

Aircraft Material Specification
35-45 TON CHROMIUM-NICKEL CORROSION-RESISTING STEEL
SOLID DRAWN CIRCULAR TUBES

(Suitable for pipe lines and high pressure hydraulic systems especially where flaring is required)

NOTE 1. This specification is one of a series issued by the Ministry of Aviation, either to meet a limited requirement not covered by any existing British Standard for aircraft material or to serve as a basis for inspection of materials the properties and uses of which are not sufficiently developed to warrant submission to the British Standards Institution for standardisation.

NOTE 2. Tubes to this specification are limited to the size range given in Table 1. The dimensions and test values for tubes of intermediate sizes may be obtained by interpolation of the appropriate values in Table 1.

NOTE 3. Tubes to this specification are suitable for flaring and for welding, brazing and silver soldering.

1. Chemical composition

1.1 The chemical composition shall be:

Element	Per cent	
	min.	max.
Carbon	—	0.10
Silicon	0.20	1.0
Manganese	0.50	2.0
Nickel	10.0	12.5
Chromium	17.0	19.0
Copper	—	0.50
Sulphur	—	0.030
Phosphorus	—	0.030
Niobium	10 x carbon content	1.20

1.2. By arrangement between manufacturer and purchaser titanium may be used in place of niobium. The titanium content shall not be less than five times the carbon content and shall not be more than 0.6 per cent.

NOTE: Attention is directed to the requirements for tubes containing titanium in Clause 15.

2. Process of manufacture

- 2.1. The steel shall be made by an electric process.
- 2.2. At a suitable stage in manufacture the hollows shall be machined all over both internally and externally to remove all surface defects including carburization.
- 2.3. The tubes shall have a smooth finish after each stage of drawing.
- 2.4. Any straightening of softened tubes shall be performed manually unless otherwise agreed between manufacturer and purchaser.

3. Condition

Tubes shall be supplied in the fully softened and descaled condition with a smooth finish complying with Clause 12. The flared ends (see Clause 9) shall be left on unless otherwise agreed between the purchaser and manufacturer and stated in the order.

4. Inspection procedure

The tubes shall be inspected in accordance with Section One of British Standard T.100 and the specific requirements of this specification.

5. Selection and preparation of test samples

- 5.1. A batch shall comprise up to 400 ft of tubes of the same nominal dimensions, that have been made from the same cast and softened together or consecutively under the same conditions.
- 5.2. A test sample shall be selected from one tube in each batch for the tensile test and flattening test specified in Clause 6.
- 5.3. Unless otherwise agreed between the purchaser and manufacturer a sample of at least one 2 ft length of tube from every batch shall be subjected to the distension test specified in Clause 7. This sample shall be selected prior to the hydraulic test specified in Clause 10.
- 5.4. A sample not less than 1½ in long shall be taken from each tube for the test for surface carburization and susceptibility to weld decay in Clause 8.

- 5.5. Samples having a combined length of not less than 10 ft shall be selected from not less than 3 tubes from every batch complying with all the other tests and shall be examined internally and externally for surface defects in accordance with Clause 11.3.
- 5.6. A test sample shall be selected from one tube in each batch for the test for surface finish in Clause 12.
- 5.7. Test samples selected in accordance with Clauses 5.2, 5.3, 5.4 and 5.5 shall not be heat treated or mechanically worked after having been separated from the material they represent other than that required in the performance of the test.

6. Mechanical tests

6.1 The mechanical properties obtained from test pieces selected and prepared in accordance with Clause 5.2 and the relevant requirements of Section One of British Standard T.100 shall be as follows:

6.2. *Tensile test.*

	min.	max.
Tensile strength, tons/sq in	35.0	45.0
Longitudinal 0.2 per cent proof stress, tons/sq in ..	14.0	—
Elongation on 2 in gauge length, per cent ..		
22 SWG and thinner ..	40	—
Thicker than 22 SWG ..	45	—

