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R 952

TENSILE TESTING OF LIGHT METAL AND LIGHT METAL ALLOY TUBES

1st EDITION

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BRIEF HISTORY

The ISO Recommendation R 952, *Tensile testing of light metal and light metal alloy tubes,* was drawn up by Technical Committee ISO/TC 79, *Light metals and their alloys,* the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question led, in 1966, to the adoption of a Draft ISO Recommendation.

In March 1967, this Draft ISO Recommendation (No. 1132) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Belgium	Israel	Switzerland
Canada	Italy	Thailand
Chile	Japan	Turkey
Czechoslovakia	Netherlands	U.A.R.
France	New Zealand	United Kingdom
Germany	Norway	U.S.A.
Greece	Poland	U.S.S.R.
Hungary	South Africa, Rep. of	Yugoslavia
India	Sweden	

No Member Body opposed the approval of the Draft.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in January 1969, to accept it as an ISO RECOMMENDATION.

ISO Recommendation	R 952	January 1969

TENSILE TESTING
OF LIGHT METAL AND LIGHT METAL ALLOY TUBES

1. SCOPE

This ISO Recommendation relates to the tensile testing of light metal and light metal alloy tubes.

2. PRINCIPLE OF TEST

The test consists in subjecting a length of tube of full section, or a longitudinal strip of full thickness, cut from the wall of a tube, or a round proportional test piece machined from the wall of a tube, to tensile stress, generally to fracture, with a view to determining one or more of the mechanical properties enumerated in clauses 6.1, 6.5, 6.6 and 6.7.

The test is carried out at ambient temperature unless otherwise specified.

3. DEFINITIONS

3.1 *Gauge length.* At any moment during the test, the prescribed length of the test piece on which elongation is measured. In particular a distinction should be made between the two following lengths :

3.1.1 *Original gauge length* (L_o). Gauge length before the test piece is strained.

3.1.2 *Final gauge length* (L_u). Gauge length after the test piece has been fractured and the fractured parts have been carefully fitted together so that they lie in a straight line.

3.2 *Percentage permanent elongation.* Variation of the gauge length of a test piece subjected to a prescribed stress (see clause 3.7) and, after removal of the same, expressed as a percentage of the original gauge length. If a symbol is used for this elongation, it should be supplemented by an index indicating the prescribed stress.

3.3 *Percentage elongation after fracture* (A). Permanent elongation of the gauge length after fracture, $L_u - L_o$, expressed as a percentage of the original gauge length, L_o.

3.4 *Percentage reduction of area* (Z). Ratio of the maximum change in the cross-sectional area which has occurred during the test, $S_o - S_u$, to the original cross-sectional area S_o, expressed as a percentage.

3.5 *Maximum load* (F_m). The highest load which the test piece withstands during the test.

3.6 *Final load* (F_u). Load imposed on the test piece at the moment of complete fracture.

3.7 *Stress* (actually "nominal stress"). At any moment during the test, load divided by the original cross-sectional area of the test piece.

3.8 *Tensile strength* (R_m). Maximum load divided by the original cross-sectional area of the test piece, i.e. the stress corresponding to the maximum load.

3.9 *Permanent set stress* (R_r). Stress at which, after removal of load, a prescribed permanent elongation, expressed as a percentage of the original gauge length, occurs (see clause 3.2 and Fig. 4*a*).

3.10 *Proof stress (non-proportional elongation) or yield strength (offset)** (R_p). Stress which produces, while the load is still applied, a non-proportional elongation equal to the specified percentage of the original gauge length, L_o.

When a proof stress or a yield strength is specified, the non-proportional elongation should be stated; e.g. proof stress or yield strength 0.2 % (see Fig. 4*b*).

The symbol used for this stress should be supplemented by an index giving the prescribed percentage of the original gauge length, e.g. 0.2 %.

* This last term is used in the United States of America and in Canada.

