

# British Standard Aerospace Series: Procedure for Inspection and testing of steel tubes

Série aérospatiale. Méthode de contrôle et d'essai des tubes en acier

Luftraumserie. Untersuchungs- und Prüfverfahren für Stahlrohre

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## FOREWORD

This British Standard covers the general inspection and testing requirements for steel tubes to be used for aerospace purposes. The procedure set out herein is primarily for use in conjunction with related material specifications in the 'T' series of British Standards and in the Ministry of Defence (Procurement Executive) D.T.D. series. It may also be used with other material specifications by agreement between the manufacturer and the purchaser.

The first edition of this British Standard was published in June 1948 and a revised edition, which incorporated changes agreed between the manufacturers and users of the materials in the light of working to the provisions of the first

edition, was published in April 1972. This further revision has been undertaken to take account of new manufacturing processes and techniques, in accord with the latest edition of S 100.

In this revision, new requirements for release documentation and an appendix (appendix B) relating to standards of cleanness have been added, and the requirements for the bend test (as an alternative to the flattening test), the proof bend test and the impact test have been deleted. In addition, all values are now given in SI units only and the tables of dimensional tolerances have been deleted.

## SECTION ONE. GENERAL REQUIREMENTS

### 1. SCOPE

This British Standard specifies the general requirements for the inspection and testing of steel tubes to be used for aerospace purposes and other critical applications.

**NOTE. Hollow bar is not regarded as tube (see S100).**

### 2. GENERAL

2.1 In this standard, whenever agreement between the manufacturer and the purchaser is required, the onus is on the purchaser to obtain the concurrence of the parent design authority. If such concurrence is mandatory the word 'purchaser' is marked with an asterisk.

2.2 The 'Quality Assurance Authority' referred to throughout this standard shall be as stated in the contract or the accredited representative of the authority stated.

### 3. REFERENCES

This standard makes reference to the following standards publications.

- |         |                                                                                                                                          |
|---------|------------------------------------------------------------------------------------------------------------------------------------------|
| A 4     | Test pieces and test methods for metallic materials for aircraft                                                                         |
| M 46    | Tubing outside diameters and thicknesses                                                                                                 |
| S 100   | Procedure for inspection and testing of wrought steels (other than sheet, strip and tubes)                                               |
| BS 240  | Method for Brinell hardness test<br>Part 1 Testing of metals<br>Part 2 Verification of the testing machine                               |
| BS 427  | Method for Vickers hardness test<br>Part 1 Testing of metals<br>Part 2 Verification of the testing machine                               |
| BS 891  | Method for Rockwell hardness test<br>Part 1 Testing of metals<br>Part 2 Verification of the testing machine                              |
| BS 1134 | Method for the assessment of surface texture                                                                                             |
| BS 1639 | Method for bend testing of metals                                                                                                        |
| BS 1837 | Methods for the sampling of iron, steel, permanent magnet alloys and ferro-alloys                                                        |
| BS 4175 | Method for Rockwell superficial hardness test (N and T scales)<br>Part 1 Testing of metals<br>Part 2 Verification of the testing machine |

The latest issues of these standards shall be used.

### 4. DEFINITIONS

For the purposes of this British Standard and associated material specifications the following definitions apply.

#### 4.1 batch. Tubes

- (a) from the same cast;
- (b) manufactured under the same processing conditions;
- (c) of the same nominal dimensions; and
- (d) if heat treated, in the same heat treatment condition and from the same heat treatment charge or, in the case of continuous heat treatment, from a run of not more than 8 h.

4.2 billet. A length of wrought material which may be solid or hollow and which is intended for hot working.

4.3 cast. A melt of known chemical composition or a portion of that melt intended for the production of tubes.

4.4 parent cast. A melt of known chemical composition or a portion of that melt used to produce consumable electrodes.

4.5 vacuum arc remelted cast. An ingot produced by arc remelting a consumable electrode under vacuum.

4.6 electroslag (electroflux) remelted cast. An ingot produced by remelting one or more consumable electrode(s) under a protective slag (flux) layer heated by electrical resistance methods.

4.7 oxygen steelmaking process. A steelmaking process using commercially pure oxygen (99 % purity) excluding air or mixed air/oxygen blowing processes.

4.8 tube. A hollow product of uniform thickness having a length greater than the outside diameter.

### 5. CHEMICAL COMPOSITION

5.1 The chemical composition of the steel shall comply with the requirements of the relevant material specification. The values stipulated in that specification shall be applied to the satisfaction of the Quality Assurance Authority. Except as required by 5.2, an analysis of every cast shall be made for the specified elements and a certificate of analysis shall be supplied to the purchaser.

5.2 Each vacuum arc remelted or electroslag remelted cast shall be analysed. The position(s) of the sample(s) and the elements to be determined per cast shall be as required by the material specification.