6.3. *Flattening test.*

Distance between inner sides of test piece in direction of flattening 1T

7. Distension test

- 7.1. The sample selected in accordance with Clause 5.3 shall be subjected to the following test:
- 7.2. The mean diameter at the centre of the length of the test sample shall be determined by measurement of two diameters at right angles with an instrument having a sensitivity of 0.0001 in. The appropriate hydraulic pressure in Column 8 of Table 1 shall be applied and maintained for not less than 30 seconds. After release of the pressure the mean diameter shall be determined by measurement of two diameters at right angles at the previous position and the permanent increase in the mean diameter of the tube observed.
- 7.3. The permanent increase in mean diameter resulting from this test shall not exceed 0.2 per cent of the mean diameter.
- 7.4. If the test sample fails to meet the requirements of Clause 7.3 the batch of tubes shall be rejected or may be retested in accordance with Clause 13.2.

8. Tests for surface carburization and susceptibility to weld decay

Samples selected in accordance with Clause 5.4 shall be tested as required by Appendix I. If the sample shows crazing or fissuring of the surface the tube represented shall be rejected.

NOTE. Where it has been demonstrated that the production of tube has been maintained at a consistent quality, by agreement with the Inspecting Authority, the frequency of testing may be reduced to samples taken from not less than 25 per cent of the tubes in the batch.

9. Drifting test

- 9.1. Every tube shall be subjected to the drifting test of British Standard A4.
- 9.2. Both ends of the tube shall, without showing signs of cracking, withstand being drifted to an angle of $32^\circ \pm \frac{1}{2}^\circ$ as shown in Fig. 1 until the inside diameter (d) of the drifted end has a dimension not less than that given for the appropriate tube size in Column (7) in Table 1.

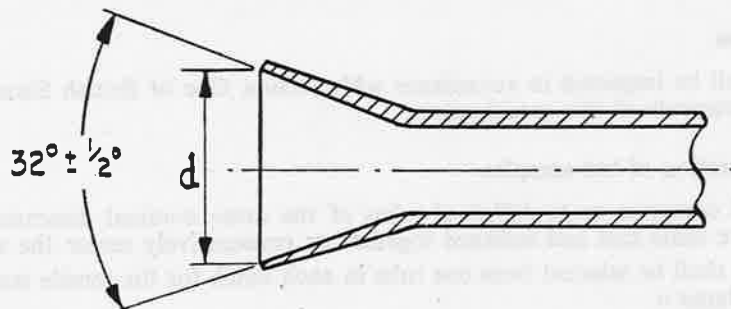


Fig. 1

- 9.3. Drifting tests shall be made by the application of steadily applied pressure to the drift or by other means agreed between the manufacturer and purchaser.

- 9.4. Any tube which does not comply with the drifting test shall be rejected. At the option of the manufacturer rejected tubes may be re-softened and re-tested in accordance with Clause 13.3 as a batch.

10. Hydraulic pressure test

- 10.1. Every tube shall be subjected for not less than 30 seconds to the hydraulic pressure appropriate to the tube size as specified in Column (9) of Table 1.
- 10.2. Any tube showing defects such as leaks, cracks, pinholes, or bulges when subjected to the hydraulic pressure or after release of the pressure shall be rejected.

11. Examination of finished tubes and test samples for surface defects

- 11.1. Every tube shall be visually examined for surface defects.
- 11.2. Every tube shall be non-destructively tested by a method approved by the Inspecting Authority. The sensitivity of the equipment shall be adjusted to clearly detect a longitudinal artificial defect. For tubes up to and including $\frac{1}{8}$ in outside diameter the artificial defect shall be in the form of a notch of radial depth of 0.003 in or 10 per cent of the nominal wall thickness of the tube, whichever is the greater, having a length of $\frac{1}{2}$ in and a maximum width of 0.005 in. For tubes greater than $\frac{1}{8}$ in outside diameter up to and including $1\frac{1}{4}$ in outside diameter the artificial defect shall be in the form of a notch of a radial depth of 0.003 in or 5 per cent of the nominal wall thickness of the tube, whichever is the greater, having a length of $\frac{1}{2}$ in and a maximum width of 0.005 in. For tubes greater than $1\frac{1}{4}$ in outside diameter up to and including $2\frac{1}{2}$ in outside diameter the artificial defect shall be in the form of a notch of a radial depth of 0.004 in or 10 per cent of the thickness of the tube, whichever is the greater, having a length of $\frac{1}{2}$ in and a maximum width of 0.005 in. Any signals given by natural defects in the tube being tested equal to or greater than the signal given by the appropriate artificial defect will be cause for rejection of the tube.
- 11.3. The test samples selected in accordance with Clause 5.5 shall be examined internally and externally for surface defects. The samples shall be split along the entire length for inspection of the internal surface. If the test samples reveal any defect deeper than 5 per cent of the wall thickness the tubes shall be retested in accordance with Clause 13.4 or rejected.
- 11.4. In cases of doubt or dispute the depth of a defect shall be measured on a transverse section of the tube.