4. SYMBOLS AND DESIGNATIONS

Reference number*	Symbol	Designation
1	D	External diameter of round tube
2	d	Internal diameter of round tube
3	a	Thickness of tube
4	b	Width of longitudinal strip or parallel portion of test piece
5	L_o	Original gauge length **
6	L_c	Parallel length
7	L_t	Total length of test piece
8	–	Gripped ends
9	S_o	Original cross-sectional area of the gauge length
10	L_u	Final gauge length
11	S_u	Minimum cross-sectional area after fracture
12	F_m	Maximum load
13	R_m	Tensile strength **
14	F_u	Final load, i.e. at moment of complete fracture
15	$L_u - L_o$	Permanent elongation after fracture
16	A	Percentage elongation after fracture $A = \frac{L_u - L_o}{L_o} \times 100$
17	Z	Percentage reduction of area $Z = \frac{S_o - S_u}{S_o} \times 100$
18	R_r	Permanent set stress
19	–	Specified permanent set
20	R_p	Proof stress (non-proportional elongation) or yield strength (offset)
21	–	Specified non-proportional elongation

* See Figures 1 to 4.

** In correspondence and where no misunderstanding is possible, the symbols L_o and R_m may be replaced by L and R respectively.

5. TEST PIECES

5.1 Type of test piece

The test piece may consist of a length of the tube of full section or a longitudinal strip of full thickness, cut from the wall of the tube, or a round proportional test piece machined from the wall. Tubes should be tested in full section whenever practicable. The type of test piece used should be specified in the specification for the material, and in any case should be stated in the test report.

5.2 Tests on tubes of full section

5.2.1 Tubes should be plugged at each end for gripping. The parallel length of the plug projecting beyond the grip in the direction of the gauge length should not exceed the external diameter D of the tube, and its shape should be such that it does not interfere with the elongation of the gauge length. (See also clauses 5.5 and 5.6.)

5.2.2 The free length between the end of each plug and the nearest gauge mark should be between $\frac{D}{4}$ and D. In cases of arbitration, this length should always be as great as possible, i.e. close to D.

5.3 Tests on strips cut longitudinally from tubes

5.3.1 The test piece should have a parallel length and may have enlarged ends for gripping, in which case there should be a transition radius between the gripped ends and the parallel length. (See also clauses 5.5 and 5.6.)

5.3.2 The parallel length should not be flattened, but the enlarged ends may be flattened for gripping in the testing machine. The width b of the test piece should be approximately 12.5 mm (0.5 in).

5.3.3 The parallel length should be parallel to within 0.1 mm (0.005 in), but may be tapered within this tolerance from the ends to the centre.

When the test piece has enlarged ends, the parallel length should be between

$$L_o + \frac{b}{2} \quad \text{and} \quad L_o + 2b$$

where b is the width of the parallel length.

5.4 Tests on round proportional test pieces machined from the wall

Round proportional test pieces machined from the wall of the tube should comply with the requirements of clauses 5.3 and 5.5.

5.5 Measurement of elongation

As a rule, proportional test pieces should be used, the elongation being measured on a gauge length

$$L_o = k\sqrt{S_o}$$

where k may be equal to 4, 4.5, 5.65, 8.16 or 11.3.

NOTE. – The international use of proportional test pieces with $k = 4, 4.5, 8.16$ and 11.3 should be regarded as an interim measure, and these should only be used in connection with existing specifications. These values of k may be cancelled after a period to be determined later.

5.6 Use of fixed original gauge length

A fixed gauge length of 50 mm (2 in) may be used when the test is carried out on a strip cut longitudinally from the tube, or when tubes are tested in full section.

5.7 Determination of original cross-sectional area

5.7.1 The cross-sectional area of the test piece should be determined to an accuracy of ± 1 % unless otherwise agreed.

5.7.2 The cross-sectional area of a test piece consisting of the full section of the tube, or of a parallel strip cut from the tube and without enlarged ends, may be calculated from the mass of the measured length of the test piece if the density of the material is known.

5.7.3 The cross-sectional area of a curved strip, of which the sides of the cross-section are parallel, cut from a round tube should be determined by linear measurement and calculation (see Annex).

6. METHOD OF TEST

6.1 Determination of elongation – General case

As a rule, elongation should be determined on the gauge length which, before the test, is marked to 0.25 mm (0.01 in).

6.1.1 The fractured parts of the test piece are carefully fitted together so that they lie in a straight line. The increase in gauge length after test is measured to approximately 0.25 mm (0.01 in).

6.1.2 In principle, this type of determination is valid only if the distance between the fracture and the nearest gauge mark is not less than

(*a*) 1/3 of the gauge length after fracture for test pieces with

$$L_o = 4\sqrt{S_o}\ ;\quad L_o = 4.5\sqrt{S_o}\ ;\quad L_o = 5.65\sqrt{S_o}$$

(*b*) 1/4 of the gauge length after fracture for test pieces with

$$L_o = 8.16\sqrt{S_o}$$

(*c*) 1/5 of the gauge length after fracture for test pieces with

$$L_o = 11.3\sqrt{S_o}$$

6.1.3 The measurement is valid in any case if the elongation reaches the specified value, whatever the position of the fracture.