5.3 Analytical samples shall be selected and prepared in accordance with the relevant requirements of BS 1837.

5.4 Elements not quoted in the material specification shall not be intentionally added to the steel except for the purpose of finishing the heat; reasonable precautions shall be taken to prevent their inclusion during manufacture.

**NOTE.** For special applications, the purchaser\*, in agreement with the manufacturer, may set a limit to the amount of one or more such elements and may require the amount of such elements to be stated in the certificate of analysis.

\* See 2.1.



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PROCEDURE FOR INSPECTION AND TESTING OF STEEL TUBES

Revised text

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October 1979

## CONTENTS

Under 'APPENDICES', after item 'B' insert the following new item:

|                             |            |
|-----------------------------|------------|
| 'C. Notes on tables 2 to 7' | Page<br>15 |
|-----------------------------|------------|

Delete the next heading, 'TABLE', and substitute 'TABLES'.

After '1. Maximum permissible inclusion contents' insert the following new items:

|                                                                                  |    |
|----------------------------------------------------------------------------------|----|
| '2. Tolerances on dimensions of cold drawn and tempered tubes: metric dimensions | 17 |
|----------------------------------------------------------------------------------|----|

|                                                                                                       |    |
|-------------------------------------------------------------------------------------------------------|----|
| 3. Tolerances on dimensions of annealed, normalized or hardened and tempered tubes: metric dimensions | 18 |
|-------------------------------------------------------------------------------------------------------|----|

|                                                                                                         |    |
|---------------------------------------------------------------------------------------------------------|----|
| 4. Tolerances on dimensions of corrosion- and heat-resisting tubes: austenitic steel: metric dimensions | 19 |
|---------------------------------------------------------------------------------------------------------|----|

|                                                                                   |    |
|-----------------------------------------------------------------------------------|----|
| 5. Tolerances on dimensions of cold drawn and tempered tubes: imperial dimensions | 20 |
|-----------------------------------------------------------------------------------|----|

|                                                                                                         |    |
|---------------------------------------------------------------------------------------------------------|----|
| 6. Tolerances on dimensions of annealed, normalized or hardened and tempered tubes: imperial dimensions | 21 |
|---------------------------------------------------------------------------------------------------------|----|

|                                                                                                            |    |
|------------------------------------------------------------------------------------------------------------|----|
| 7. Tolerances on dimensions of corrosion- and heat-resisting tubes: austenitic steel: imperial dimensions' | 22 |
|------------------------------------------------------------------------------------------------------------|----|

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## FOREWORD

Delete the last sentence and substitute the following:

'Except in the tables of dimensional tolerances, all references to values in imperial units have been deleted.'



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Clause 11.1 Diameters and thicknesses

Delete the existing subclauses 11.1.1 and 11.1.2 and substitute the following:

'11.1.1 Unless otherwise stipulated in the material specification or order, the dimensions of round tubes shall comply with the requirements of the appropriate table as follows.

(a) Cold drawn and tempered tubes    table 2 or  
table 5

(b) Annealed, normalized or            table 3 or  
hardened and tempered tubes        table 6

(c) Corrosion- and heat-resisting    table 4 or  
tubes: austenitic steel                table 7

The two sets of requirements, based on metric units (tables 2, 3 and 4) and imperial units (tables 5, 6 and 7) respectively, are not interchangeable. The relevant set shall be applied, depending on whether the dimensions stated on the order are expressed in metric or imperial units.

11.1.2 The tolerances on the dimensions of tubes not covered by tables 2 to 7, and of non-circular tubes, shall be agreed between the manufacturer and the purchaser\* and stated on the order.

NOTE. In these cases it may be necessary also to agree the methods of testing.'

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Clause 11.2 Straightness

At the end of the clause, insert the following:

'Unless otherwise stated on the order, machine straightening shall be used.'

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Clause 18.2

Delete the existing clause and substitute the following:

'18.2 Immediately before despatch, each tube shall be checked for its class of composition e.g. nickel steel, nickel-chrome steel, etc. Evidence of such testing may remain on the tube except for finished cut lengths which shall be checked as an operation immediately before cutting. Adequate precautions shall be taken with finished cut lengths to ensure that no mix of composition occurs. The method of testing, which shall be agreed with the Quality Assurance Authority, may be by means of a spark test, a spectroscope, an electromagnetic sorting appliance or by any other suitable method. Hardness testing alone may suffice in some instances.'

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New appendix and tables. After figure 3 insert the attached new text and tables as pages 15-22.



## APPENDIX C

## NOTES ON TABLES 2 TO 7

## C.1 General

C.1.1 In tables 2, 3 and 4, the tolerances underlined are those for nominal outside diameters and thicknesses in metric units selected from the preferred R 10 series specified in M 46.

