 max.
Boron	0.0010 max.
Cobalt	0.050 max.
Columbium	0.050 max.
Copper	0.10 max.
Phosphorus	0.020 max.
Silicon	0.75 max.
Sulfur	0.010 max.
Tantalum	0.020 max.
Vanadium	0.20 max.
Iron	Balance

Table 2. Tensile Property Requirements For Type 316 Stainless Steel

Material Condition	Temperature °F (°C)	Tensile Strength ksi (MPa)	Yield Strength 0.2% Offset ksi (MPa)	Min. Elongation in 2 in. (51 mm) (%)
20% Cold Worked	Room	100 to 130 (689 to 896)	85 to 115 (586 to 793)	15
20% Cold Worked	1000 (538)	75 to 100 (517 to 689)	60 to 90 (414 to 620)	7

temper point condition shall be reported for information only. The tensile properties of finished tubes of other material types, other levels of cold work, or both, shall be as specified in the Ordering Data.

3.2.2 Hardness. The Vickers hardness values on samples of finished duct tubes taken across the wall thickness of a flat and a corner shall not exceed the values specified in the Ordering Data.

3.3 Nondestructive Examination Requirements.

3.3.1 Penetrant Examination, Finished Ducts. Interior and exterior surfaces of finished duct tubes shall be free of defects as shown by fluorescent penetrant examination specified in 4.5. (See Table 4, Item 6.)

3.3.2 Ultrasonic Examination. Finished duct tube blanks shall be ultrasonically examined as specified in 4.5. (See Table 4, Item 7.)

3.4 Metallographic Requirements.

3.4.1 Inclusions. The inclusion content of billets shall not exceed the limits set forth in Table 3 when determined as described in ASTM E 45, Microscope Method D. A maximum of 10 percent of the fields may show inclusions at the next higher density to that specified and a maximum of 1 percent of the fields may show inclusions at the second higher density. | A1

Table 3. Inclusion Content Limits

Inclusion Type (ASTM E 45)							
Sulfide Type (A)		Alumina Type (B)		Silicate Type (C)		Globular Oxides(D)	
Thin	Thick	Thin	Thick	Thin	Thick	Thin	Thick
1	1	1	1	1	1	1	1

3.4.2 Intergranular Attack. Finished duct tubes shall be metallographically examined to verify freedom from intergranular attack.

3.4.3 Carbide Precipitation. Finished duct tubes shall be metallographically examined as specified in 4.5. [See Table 4, Item 8(c)] to verify freedom from visible carbide precipitation at grain boundaries after heat treatment as specified in 3.7.1 (d). | C

3.5 Surface Requirements.

3.5.1 Surface Condition. The finished duct tubes shall be free of visible oxide, scale, splits, laps, cracks, seams, inclusions, and other defects.

3.5.2 Surface Roughness. All surfaces of finished duct tubes shall meet or exceed the requirements in the Ordering Data.

3.5.3 Surface Marring. Finished duct tubes shall be free of scratches, dents, or mars except of the dimensions and types listed

below. Surface imperfections such as handling marks, light mandrel, and die or roll marks will not be considered as injurious defects provided they are less than 0.002 inch (0.05 mm) in depth, and do not reduce the wall thickness to less than the minimum specified in the Ordering Data. Corner defects on the outside diameter and the inside diameter shall be limited to 1/2 inch (13 mm) in length and less than 0.002 inch (0.05 mm) in depth. Removal of such defects by grinding, buffing or polishing is considered a repair subject to requirements of 3.8, but is permitted provided all other dimensions and surface finish requirements are maintained. Polishing of duct tubes and duct tube blanks solely to improve surface finish is not construed as a repair or rework operation. The bottom of these defects shall be visible, rounded, and well faired in as confirmed by visual inspection as specified in 4.5 (see Table 4, Item 9) and by penetrant examination as specified in 4.5. (See Table 4, Item 6.)

3.5.4 Residual Chloride and Fluoride. The amount of residual chloride and fluoride on duct tubes after final inspection shall each be less than 0.5 $\mu\text{g}/\text{in.}^2$ (0.8 mg/m^2) of duct tube surface.