12. Surface finish

The sample selected in accordance with Clause 5.6 shall be examined for surface finish in accordance with BS. 1134. The C.L.A. shall be determined in a longitudinal direction at five positions on the external surface and the mean of these readings shall not exceed C.L.A. 32.

13. Retests

- 13.1. *Tensile test and flattening test.* If any test piece fails to comply with the tests specified in Clause 6 the manufacturer may adopt one of the following procedures.
- (i) Two further samples shall be selected from the batch, one of which shall be from the tube originally selected from a position adjacent to that occupied by the original sample, unless that tube has been withdrawn by the manufacturer. Test pieces prepared from both these further samples shall meet the appropriate requirements of Clauses 6.2 or 6.3.
 - (ii) The batch of tubes shall be re-softened and tested in accordance with Clause 6 and subsequent clauses of the specification.
- 13.2. *Distension test.* If the test sample fails to meet the requirements of Clause 7.3, twice the number of samples selected in Clause 5.3, one of which shall be from the tube which failed originally unless that tube has been withdrawn by the manufacturer, shall be selected and retested in accordance with Clause 7.2. If any of the retest samples fail to meet the requirements of Clause 7.3 the batch of tubes shall be rejected.
- 13.3. *Drifting test.* Tubes failing to meet the requirements of Clauses 9.2 and 9.3 may be re-softened and re-tested in accordance with Clauses 5.2, 5.3, 5.4, 6, 7, 8 and 9 as a batch.
- 13.4. *Examination of finished tubes and test samples for surface defects.* If the test samples reveal any defect deeper than that specified in Clause 11.3, the test equipment of the non-destructive test shall be re-standardised and the batch of tubes again non-destructively tested. Also samples of tube having a combined length of not less than 20 ft selected from not less than 6 tubes in the batch shall be examined in accordance with Clause 11.3. Three of the additional samples shall be taken from the tubes originally examined unless these are withdrawn by the manufacturer. If the re-tested tubes reveal any defect deeper than the size specified in Clause 11.3 the tubes shall be rejected.

14. Dimensions

- 14.1 Tubes shall comply with the dimensions specified in Table 1.
- 14.2. The requirements for straightness shall be agreed between manufacturer and purchaser.

15. Identification

In addition to the requirement of B.S. T.100 each tube shall be distinctly marked in ink along its entire length with the specification number, the stabilising element niobium (or titanium as appropriate, see Clause 1.2), the batch number, and the nominal outside diameter and wall thickness.

NOTE. If the tubes are heat treated after delivery the ink marking should be removed to avoid risk of carburization.

Approved for issue,

N. J. L. MEGSON,

Director of Materials and Structures Research and Development.

APPENDIX I

**Method of testing for surface carburization
and susceptibility to weld decay**

The sample shall be heated to 650°C for 30 minutes, cooled in air and then immersed for 72 hours in a boiling solution having the following composition:

111 grammes copper sulphate crystals (Cu SO₄, 5H₂O),
98 grammes sulphuric acid 1.84 specific gravity,
made up to 1 litre with distilled water.

Precautions shall be taken during boiling to prevent concentration due to evaporation. The sample then shall be subjected to the following tests:

(a) A length of approximately $\frac{1}{2}$ in shall be cut from the sample and flattened until the distance between the opposite faces of the bore is not less than 2T (where T = thickness of tube).

The remainder of the sample shall be subjected to one of the following tests (b) or (c).

