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ISO RECOMMENDATION R 1555

COPPER AND COPPER ALLOY ROLLED FLAT PRODUCTS (THICKNESS LESS THAN 2.5 mm (0.1 in))

TENSILE TEST

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BRIEF HISTORY

The ISO Recommendation R 1555, *Copper and copper alloy rolled flat products (thickness less than 2.5 mm (0.1 in)) – Tensile test*, was drawn up by Technical Committee ISO/TC 26, *Copper and copper alloys*, the Secretariat of which is held by the Deutscher Normenausschuss (DNA).

Work on this question led to the adoption of Draft ISO Recommendation No. 1555, which was circulated to all the ISO Member Bodies for enquiry in March 1968.

The Draft was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Australia	Israel	Switzerland
Belgium	Italy	Thailand
Canada	Netherlands	Turkey
Chile	New Zealand	U.A.R.
Finland	Norway	United Kingdom
France	Poland	U.S.A.
Germany	South Africa, Rep. of	Yugoslavia
India	Spain	
Iran	Sweden	

No Member Body opposed the approval of the Draft.

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

ISO Recommendation R 1555 August 1971

COPPER AND COPPER ALLOY ROLLED FLAT PRODUCTS

(THICKNESS LESS THAN 2.5 mm (0.1 in))

TENSILE TEST

1. SCOPE

This ISO Recommendation describes a method of tensile testing rolled flat products of copper and copper alloys of thickness less than 2.5 mm (0.1 in) and not less than 0.15 mm (0.006 in).

By agreement between the purchaser and the supplier, the test may also be applied to material having a thickness less than 0.15 mm, but it is emphasized that special precautions are necessary in order to obtain reproducible results.

2. PRINCIPLE

The test consists in subjecting a test piece to increasing tensile stress, generally to fracture, with a view to determining one or more of the mechanical properties enumerated hereafter. The test is carried out at ambient temperature, unless otherwise specified.

3. DEFINITIONS

3.1 *Gauge length*. At any moment during the test, the length of the portion of the test piece on which an increase in length is measured. In particular, a distinction should be made between the following :

(*a*) *the original gauge length* (L_o). Gauge length before the test piece is strained, and

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

3.3 *Percentage permanent elongation*. Increase in the gauge length of a test piece subjected to a stress after removal of that stress, expressed as a percentage of the original gauge length.

3.4 *Stress at specified permanent set* (R_r). Stress at which, after removal of load, the specified percentage permanent elongation occurs.

3.4.1 The symbol used for this stress is supplemented by an index giving the specified percentage elongation.

3.5 *Proof stress* (R_p)*. Stress at which the specified percentage non-proportional elongation occurs.

3.5.1 The symbol used for this stress is supplemented by an index giving the specified percentage non-proportional elongation.

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

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

3.8 *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.

4. SYMBOLS AND DESIGNATIONS

Reference number	Symbol	Designation
1	a	Thickness of a flat test piece
2	b	Width of a flat test piece
3	L_o**	Original gauge length
4	L_c	Parallel length
5	L_t	Total length
6	–	Gripped ends
7	S_o	Original cross-sectional area of the gauge length
8	L_u	Gauge length after fracture
9	F_m	Maximum load
10	R_m**	Tensile strength
11	$L_u - L_o$	Permanent elongation after fracture
12	A	Percentage elongation after fracture $\frac{L_u - L_o}{L_o} \times 100$
13	R_r	Stress at specified permanent set
14	–	Specified permanent set
15	R_p	Proof stress
16	–	Specified non-proportional elongation

* In the United States of America and Canada this stress is called "yield strength (offset)" in contrast to the stress called "yield strength" which corresponds to a specified total elongation (usually 0.5 % with the test piece under tension).

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

5. TEST PIECE

5.1 The test piece should have a width b of 12.5 mm (0.5 in) or be of the full width of the material if this is less than 12.5 mm (0.5 in). It should have the gauge length L_o = 50 mm (2 in) for thicknesses between 0.5 and 2.5 mm (0.020 and 0.1 in) and the gauge length L_o = 100 mm (4 in) for thicknesses less than 0.5 mm (0.020 in) respectively. Other gauge lengths may be used by agreement between the purchaser and the supplier.

5.2 When the test piece is machined (see clause 5.5) to width b of 12.5 mm (0.05 in) (see clause 5.1), it should have enlarged ends and the parallel length L_c should be not less than $L_o + b$. For a test piece with enlarged ends, there should be a transition radius of not less than 20 mm (0.8 in) between the gripped ends and the parallell length (see Figure 1).