6.2 Determination of elongation – Special case

To avoid the possibility of test pieces being rejected because the fracture has occurred outside the limits specified in clause 6.1, the following method may be employed :

6.2.1 Before testing, subdivide the gauge length L_o into N equal parts.

6.2.2 After testing, designate by A the end mark on the shorter piece. On the larger piece, designate by B the graduation mark the distance from which to the fracture is most nearly equal to the distance from the fracture to the end mark A.

6.2.3 If n is the number of intervals between A and B, the elongation after fracture is determined as follows :

(*a*) *If $N - n$ is an even number* (see Fig. 5*a*)

Measure the distance between A and B and the distance from B to a graduation mark C at $\frac{N-n}{2}$ intervals from B. Then calculate the elongation after fracture from the formula

$$A = \frac{\overline{AB} + 2\,\overline{BC} - L_o}{L_o} \times 100\ \%$$

(*b*) *If $N - n$ is an odd number* (see Fig. 5*b*)

Measure the distance between A and B and the distance from B to the graduation marks C′ and C″

at $\frac{N-n-1}{2}$ and $\frac{N-n+1}{2}$ intervals from B

Then calculate the elongation after fracture from the formula

$$A = \frac{\overline{AB} + \overline{BC'} + \overline{BC''} - L_o}{L_o} \times 100\ \%$$

6.3 Rate of testing

6.3.1 If the proof stress or yield strength is to be determined, the speed of the machine should be regulated so that a satisfactory strain record is obtained. It should be such that in no case does the rate of loading of the test piece exceed 1 kgf/mm^2 * (0.6 tonf/in^2 or 1420 lbf/in^2) per second.

* 1 kgf/mm^2 = about 9.8 N/mm^2 (9.8 newtons per square millimetre). (See ISO Recommendation R 31, Part III, *Quantities and units of mechanics.*)

6.3.2 In the plastic range, the rate of strain at any moment should be not higher than 40 % of the gauge length per minute; no value is fixed for the lower limit of this rate. When the proof stress or yield strength is not to be determined, the rate of testing in the elastic range may be as high as that permitted for the plastic range.

6.3.3 In all cases the rate of testing in each range should be as uniform as possible and the change of rate from one range to the other should be made gradually and without shock.

6.4 Measurement of load

Load corresponding to specified stresses should be determined on a testing machine compatible in accuracy with Grade 1.0 of ISO Recommendation R 147, *Load calibration of testing machines for tensile testing of steel.*

6.5 Determination of permanent set stress

For the accurate determination of the permanent set stress (0.2 % or any other specified value), the method of measurement of the permanent elongation for successively applied increasing loads (unloading method) should be used as follows :

Increasing loads are successively applied to the test piece and maintained in each case for about 10 seconds. After removal of each load the permanent elongation which the test piece has taken is measured. The test is stopped when the elongation exceeds 0.2 % or whatever the prescribed percentage may be. The stress corresponding to the specified value of percentage permanent elongation is then obtained by interpolation.

6.6 Determination of proof stress or yield strength

The proof stress or yield strength should be determined as follows :

An accurate curve is plotted or drawn autographically, taking the loads as ordinates and the corresponding elongations as abscissae. A straight line is drawn on the graph parallel to the straight part of the curve, at a distance from the straight part, measured along the axis of the abscissae, equal to the prescribed percentage of the initial gauge length. The desired stress corresponds to the point of intersection of the straight line and the curve.

6.7 Proving tests

Where it is desired merely to verify that the material possesses the specified minimum proof stress or yield strength, the following method may be used :

The test piece is placed for between 10 and 12 seconds under the load corresponding to the specified proof stress and it is verified, after release of the load, that the permanent elongation remains equal to or less than the prescribed percentage of the initial length.

NOTE. – The methods described in clauses 6.5 and 6.7 above should not be used for magnesium and its alloys.