3.5.5 Cleanliness. All cleaning procedures and techniques shall be in accordance with RDT F 5-1. Finished duct tubes shall be free of residual iron, other metallic particles, oil, grease, lubricants, residual cleaning compounds, dirt, chips, and all other extraneous material, and shall be cleaned in nitric acid after final inspection tests and just prior to packaging by the process specified below.

a. Precleaning. Components shall be precleaned with a approved soak cleaner and shall be thoroughly rinsed with water before immersion in the nitric acid solution.

b. Final Cleaning. Components shall be treated with nitric acid prepared as follows:

1. Grade	Reagent grade
2. Concentration	10 to 14 percent
3. Temperature	Room
4. Time	10 min., or until free surface iron has been removed

c. Rinsing. Components shall be thoroughly rinsed in water, not exceeding 185°F (85°C), meeting the requirements for Grade B as specified in RDT F 5-1.

d. Drying. Components shall be dried in air at a temperature not exceeding 185°F (85°C).

e. Contact Preservatives. Contact preservatives shall not be used.

3.6 Duct Tube Dimensions. Duct tubes shall meet the dimensional requirements specified in the Ordering Data.

3.7 Processes.

3.7.1 Manufacture.

a. Melting. The steel shall be made by double vacuum melting process, using virgin materials only with no scrap additions. Material melted to this standard and recovered from the double vacuum melting process shall be acceptable for remelting. The process shall consist of a vacuum induction melt followed by a consumable electrode vacuum arc remelt. Any proposed alternative to this melting process shall require written approval. Additions of rare earth during melting are prohibited.

b. Tube Making. Duct tubes shall be made by an approved seamless process.

c. Special Handling. Handling methods shall prevent duct tube-to-tube contact during processing, cleaning, and storage and shall be consistent with the preservation of a mar-free surface finish. Special handling procedures shall be provided to maintain the identity of duct tubes at all times. The proposed handling methods shall be submitted for approval prior to use.

d. Heat Treating. Prior to any final cold working operation, the duct tubes shall be bright hydrogen-annealed. Duct tubes required in the annealed condition shall be bright hydrogen-annealed. The dew point of the gas at the hydrogen inlet shall be less than -80°F (-62°C), and the dew point of the hydrogen at exit shall not exceed -40°F (-40°C). The temperature and time shall be selected to ensure carbide solution and proper grain size as described in 3.1.2. Cooling shall be at a rate rapid enough to avoid visible carbide precipitation as described in 3.4.3. Alternate annealing processes that do not result in intergranular attack may be used with prior approval. Cold worked tubes shall be cold worked to finished size and delivered without further heat treatment.

e. Cleanliness During Manufacture. Duct tubes shall be cleaned prior to each annealing operation and after each cutting operation prior to further reduction. Only fresh lubricants shall be used and they shall be readily removable by commercial cleaning agents. All lubricants shall be removed prior to any heat treatment.

f. Cold Work. Duct tubes shall be cold worked as specified in the Ordering Data subsequent to the final bright anneal. Percent cold work shall be based upon reduction in the cross-sectional area. Percent cold work determined by reduction in transverse area shall be calculated using Equation 1.

$$Cw = \frac{A_1 - A_2}{A_1} \times 100 \quad (1)$$

where

Cw = percent cold work

A₁ = tubing cross-sectional area prior to final cold work

A₂ = tubing cross-sectional area after final cold work.

The cold working procedure and method for measuring percent cold work shall be submitted for approval prior to use. The duct tubes shall have uniform cold work as produced by cold working hexagonal shaped stock to final hexagonal dimensions.

3.7.2 Lotting. Duct tubes shall be lotted on the basis of items of the same nominal dimensions produced from the same heat, processed consecutively, and annealed under identical parameters. Any sub-lotting shall be as specified in the Ordering Data.