5.3 By agreement, a test piece with parallel sides may be used, and for such a test piece without enlarged ends, the length L_c should be the distance between the inner ends of the grips of the testing machine. This distance should be not less than $L_o + b$.

5.4 The ends of the test pieces should be gripped in a manner ensuring that the centre line of the tension coincides with the longitudinal axis of the test piece and that the tension is uniformly distributed across the width of the ends. To meet these requirements, and to minimize the possibility of tearing and buckling of the test piece, the inserts of the grips should be ground and polished or they should have interlays of material softer than that being tested. The full width of the ends of the test piece should be gripped. One of the grips at least should also be pivoted.

5.5 It is essential that great care be taken during the preparation of the test piece to avoid over-heating or excessive work hardening of the edges. The edges of the test piece should be machined without notches.

5.5.1 For very thin materials, it is recommended that strips having a width of approximately 20 mm (0.8 in) be cut and put together with interlays of paper, the paper being resistant to cutting oil. It is recommended that each parcel of strips be assembled with a thicker strip on each side before machining to final test piece size.

5.5.2 A method of machining is as follows. The assembly of test pieces may be milled using a sharp multi-toothed milling cutter, the direction of traverse being parallel with the longitudinal axis of the test piece.

5.5.3 Alternatively, masking and etching techniques may be used for test piece preparation.

5.5.4 After preparation as described in clause 5.5.3 or 5.5.4, the edges of the test piece should be carefully smoothed in a longitudinal direction with a fine grade of emery paper. If the material is suitable, electro-polishing may also be used.

5.5.5 If, on completion of preparation, any transverse scratch marks are visible when viewed at × 20 magnification, the test piece should be discarded.

6. DETERMINATION OF ELONGATION AFTER FRACTURE

6.1 Mark the gauge length on the test piece before the test, to a suitable accuracy. Perform the marking in such a manner that it does not cause fracture at the gauge marks.

6.1.1 Carefully fit together the fractured parts of the test piece, so that they lie in a straight line. Measure the increase in gauge length after test to the nearest 0.25 mm (0.01 in).

6.1.2 This type of determination is only valid if the distance between the fracture and the nearest end of the gauge length is greater than or equal to 0.25 L_o. To minimize the rejection of tests due to fracture occurring outside this limit, two or more overlapping gauge lengths may be marked on the test piece.

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

7. RATE OF STRAINING

If the rate of straining is considered to be of importance, it should be the subject of special agreement. For the determination of the proof stress it should in no case exceed 0.06/min.

8. MEASUREMENT OF LOAD

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

9. DETERMINATION OF STRESS AT SPECIFIED PERMANENT SET

9.1 Determine this stress by the unloading method as follows : successively apply increasing loads to the test piece and maintain in each case for between 10 and 12 seconds. After removal of each load measure the permanent elongation which the test piece has taken, using a suitable extensometer. Stop the test when this elongation exceeds the specified percentage. The stress corresponding to the specified permanent elongation is then obtained by interpolation. (See Figure 3(*a*).)

9.2 Special agreement may be made for the substitution for this method of the proving test (section 11).

10. DETERMINATION OF PROOF STRESS

10.1 Determine this stress as follows : using a suitable extensometer, plot a curve taking the loads as ordinates and the corresponding elongations as abscissae. Draw a straight line 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 specified percentage of the original gauge length. (See Figure 3(*b*).) The desired stress corresponds to the point of intersection of the straight line and the curve.

10.2 In the case of curves which show no initial straight portion, the required slope may be determined by loading to a stress in the neighbourhood of the proof stress, unloading to a small residual stress, and re-loading without removing the extensometer. A reloading curve will then generally show a straight portion which defines the required slope. (See Figure 3(*c*).)

11. PROVING TEST

For specified permanent set stress : subject the test piece to the load corresponding to the specified permanent set stress for between 10 and 12 seconds, using a suitable extensometer, verify that the permanent elongation, after removal of the load, is not greater than the specified value.

12. TEST REPORT

The test report should include the following particulars :

(*a*) the reference of the method used;
(*b*) the gauge length used, if longer than 50 or 100 mm;
(*c*) the results and the method of expression used;
(*d*) any unusual features noted during the determination;
(*e*) any operation not included in this ISO Recommendation, or regarded as optional.