(b) The sample shall be split longitudinally into two equal pieces which shall then be flattened taking care to avoid reverse bending and damage to the surface of the bore.

(c) The sample shall be cut transversely to leave approximately 10 per cent of the circumference, bent back to an included angle of 90° to disclose the bore.

The external surface of the sample subjected to (a) and the internal surface of the sample subjected to either (b) or (c) shall be examined at a magnification of X20 and shall be free from fissuring or crazing.

In cases of doubt or dispute, freedom from intergranular attack shall be verified by sectioning and microscopic examination at a magnification of X200.

AIV
1

TABLE 1

(1) Nominal outside diameter of tube	(2) Tolerances on outside diameter		(3) *Ovality		(4) Nominal wall thickness		(5) Limits on wall thickness		(6) Extreme in	(7) Minimum inside diameter 'd' after drifting (see Fig. 1)	(8) Distension test pressure	(9) Hydraulic test pressure
	Mean	in ±	in ±	S.W.G.	in	Mean	in					
								in				
$\frac{3}{16}$	0.002	0.003	0.003	24	0.022	0.022-0.025	0.020-0.027	0.23	8,300 11,000	5,500 7,300		
	0.002	0.003	0.003	22	0.028	0.028-0.032	0.025-0.035	0.23				
$\frac{1}{4}$	0.002	0.003	0.003	24	0.022	0.022-0.025	0.020-0.027	0.33	6,100 7,900	4,000 5,200		
	0.002	0.003	0.003	22	0.028	0.028-0.032	0.025-0.035	0.32				
$\frac{5}{16}$	0.002	0.003	0.003	24	0.022	0.022-0.025	0.020-0.027	0.40	4,700 6,200 8,200	3,100 4,100 5,400		
	0.002	0.003	0.003	22	0.028	0.028-0.032	0.025-0.035	0.40				
	0.002	0.003	0.003	20	0.036	0.036-0.040	0.032-0.044	0.39				
	0.002	0.003	0.003	18	0.048	0.048-0.052	0.043-0.057	0.47				
$\frac{3}{8}$	0.002	0.003	0.003	22	0.028	0.028-0.032	0.025-0.035	0.46	5,000 6,700 9,200	3,300 4,500 6,100		
	0.002	0.003	0.003	20	0.036	0.036-0.040	0.032-0.044	0.45				
	0.002	0.003	0.003	18	0.048	0.048-0.052	0.043-0.057	0.54				
	0.002	0.003	0.003	17	0.056	0.056-0.060	0.050-0.066	0.53				
$\frac{1}{2}$	0.002	0.003	0.003	22	0.028	0.028-0.032	0.025-0.035	0.51	4,400 5,700 7,700	2,900 3,800 5,100		
	0.002	0.003	0.003	20	0.036	0.036-0.040	0.032-0.044	0.61				
	0.002	0.003	0.003	18	0.048	0.048-0.052	0.043-0.057	0.60				
	0.002	0.003	0.003	17	0.056	0.056-0.060	0.050-0.066	0.59				
$\frac{5}{8}$	0.002	0.003	0.003	22	0.028	0.028-0.032	0.025-0.035	0.58	3,600 4,800 6,700 7,900	2,400 3,200 4,500 5,300		
	0.002	0.003	0.003	20	0.036	0.036-0.040	0.032-0.044	0.73				
	0.002	0.003	0.003	18	0.048	0.048-0.052	0.043-0.057	0.72				
	0.002	0.003	0.003	17	0.056	0.056-0.060	0.050-0.066	0.71				
$\frac{3}{4}$	0.002	0.003	0.003	22	0.028	0.028-0.032	0.025-0.035	0.70	3,000 3,900 5,300 6,200	2,000 2,600 3,500 4,100		
	0.002	0.003	0.003	20	0.036	0.036-0.040	0.032-0.044	0.86				
	0.002	0.003	0.003	18	0.048	0.048-0.052	0.043-0.057	0.85				
	0.002	0.003	0.003	17	0.056	0.056-0.060	0.050-0.066	0.82				
$\frac{7}{8}$	0.002	0.004	0.004	22	0.028	0.028-0.032	0.025-0.035	0.79	2,400 3,200 4,300 5,800 6,600	1,600 2,100 2,800 3,800 4,400		
	0.002	0.004	0.004	20	0.036	0.036-0.040	0.032-0.044	0.78				
	0.002	0.004	0.004	18	0.048	0.048-0.052	0.043-0.057	0.98				
	0.002	0.004	0.004	15	0.072	0.072-0.078	0.065-0.085	0.97				
1	0.002	0.004	0.004	22	0.028	0.028-0.032	0.025-0.035	0.94	2,100 2,700 3,700 4,300 5,500 6,200	1,400 1,800 2,400 2,800 3,600 4,100		
	0.002	0.004	0.004	20	0.036	0.036-0.040	0.032-0.044	0.93				
	0.002	0.004	0.004	18	0.048	0.048-0.052	0.043-0.057	0.91				
	0.002	0.004	0.004	14	0.080	0.080-0.086	0.072-0.094	0.88				

