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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO RECOMMENDATION

R 400

iTeh STANDARD PREVIEW

TENSILE TESTING OF COPPER AND COPPER ALLOYS

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ISO/R 400:1964

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To become ISO 6892-1984

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BRIEF HISTORY

The ISO Recommendation R 400, *Tensile Testing of Copper and Copper Alloys*, 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 by the Technical Committee began in 1958 and led, in 1961, to the adoption of a Draft ISO Recommendation.

In February 1962, this Draft ISO Recommendation (No. 498) was circulated to all the ISO Member Bodies for enquiry. It was approved by the following Member Bodies:

Australia	India	Spain
Bulgaria	Italy	Sweden
Burma	Japan	Switzerland
Canada	Netherlands	Turkey
Denmark	Poland	United Kingdom
Finland	Portugal	U.S.S.R.
Germany	Republic of South Africa	Yugoslavia

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Three Member Bodies opposed the approval of the Draft:

Belgium
France
U.S.A.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in November 1964, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 400 November 1964

TENSILE TESTING OF COPPER AND COPPER ALLOYS

1. SCOPE

This ISO Recommendation applies to the tensile testing of wrought and cast products of copper and copper alloys of diameter not less than 5 mm (0.2 in) or thicknesses not less than 2.5 mm (0.1 in). For the tensile testing of certain products of smaller dimensions and for tubes, other ISO Recommendations are applicable.

2. PRINCIPLE OF TEST

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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.

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3. DEFINITIONS

3.1 *Gauge length.* At any moment during the test, the length of the cylindrical or prismatic 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. (See Fig. 4(a)).

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. (See Fig. (4*b*)).

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

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

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

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3.8 *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.

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3.9 *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.

3.10 *Percentage reduction of area after fracture* (Z). Maximum change in cross-sectional area after fracture, $S_o - S_u$, expressed as a percentage of the original cross-sectional area S_o.

3.11 *Percentage elongation factor at point of constriction* (Z_u). Maximum change in cross-sectional area after fracture, $S_o - S_u$, expressed as a percentage of the minimum cross-sectional area after fracture S_u.

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* 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 per cent) with the test piece under tension.

4. SYMBOLS AND DESIGNATIONS

Number	Symbol	Designation
1	d	Diameter of the circular section of the gauge length of the test piece, or, with other test sections, the diameter of the minimum circumscribing circle*
2	a	Thickness of a flat test piece
3	b	Width of a flat test piece
4	L_o**	Original gauge length
5	L_c	Parallel length
6	L_t	Total length
7	—	Gripped ends
8	S_o	Original cross-sectional area of the gauge length
9	L_u	Gauge length after fracture
10	S_u	Minimum cross-sectional area of the gauge length after fracture
11	F_m	Maximum load
12	R_m**	Tensile strength
13	F_u	Final load, i.e. load at moment of fracture
14	L_u–L_o	Permanent elongation after fracture
15	A	Percentage elongation after fracture $\frac{L_u - L_o}{L_o} \times 100$
16	Z	Percentage reduction of area after fracture $\frac{S_o - S_u}{S_o} \times 100$
17	Z_u	Percentage elongation factor at point of constriction $\frac{S_o - S_u}{S_u} \times 100$
18	R_r	Stress at specified permanent set
19	—	Specified permanent set
20	R_p	Proof stress
21	—	Specified non-proportional elongation

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* The minimum circumscribing circle is the smallest circle which completely circumscribes the whole periphery of the cross-section, but it need not pass through more than two points.

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

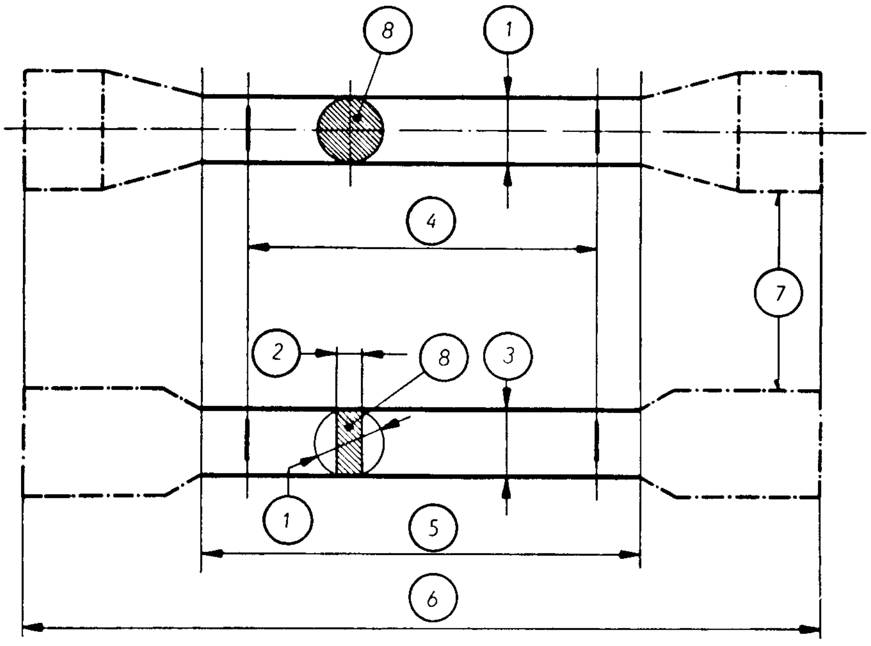

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Fig. 1

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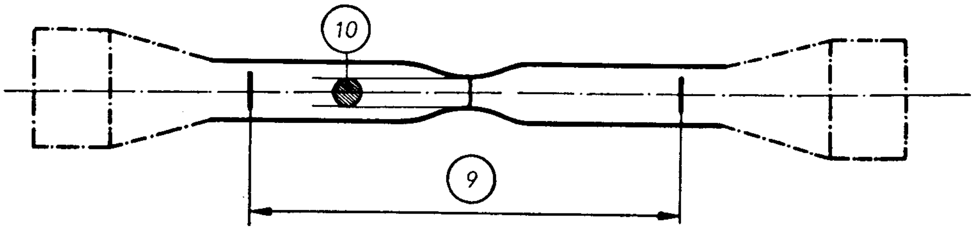

Fig. 2

Note: The form of end of test piece as shown is intended only as a guide.