C.1.2 In tables 5, 6 and 7, the tolerances underlined are those for common stock sizes in imperial units.

C.1.3 The tolerances on the inside diameter of tubes ordered by outside diameter and thickness and the tolerances on the outside diameter of tubes ordered by inside diameter and thickness will not necessarily be those given in the tables.

C.2 Definitions. For the purposes of this British Standard the following definitions apply.

C.2.1 tolerance on mean diameter. The amount by which the sum of any two diameters at right angles, divided by two, may depart from the nominal diameter.

C.2.2 total out-of-round. The maximum permissible difference between the largest and smallest diameters at any point in the tube.

C.2.3 tolerance on out-of-round. The amount by which the largest (or smallest) diameter, measured at any point in the tube, may depart from the nominal diameter.

C.2.4 mean thickness. The sum of the thicknesses measured at the ends of any two diameters at right angles, divided by four.

C.2.5 extreme thickness. The greatest (or least) thickness at any point.

C.2.6 total mean tolerance. The algebraic sum of the tolerances on the mean diameter.

C.3 Tolerances. The limits given in the tables are derived as follows.

NOTE.  $D$  is the nominal outside diameter;  $T$  is the nominal thickness;  $M$  is the total mean tolerance.

TABLES 2, 3 AND 4

TABLES 5, 6 AND 7

(a) Tolerance on mean inside or outside diameter

| $D$          | <u>Tolerance</u>                                                  | $D$                    | <u>Tolerance</u>                                                 |
|--------------|-------------------------------------------------------------------|------------------------|------------------------------------------------------------------|
| $\leq 38$ mm | $\pm 0.08$ mm                                                     | $\leq 1\frac{1}{2}$ in | $\pm 0.003$ in                                                   |
| $> 38$ mm    | $\pm 0.025$ mm for each<br>12.5 mm of diameter or<br>part thereof | $> 1\frac{1}{2}$ in    | $\pm 0.001$ in for each<br>1/2 in of diameter or<br>part thereof |

(b) Tolerance on extreme outside diameter

$\pm(M + 0.04)$  mm or as derived from the formula in (1), (2) or (3) below, as appropriate, whichever is the greater, each limit taken to the nearest 0.02 mm under the calculated value.

$\pm(M + 0.002)$  in or as derived from the formula in (1), (2) or (3) below, as appropriate, whichever is the greater, each limit taken to the nearest 0.001 in under the calculated value.

TABLES 2, 3 AND 4

(1) Cold drawn and tempered tubes

$$\pm \left( 0.254 + \frac{1.2D^3}{(1000T)^2} - \frac{M}{4} \right) \text{ mm}$$

(2) Annealed, normalized or hardened and tempered tubes

$$\pm \left( 0.254 + \frac{2D^3}{(1000T)^2} - \frac{M}{4} \right) \text{ mm}$$

(3) Corrosion- and heat-resisting tubes

$$\pm \left( 0.254 + \frac{3D^3}{(1000T)^2} - \frac{M}{4} \right) \text{ mm}$$

NOTE. The limits on extreme outside diameter are based on the mean diameter and indicate the maximum out of round permissible.

TABLES 5, 6 AND 7

$$\pm \left( 0.005 + \frac{0.6D^3}{(1000T)^2} \right) \text{ in}$$

$$\pm \left( 0.005 + \frac{D^3}{(1000T)^2} \right) \text{ in}$$

$$\pm \left( 0.005 + \frac{1.5D^3}{(1000T)^2} \right) \text{ in}$$

NOTE. The limits on extreme outside diameter are based on the nominal diameter, i.e. at no point in the tube shall the lowest reading of the diameter be less than the nominal diameter minus the tolerance, and the highest reading shall not be more than the nominal diameter plus the tolerance. The average diameter so obtained shall be within the limits (nominal diameter plus and minus the tolerance on mean diameter).

(c) Mean thickness

| <u>T</u>           | <u>Tolerance</u> |
|--------------------|------------------|
| mm                 | mm               |
| $T \leq 0.6$       | $\pm 0.04$       |
| $0.6 < T \leq 1.4$ | $\pm 0.05$       |
| $1.4 < T$          | $\pm 4 \%$       |

| <u>T</u>               | <u>Tolerance</u> |
|------------------------|------------------|
| in                     | in               |
| $T \leq 0.022$         | +0.003<br>-0     |
| $0.022 < T \leq 0.056$ | +0.004<br>-0     |
| $0.056 < T$            | +8 %<br>-0       |

(d) Extreme thickness

(1) Maximum thickness

$$1.1 \times \text{actual mean thickness}$$

$$1.1T + M$$

(2) Minimum thickness

$$0.9 \times \text{actual mean thickness}$$

$$0.9T$$

C.4 Eccentricity. At any one section, the variation in thickness shall be not greater than 10 % of the actual mean thickness.