3.7.3 Identification. Duct tubes shall be marked and processed in a manner that will ensure individual duct tube identity. Individual duct tubes shall be identified with a lot code, and each duct tube shall be assigned a sequential number as specified in the Ordering Data. The numbering system shall be designed to identify the supplier, lot, and tube number. Duct tubes shall be marked using an electrolytic etch. The electrolytic etch technique shall be submitted for approval.

3.8 Repair and Rework. Repaired and reworked duct tubes shall meet the requirements of this standard. Repair and rework shall be permitted only after prior approval.

3.9 Archive Samples. Archive samples shall be supplied as specified in the Ordering Data.

4 QUALITY ASSURANCE REQUIREMENTS

4.1 Quality Assurance Program Requirements. The supplier shall plan, establish, implement, and maintain a documented quality assurance program that fulfills all requirements of Sections 1, 2, 4, 5, and 8 of RDT F 2-2 and any additional quality assurance requirements of the Ordering Data.

4.2 Quality Assurance Documentation. The supplier is responsible for the preparation of all quality assurance documentation required by the applicable sections of RDT F 2-2. The purchaser will specify the documents required and submittal times in the Ordering Data. The granting of process or procedural approvals by the purchaser shall not be construed to relieve the supplier in any way or to any extent from the full responsibility for delivering items conforming with all requirements of this standard and the Ordering Data.

4.3 Records. Records shall be maintained for each duct tube lot which are traceable to feed materials and heat numbers and showing

complete fabrication and sequence of operations from melt through drawing, annealing, and cold work. Records shall include the number and type of forming operations, the sequence of such operations indicating the duct tube size at each stage, the sequence of annealing operations detailing the time, temperature, atmosphere of the annealing cycle, and grain size of annealed material. This information shall be supplied with the test reports on all delivered duct tubes.

4.4 Responsibility. Unless otherwise specified, the supplier shall be responsible for the performance of all tests and inspections required prior to submission of any item for acceptance. The performance of such tests and inspections does not limit the right of the purchaser to conduct such other tests and inspections as deemed necessary to assure that all items are in conformance with all requirements of this standard and the Ordering Data. Except as otherwise specified, the supplier may use either his own or any commercial laboratory acceptable to the purchaser. Records of all tests and examinations shall be kept complete and available to the purchaser.

4.5 Inspection Requirements. Inspection requirements are listed in Table 4. Where "lot qualification" is listed as the inspection plan or type, the lot shall be accepted only when all of the required number of samples meet the referenced requirements. Reference test methods are the preferred methods. Actual methods used shall be equal to or better than the methods referenced and shall be approved by the purchaser. Where 100 percent inspection for dimensional characterization is required, an acceptance criteria shall be established based upon the exhibited measurement error, which shall result in not more than 5 percent chance of accepting items deviating from the specified tolerance range by more than 10 percent.

All metallurgical samples prepared for tests specified in Table 4, Items 2, 3, 4, 5, and 8 shall be submitted with the duct tubes. Each tested sample shall be identified with a number identical to the duct tube from which it was taken.

Where the method of gaging is not given in Table 4, Item 10, the proposed method of gaging shall be submitted for approval.

4.6 Purchaser's Inspection. The purchaser's representatives shall be provided, free of cost, all reasonable access to facilities to satisfy themselves that the material meets the requirements of this standard and the Ordering Data. Duct tubes which are released by the purchaser's inspector at the place of manufacture, but are subsequently shown through tests or analysis not to conform with this standard and the Ordering Data, are subject to rejection.