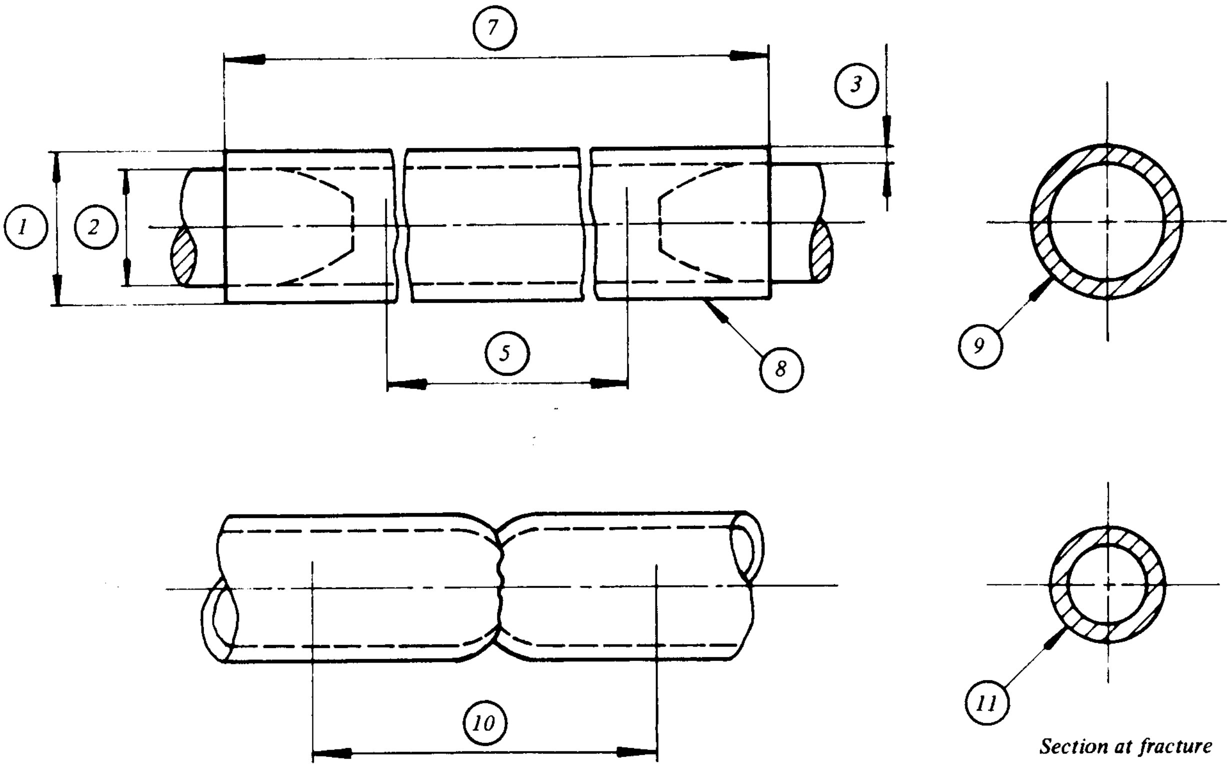

FIG. 1 – Test on full section

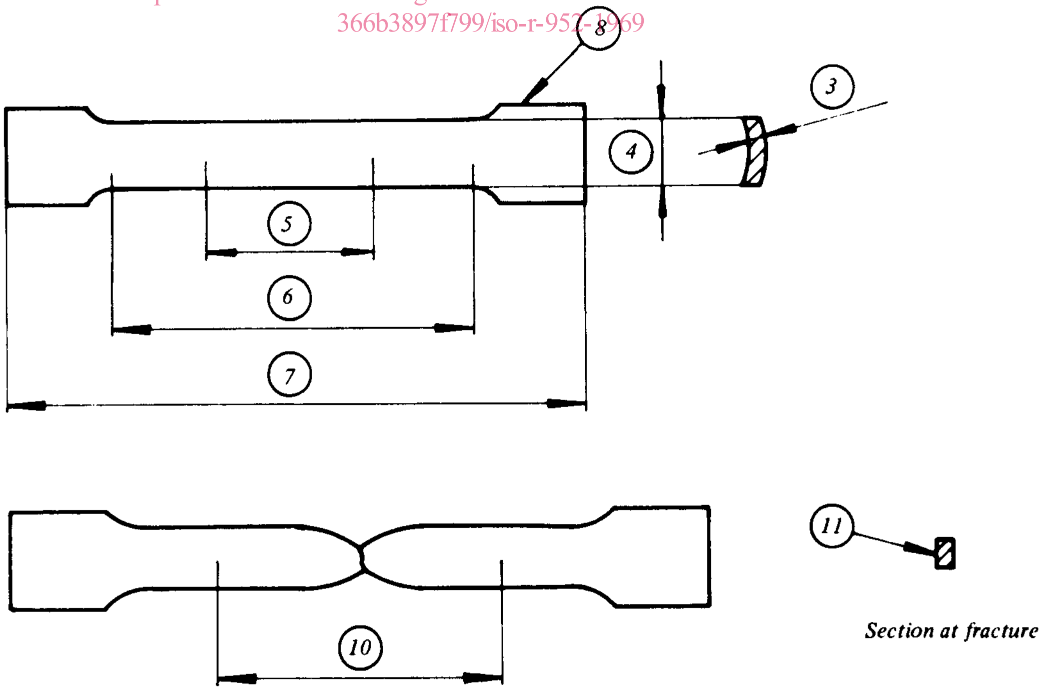

FIG. 2 – Test on longitudinal strip

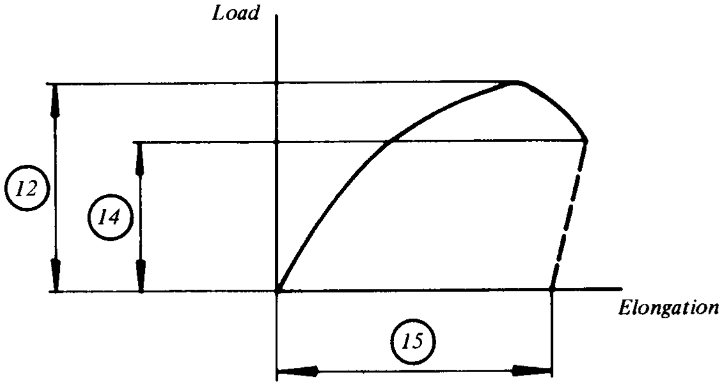

FIG. 3 – Tensile test diagram

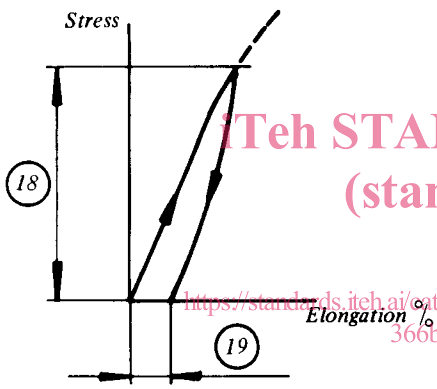

FIG. 4*a* – Determination of permanent set stress