TABLE 1 (continued)

(1) in	(2) in ±	(3) in ±	(4)		(5) in	(6) in	(7) in	(8) lb/sq in	(9) lb/sq in
			S.W.G.	in					
1	0.002	0.004	22	0.028	0.028-0.032	0.025-0.035	1.11	1,800	1,200
	0.002	0.004	20	0.036	0.036-0.040	0.032-0.044	1.10	2,400	1,600
	0.002	0.004	18	0.048	0.048-0.052	0.043-0.057	1.07	3,200	2,100
	0.002	0.004	16	0.064	0.064-0.069	0.057-0.075	1.04	4,300	2,800
	0.002	0.004	15	0.072	0.072-0.078	0.065-0.085	1.02	4,900	3,200
1½	0.002	0.004	14	0.080	0.080-0.086	0.072-0.094	1.01	5,400	3,600
	0.002	0.004	13	0.092	0.092-0.099	0.083-0.108	0.99	6,200	4,300
	0.003	0.004	22	0.028	0.028-0.032	0.025-0.035	1.36	1,400	900
	0.003	0.004	20	0.036	0.036-0.040	0.032-0.044	1.35	1,800	1,200
	0.003	0.004	18	0.048	0.048-0.052	0.043-0.057	1.32	2,500	1,600
1½	0.003	0.004	16	0.064	0.064-0.069	0.057-0.075	1.29	3,300	2,200
	0.003	0.004	14	0.082	0.080-0.086	0.072-0.094	1.26	4,200	2,800
	0.003	0.005	22	0.028	0.028-0.032	0.025-0.035	1.62	1,100	700
	0.003	0.005	20	0.036	0.036-0.040	0.032-0.044	1.60	1,500	1,000
	0.003	0.005	18	0.048	0.048-0.052	0.043-0.057	1.58	2,100	1,400
2	0.003	0.005	16	0.064	0.064-0.069	0.057-0.075	1.54	2,800	1,800
	0.003	0.005	14	0.080	0.080-0.086	0.072-0.094	1.51	3,600	2,400
	0.003	0.005	13	0.092	0.092-0.099	0.083-0.108	1.49	4,100	2,700
	0.004	0.006	18	0.048	0.048-0.052	0.043-0.057	2.06	1,500	1,000
	0.004	0.006	16	0.064	0.064-0.069	0.057-0.075	2.03	2,000	1,300
2½	0.005	0.007	18	0.048	0.048-0.052	0.043-0.057	2.67	1,200	800
	0.005	0.007	16	0.064	0.064-0.069	0.057-0.075	2.65	1,600	1,100

*The tolerance on ovality in column 3 indicates the amount by which the largest (or smallest) diameter, measured at any point in the tube, may depart from the mean diameter derived by measuring the maximum and minimum diameters with a sensitivity of 0.0001 in.

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and published by

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Price 1s. 3d. net

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SOLID DRAWN CIRCULAR TUBES**

**(Suitable for pipe lines and high pressure hydraulic systems especially
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Appendix 1. Paragraph (a)

Delete: not less than 2T

Insert: not more than 2T

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