5. TEST PIECES

5.1 The cross-section of the test piece may be circular, square, rectangular, hexagonal or, in special cases, of other form. For test pieces of rectangular section, it is recommended that a ratio of 4 : 1 for sides should not be exceeded.

5.1.1 There should be a transition radius between the gripped ends and the parallel length of a machined test piece; the gripped ends may be of any shape to suit the holders of the testing machine. Sections, bars, and test pieces cast to shape, etc. may be tested without being machined.

5.2 In general the diameter of machined cylindrical test pieces is not less than 6.0 mm (0.24 in).

5.2.1 Care should be taken during machining to avoid overheating or excessive work hardening the test piece surface.

NOTE
If it is necessary to machine test pieces of smaller diameter, special precautions should be taken to avoid deformation of the test piece.

5.2.2 The sides and edges of flat test pieces should be smooth.

5.3 The parallel length L_c should be parallel within 0.05 mm (0.002 in) of the mean value of the diameter or width. Unmachined surfaces should be parallel within 0.25 mm (0.01 in) of the mean value of the thickness.

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5.4 In general, the cross-sectional area is calculated from measurements of the necessary dimensions with an accuracy of $\pm$ 0.5 per cent in each dimension. Where this accuracy cannot readily be obtained, the method of measurement should be specified in the material specification.

5.5 As a general rule, only test pieces complying with the requirement that $L_o = k\sqrt{S_o}$, where k may be equal to 4–4.5–5.65–8.16 or 11.3, are used for the tensile test; these test pieces are known as proportional test pieces.

5.5.1 The value of L_o thus calculated should be rounded off to the nearest 5 mm (0.2 in).

5.5.2 As a general rule, it is recommended that the value of k should be 5.65 except for material of small section if the calculated gauge length L_o with $k = 5.65$ is less than 25 mm. In this case k should normally be 11.3.

The use of the other values of k, namely $k = 4 - 4.5$ and 8.16 should be regarded as an interim measure and these should be used only in connection with existing specifications. These values of k may be deleted after a period to be determined later.

5.6 The parallel length L_c is between $L_o + \frac{d}{2}$ and $L_o + 2d$.

5.6.1 Provided there is sufficient material, the length $L_o + 2d$ is always used for arbitration purposes.

5.7 If test pieces with rectangular cross-sections are to be cut from a batch of sections, a uniform parallel length is adopted which should lie between $L_0 + d$ and $L_0 + 2d$, where L_0 and d refer to the test piece of the batch with the largest cross-section.

5.8 In special circumstances test pieces other than proportional test pieces, as defined in Clause 5.5, may be used by prior agreement.

5.8.1 If non-proportional test pieces are used, the gauge length used and the cross-section of these test pieces should be mentioned in the test report.

6. DETERMINATION OF ELONGATION AFTER FRACTURE

6.1 The gauge length is marked on the specimen before the test to a suitable accuracy. The marking is performed in such a manner that it does not cause fracture at the gauge marks.

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 the nearest 0.25 mm (0.01 in).

6.1.2 This type of determination is valid only if the distance between the fracture and the nearest gauge mark is greater than or equal to 0.25 L_0.

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

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6.2 To avoid the possibility of rejection of test pieces due to the fracture being outside the limits specified in Clause 6.1.2, the following method may be employed:

6.2.1 Before testing, subdivide the gauge length L_0 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 be 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

$$\text{at } \frac{N-n}{2} \text{ intervals from } B;$$

then calculate the elongation after fracture from the formula:

$$A = \frac{AB + 2BC - L_0}{L_0} \times 100.$$

(*b*) If $N - n$ is an uneven number (see Fig. 5 (*b*)), measure the distance between *A* and *B* and the distance from *B* to the graduation marks *C′* and *C″*

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

then calculate the elongation after fracture from the formula:

$$A = \frac{AB + BC' + BC'' - L_0}{L_0} \times 100.$$

7. RATE OF LOADING

If the rate of loading 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 1 kgf/mm² (0.6 tonf/in²) per second.

8. MEASUREMENT OF LOAD

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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.*

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9. DETERMINATION OF STRESS AT SPECIFIED PERMANENT SET

9.1 The unloading method of determining this stress is 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, using a suitable extensometer. The test is stopped when this elongation exceeds the specified percentage. The stress corresponding to the specified permanent elongation is then obtained by interpolation.

9.2 Special agreement may be made for the substitution for this method of the proving test (Clause 11.1).

10. DETERMINATION OF PROOF STRESS

10.1 This stress is determined as follows: Using a suitable extensometer, a curve is plotted, 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 specified percentage of the original gauge length. (See Fig. 4 (*b*)). The desired stress corresponds to the point of intersection of the straight line and the curve.