4.7 Measuring and Test Equipment.

4.7.1 Environmental Controls. Measuring and test equipment and measurement standards shall be calibrated and utilized in an environment

Table 4. Quality Conformance Inspection

Item	Requirement	Inspection Plan	Reference Test Method	
1. Chemical composition				
a. Ingots	3.1.1	Each ingot.	Chemical analysis of top and bottom of each ingot in accordance with RDT F 11-3.	C
b. Finished duct tubes	3.1.1	Lot qualification based upon tests of 3 randomly selected samples per lot.	Chemical analysis in accordance with RDT F 11-3.	C
2. Grain size	3.1.2	Lot qualification based upon tests of 3 randomly selected samples per lot.	The grain size shall be determined in accordance with ASTM E 112 using reference Plate II for comparison. Grain size determination shall be made on the wall of a cylindrical tube and on a flat and a corner of a noncylindrical tube. In case of disagreement, the planimetric procedure shall be used to establish the grain size.	
3. Corrosion resistance	3.1.3	Lot qualification based upon tests of 3 randomly selected samples per lot.	Corrosion resistance shall be determined in accordance with ASTM A 262, Practice E. Flattening shall be in accordance with ASTM A 450, para. 4.	A1

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item	Requirement	Inspection Plan	Reference Test Method
4. Mechanical properties			
a. Room temp. tensile test	3.2.1	Lot qualification based upon tests of 3 randomly selected samples per lot. (Variables data to be reported).	Room temperature tensile properties shall be determined using methods described in ASTM A 370. Gage length shall be consistent with ASTM E 8. The strain rate shall be 0.05 in./(in.)(min) [0.05 mm/(mm)(min)] until the yield point is reached. In determining the tensile strength, the rate of separation of the heads under load shall not exceed 1/2 in./(in.)(min) [1/2 mm/(mm)(min)] of gage length.
b. 1000°F (528°C) tensile test	3.2.1	Lot qualification based upon tests of 3 randomly selected samples per lot. (Variables data to be reported).	Elevated temperature tensile testing shall comply with ASTM E 21. Gage length shall be consistent with ASTM E 8. The strain rate shall be 0.05 in./(in.)(min.) [0.05 mm/(mm)(min)] until the yield point is reached. In determining the tensile strength, the rate of separation of the heads under load shall not exceed 1/2 in./(in.)(min) [1/2 mm/(mm)(min)] of gage length.

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item	Require- ment	Inspection Plan	Reference Test Method	
5. Hardness	3.2.2	Lot qualification based upon tests of 3 randomly selected samples per lot. (Variables data to be reported).	Microhardness shall be measured on mounted and polished duct tube samples of full wall thickness using a 500 g load by procedures described in ASTM E 92. At least six indentations equally spaced across the flat and corner of a noncylindrical shape shall be reported.	
6. Penetrant examination finished duct tubes	3.3.1	Each duct tube	Inner and outer surfaces of tubes shall be subjected to fluorescent post-emulsifiable penetrant inspection in accordance with IX-3600 of the ASME Code, Section III. Acceptance criteria shall be in accordance with NB-2546 of the ASME Code, Section III. The penetrant materials, including cleaners, shall not exceed 0.5 percent by weight of total chloride and fluorine or sulfur. The penetrant used shall be as specified in the Ordering Data.	A1 C
7. Ultrasonic Examination	3.3.2	Each duct tube blank	After the final draw, each duct tube blank shall be inspected for internal and surface defects using	A1

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item	Requirement	Inspection Plan	Reference Test Method
			<p>pulse-echo ultrasonic techniques in accordance with RDT F 3-6. The ultrasound shall be transmitted in both circumferential directions with pulse-echo type instruments and accessory equipment capable of distinguishing the reference notches of the artificial standard described below. Acceptance criteria for the duct tube blank shall reflect the observed inherent measurement error and shall provide (with 95 percent confidence), for the rejection of a natural defect having a depth equal to 4 percent of the wall thickness. A helical scan of the duct tube blank surface shall be employed, and the speed of rotation and translation shall be maintained constant to within ± 10 percent. The pitch of the feed helix shall be small enough to permit the signal from each reference notch to appear on at least four successive revolutions of the tube. Notch standards for equipment calibration shall have the following dimensions:</p>