TABLE 2. TOLERANCES ON DIMENSIONS OF COLD DRAWN AND TEMPERED TUBES: METRIC DIMENSIONS

NOTE. See appendix C.

All dimensions are in millimetres.

| Nominal thickness | 0.6                             |                    | 0.8                             |                    | 1.0                             |                    | 1.2                             |                    | 1.6                             |                    | 2.0                             |                    | Nominal thickness |
|-------------------|---------------------------------|--------------------|---------------------------------|--------------------|---------------------------------|--------------------|---------------------------------|--------------------|---------------------------------|--------------------|---------------------------------|--------------------|-------------------|
| Mean thickness    | 0.56 - 0.64                     |                    | 0.75 - 0.85                     |                    | 0.95 - 1.05                     |                    | 1.15 - 1.25                     |                    | 1.54 - 1.66                     |                    | 1.92 - 2.08                     |                    | Mean thickness    |
| Extreme thickness | actual mean thickness<br>± 10 % |                    | actual mean thickness<br>± 10 % |                    | actual mean thickness<br>± 10 % |                    | actual mean thickness<br>± 10 % |                    | actual mean thickness<br>± 10 % |                    | actual mean thickness<br>± 10 % |                    | Extreme thickness |
| Nominal diameter  | Mean diameter                   | Total out of round | Mean diameter                   | Total out of round | Mean diameter                   | Total out of round | Mean diameter                   | Total out of round | Mean diameter                   | Total out of round | Mean diameter                   | Total out of round | Nominal diameter  |
| 5                 | ±<br>0.08                       | 0.20               | ±<br>0.08                       | 0.20               | ±<br>0.08                       | 0.20               | ±<br>0.08                       | 0.20               | ±<br>0.08                       | 0.20               | ±<br>0.08                       | 0.20               | 5                 |
| 6                 | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 6                 |
| 8                 | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 8                 |
| 10                | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 10                |
| 12                | 0.08                            | 0.22               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 12                |
| 14                | 0.08                            | 0.22               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 14                |
| 16                | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 16                |
| 18                | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.20               | 0.08                            | 0.20               | 0.08                            | 0.20               | 18                |
| 20                | 0.08                            | 0.24               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.20               | 0.08                            | 0.20               | 20                |
| 22                | 0.08                            | 0.24               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.20               | 0.08                            | 0.20               | 22                |
| 25                | 0.08                            | 0.26               | 0.08                            | 0.24               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.22               | 25                |
| 28                | 0.08                            | 0.28               | 0.08                            | 0.24               | 0.08                            | 0.24               | 0.08                            | 0.22               | 0.08                            | 0.22               | 0.08                            | 0.22               | 28                |
| 32                | 0.08                            | 0.32               | 0.08                            | 0.26               | 0.08                            | 0.24               | 0.08                            | 0.24               | 0.08                            | 0.22               | 0.08                            | 0.22               | 32                |
| 36                | 0.08                            | 0.36               | 0.08                            | 0.30               | 0.08                            | 0.26               | 0.08                            | 0.24               | 0.08                            | 0.22               | 0.08                            | 0.22               | 36                |
| 40                | 0.10                            | 0.40               | 0.10                            | 0.32               | 0.10                            | 0.28               | 0.10                            | 0.24               | 0.10                            | 0.22               | 0.10                            | 0.26               | 40                |
| 45                | 0.10                            | 0.50               | 0.10                            | 0.36               | 0.10                            | 0.30               | 0.10                            | 0.26               | 0.10                            | 0.24               | 0.10                            | 0.24               | 45                |
| 50                | 0.10                            | 0.62               | 0.10                            | 0.42               | 0.10                            | 0.34               | 0.10                            | 0.30               | 0.10                            | 0.26               | 0.10                            | 0.24               | 50                |
| 56                | 0.125                           | 0.76               | 0.125                           | 0.52               | 0.125                           | 0.40               | 0.125                           | 0.34               | 0.125                           | 0.26               | 0.125                           | 0.24               | 56                |
| 63                |                                 |                    | 0.125                           | 0.66               | 0.125                           | 0.48               | 0.125                           | 0.38               | 0.125                           | 0.30               | 0.125                           | 0.26               | 63                |
| 71                |                                 |                    | 0.15                            | 0.84               | 0.15                            | 0.60               | 0.15                            | 0.46               | 0.15                            | 0.34               | 0.15                            | 0.28               | 71                |
| 80                |                                 |                    |                                 |                    | 0.175                           | 0.78               | 0.175                           | 0.58               | 0.175                           | 0.40               | 0.175                           | 0.32               | 80                |