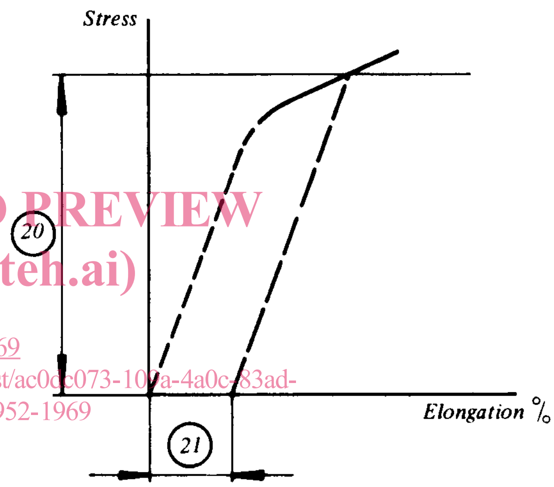

FIG. 4*b* – Determination of proof stress (non-proportional elongation) or yield strength (offset)

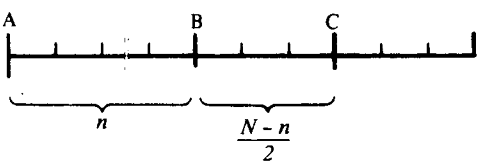

FIG. 5*a*

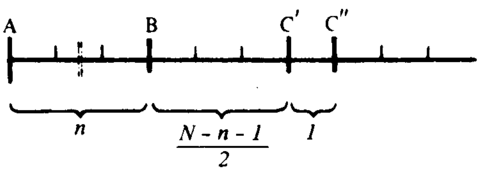

FIG. 5*b*

FIG. 5 – Determination of elongation (see clause 6.2)