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item	Require- ment	Inspection Plan	Reference Test Method		
			<u>Depth</u>	<u>Length</u>	<u>Width</u>
			4 percent of wall thickness of 0.002 in. (0.05 mm), whichever is greater, ± 7 percent of notch depth [but not less than 0.0002 in. 0.005 mm].	0.250 ± 0.010 in. (6.35 ± 0.25 mm).	Not greater than twice the depth
8. Metallographic requirements					
a. Inclusion content	3.4.1	Lot qualification based upon tests of 3 randomly selected samples per lot.	The inclusion content of the billets shall be determined as described in ASTM E 45, Microscope Method D. The fields of the samples shall be rated by comparison with Plate III.		
b. Intergranular attack	3.4.2	Lot qualification based upon tests of 3 randomly selected samples per lot.	Transverse sections of duct component tubing shall be mounted, polished, and observed at 100X. Specimen preparation shall be as described in ASTM E 3.		

A1

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item		Require- ment	Inspection Plan	Reference Test Method	
c. Carbide precipitation		3.4.3	Lot qualification based upon tests of 3 randomly selected samples per lot.	Transverse sections of tubing shall be mounted, polished, etched, and examined at 500X. Specimen preparation shall be as described in ASTM E 3. The same specimen used in examination for intergranular attack in (b) above may be used.	
9. Surface requirements					
a.	Surface condition	3.5.1	Each duct tube	Visual examination of all surfaces.	A1
b.	Surface roughness	3.5.2	Each duct tube	The duct tubes shall be examined visually on all surfaces and compared with the applicable standards specified in ANSI B46.1. Surface roughness measuring instruments may be used as a manufacturer's option as an alternate method and shall be used in case of disagreement.	A1
c.	Surface marring	3.5.3	Each duct tube	The duct tubes shall be examined visually. Areas in question on OD and ID with scratches or dents shall be examined at 10X magnification. Instruments for measuring flaw depths shall be used in case of disagreement.	A1

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item	Requirement	Inspection Plan	Reference Test Method	
d. Residual chloride & fluoride	3.5.4	Lot qualification based upon test on one randomly selected duct tube per lot.	In accordance with RDT F 11-3.	C
e. Cleanliness				
1. Visual	3.5.5	Each duct tube	Visual examination	A1
2. Wiping test	3.5.5	Each duct tube	Visual evaluation of white, clean, lint-free cotton cloths rubbed over the inner and outer surfaces of the duct tubing. The cotton cloths shall be dampened with distilled water and shall be rubbed on the surfaces with maximum finger pressure. Uniform gray discoloration of the cloths is acceptable, but presence on any cloth of any lubricants, metallic flakes, carbon, or other particles distinguished at 10X magnification, shall be cause for rejection. Rejected lots may be recleaned and resubmitted for inspection.	A1
3. Nitric acid treatment	3.5.5	Each duct tube	Supplier's records.	A1
10. Dimensions				
a. Across flats outside	3.6	Each duct tube	Standard gaging.	A1

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item	Requirement	Inspection Plan	Reference Test Method	
b. Across flats inside	3.6	Each duct tube	Standard gaging. Measurements shall be taken at 12 inch (300 mm) intervals and at each end.	A1
c. Length	3.6	Each duct tube	Standard gaging.	
d. Inside radii	3.6	Each end of each duct tube	Measurement of casting of all corners with optical comparator.	
e. End configuration				
1. Chamfer	3.6	Each duct tube	Standard gaging.	
2. Perpendicularity	3.6	Each duct tube	Standard gaging.	
f. Wall thickness	3.6	Each duct tube	Thickness measurement procedure shall comply with ASTM E 113.	
g. Straightness	3.6	Each duct tube	Granite surface plate and standard gaging.	
h. Twist	3.6	Each duct tube	Granite surface plate and standard gaging.	
i. Hexagonality	3.6	Each duct tube	Hexagonal standard block approved by the purchaser.	N
11. Melting	3.7.1(a)	Supplier certification	Supplier certification as to compliance to requirements of 3.7.1(a).	

(continued)

Table 4. Quality Conformance Inspection (Cont'd)

Item	Requirement	Inspection Plan	Reference Test Method	
12. Tubemaking	3.7.1(b)	Supplier certification	Supplier certification as to compliance to requirements of 3.7.1(b).	
13. Special handling	3.7.1(c)	Supplier certification	Supplier's records.	
14. Heat treatment	3.7.1(d)	Supplier certification	The supplier's heat treating equipment and temperature controlling devices shall be calibrated in accordance with MIL-H-6875. Dew points shall be determined by an Alnor "Dew Pointer" or equivalent.	
15. Cleanliness	3.7.1(e)	Supplier certification	Supplier's records.	
16. Cold work	3.7.1(f)	Lot qualification based upon tests of 3 randomly selected samples per lot. (Variables data to be reported).	Measure duct component tubing at temper point and after final draw. Calculate percentage cold work for each lot using Equation 1.	
17. Lotting	3.7.2	Each duct tube	Supplier's records.	A1
18. Identification	3.7.3	Each duct tube	Visual examination for identification number correctness.	
19. Repair & rework	3.8	Supplier certification	Supplier's records.	
20. Archive sample	3.9	Supplier certification	Supplier's records.	

controlled to the extent necessary to assure continued measurements of required accuracy giving due consideration to temperature, humidity, vibration, cleanliness, and other controllable factors affecting precision measurement. When applicable, compensating corrections shall be applied to calibration results obtained in an environment which departs from standard conditions.

4.7.2 Calibration. Measuring and testing equipment shall be calibrated as specified in RDT F 3-2.

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4.8 Determination of Compliance and Data Recording for Inspection and Test.

4.8.1 Tolerance Limit Interpretation. The following applies to all specified limits in this standard and Ordering Data.

a. Chemical Composition. For purposes of determining conformance with chemical composition requirements, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-handed place of figures used in expressing the limiting value, in accordance with the rounding-off method of ASTM E 29.

b. Tensile Requirements. For purposes of determining conformance with tensile requirements, an observed value or a calculated value shall be rounded off to the nearest 100 psi (689kPa) for tensile strength and to the nearest 0.1 percent for elongation, in accordance with the rounding-off method of ASTM E 29.

c. Dimensional Requirements. The method for determining conformance with dimensional requirements shall be as specified in the Ordering Data (rounding off or absolute method as defined in ASTM E 29).

4.8.2 Equipment/Technique Accuracy. Unless otherwise required or approved by the purchaser, determinations shall be made with equipment or techniques reading accurately as specified in RDT F 3-15.

C

5. PREPARATION FOR DELIVERY

5.1 Packaging. Duct tubes shall be individually packaged in polyethylene and placed in a container constructed to ensure delivery of clean, straight, undamaged material in accordance with specific requirements of the Ordering Data and to maintain conformance with RDT F 7-2.

5.2 Shipping Containers. The complete description of shipping containers for duct tubes shall be submitted for approval before being used.

5.3 Marking. Each packing box shall be legibly and conspicuously marked with the following data:

1. Purchase order number.
2. Name of supplier.
3. Lot number.
4. Number of pieces in container.
5. Gross and net weights.
6. Applicable drawing.
7. Duct number.

6. NOTES AND ORDERING DATA CHECKLIST

6.1 Intended Use. Duct tubes described by this standard are to be used in the fabrication of fuel, control rod, and other core component assemblies.

6.2 Ordering Data Checklist. The following technical and procurement data will be furnished by the purchaser. Any necessary data not furnished with the purchase document shall be requested from the purchaser before submitting a bid.

<u>Title</u>	<u>Refer to Paragraph</u>
1. Drawings	2.6
2. Other Documents	2.7
3. Chemical composition	3.1.1
4. Tensile properties	3.2.1
5. Hardness	3.2.2
6. Surface roughness	3.5.2
7. Surface maring	3.5.3
8. Tube dimensions	3.6
9. Cold work	3.7.1(f)
10. Lotting	3.7.2
11. Identification	3.7.3
12. Archive samples	3.9
13. Quality assurance program requirements	4.1
14. Quality assurance documentation	4.2
15. Penetrant examination finished ducts	4.5, Table 4, Item 6
16. Dimensional requirements	4.8.1(c)
17. Packaging	5.1