# INTERNATIONAL STANDARD ISO 89

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION •МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

# Steel — Tensile testing of wire

*Acier — Essai de traction des fils*

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## FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up has the right to be represented on that Committee International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 89 was drawn up by Technical Committee ISO/TC 17, *Steel,* and circulated to the Member Bodies in March 1972.

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It has been approved by the Member Bodies of the following countries :

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| Denmark | Netherlands | United Kingdom |
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The Member Body of the following country expressed disapproval of the document on technical grounds :

Norway

This International Standard cancels and replaces ISO Recommendation R 89-1959.

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## 1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies requirements for the tensile testing of steel products which have usually been cold-worked and are of constant cross-section, either round, square, rectangular, or special. The dimensions of the cross-section are always very small compared with the usual lengths produced, and for wire of rectangular or special cross-section the ratio of width to thickness is generally less than 4. The diameter, or other characteristic dimension, is usually not greater than 10 mm.

For the tensile testing of other steel products, ISO 82, ISO 86 and ISO 375 are applicable.

## 2 REFERENCES

ISO 82, *Steel — Tensile testing.*

ISO 86, *Steel — Tensile testing of sheet and strip less than 3 mm and not less than 0,5 mm thick.*

ISO 375, *Steel — Tensile testing of tubes.*

ISO/R 147, *Load calibration of testing machines for tensile testing of steel.*

ISO/R 205, *Determination of proof stress and proving test for steel at elevated temperatures.*

ISO/R 783, *Mechanical testing of steel at elevated temperatures — Determination of lower yield stress and proof stress and proving test.*

ISO 2573, *Determination of* K-*values of a tensile testing system.* 1)

## 3 PRINCIPLE

The test consists in straining a test piece by 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. For tests at elevated temperatures, ISO/R 205 and ISO/R 783 are applicable.

1) At present at the stage of draft.

## 4 DEFINITIONS

**4.1 gauge length :** The prescribed part of the cylindrical or prismatic portion of the test piece on which elongation is measured at any moment during the test. In particular, a distinction is to be made between the following :

**4.1.1 original gauge length** ($L_o$) **:** Gauge length before the test piece is strained;

**4.1.2 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.

**4.2 extensometer gauge length** ($L_e$) **:** The length of the parallel portion of the test piece used for the measurement of extension by means of an extensometer. (The length may differ from $L_o$).

**4.3 percentage permanent elongation :** Increase in the gauge length of a test piece subjected to a prescribed stress (see 4.11) and after removal of the stress, expressed as a percentage of the original gauge length. If a symbol for this elongation is used, it is to be supplemented by an index indicating the prescribed stress.

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**4.4 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, $L_o$.

NOTE – The symbol $A$ is to be supplemented by a suffix denoting the gauge length. The suffix units are to be identified, for example $A_{10d}$, $A_{200\text{ mm}}$.

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**4.5 percentage reduction of area** ($Z$) **:** Ratio of the maximum change in 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. ($S_u$ = minimum cross-sectional area after fracture.)

**4.6 maximum load** ($F_m$) **:** The highest load which the test piece withstands during the test.

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

**4.8 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.

**4.9 proof stress (non-proportional elongation)** ($R_p$) **:** The stress at which a non-proportional elongation, equal to a specified percentage of the original gauge length, occurs. (See figure 2.)

When a proof stress ($R_p$) is specified, the non-proportional elongation is to be stated (for example 0,2 %) and the symbol used for the stress is to be supplemented by an index giving this prescribed percentage of the original gauge length, for example $R_{p0,2}$.

**4.10 proof stress (total elongation)** or **proof stress under load** ($R_t$) **:** The stress at which a non-proportional elongation plus elastic elongation, equal to a specified percentage of the original gauge length, occurs. (See figure 3.)

When a proof stress ($R_t$) is specified, or agreed between the interested parties, the total elongation is to be stated and the symbol used for the stress is to be supplemented by an appropriate index, for example $R_{t0,5}$.

NOTE – The value obtained by this total elongation method will only be equivalent to $R_p$ if suitable allowance is made for the measurement of elastic extension.

**4.11 permanent set stress** ($R_r$); **(stress at permanent set limit) :** The stress at which, after removal of load, a prescribed permanent elongation, expressed as a percentage of the original gauge length, occurs. The symbol used for this stress is to be supplemented by an index giving the prescribed percentage of the original gauge length, for example $R_{r0,2}$ (See figure 4.)

## 5 SYMBOLS AND DESIGNATIONS

Symbols and designations are given in the table below.

| Number | Preferred symbol | Designation |
|---|---|---|
| 1 | $d$ | Diameter or characteristic dimension of round wire (Figure 1) |
| 2 | $a$ | Thickness of flat wire (Figure 1) |
| 3 | $b$ | Width of flat wire (Figure 1) |
| 4 | $L_o$ [1] | Original gauge length (Figure 1) |
| 5 | $L_c$ | Parallel length |
| — | $L_e$ | Extensometer gauge length |
| 6 | $L_t$ | Total length (Figure 1) |
| 7 | — | Gripped ends (Figure 1) |
| 8 | $L_u$ | Final gauge length after fracture (Figure 1) |
| 9 | $L_u - L_o$ | Permanent elongation after fracture (Figure 5) |
| 10 | $A$ | Percentage elongation after fracture<br>$\left(\frac{L_u - L_o}{L_o}\right) 100$ |
| | (e.g. $A_{200\ mm}$) | (Percentage elongation on a gauge length of 200 mm) |
| 11 | $S_o$ | Original cross-sectional area of the gauge length (Figure 1) |
| 12 | $S_u$ | Minimum cross-sectional area after fracture (Figure 1) |
| 13 | $R_p$<br>(e.g. $R_{p0,2}$) | Proof stress (non-proportional elongation) or yield strength (offset)[2] (Figure 2)<br>(0,2 % proof stress) |
| 14 | $R_t$<br>(e.g. $R_{t0,5}$) | Proof stress (total elongation) or yield strength (total elongation)[2] (Figure 3)<br>(0,5 % total elongation) |
| 15 | $R_r$<br>(e.g. $R_{r0,2}$) | Permanent set stress (Figure 4)<br>(0,2 % permanent set stress) |
| 16 | $F_m$ | Maximum load |
| 17 | $Z$ | Percentage reduction of area<br>$\left(\frac{S_o - S_u}{S_o}\right) 100$ |
| 18 | $R_m$ [1] | Tensile strength $\frac{F_m}{S_o}$ (Figure 5) |

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

2) The latter term is used in the U.S.A. and in Canada.

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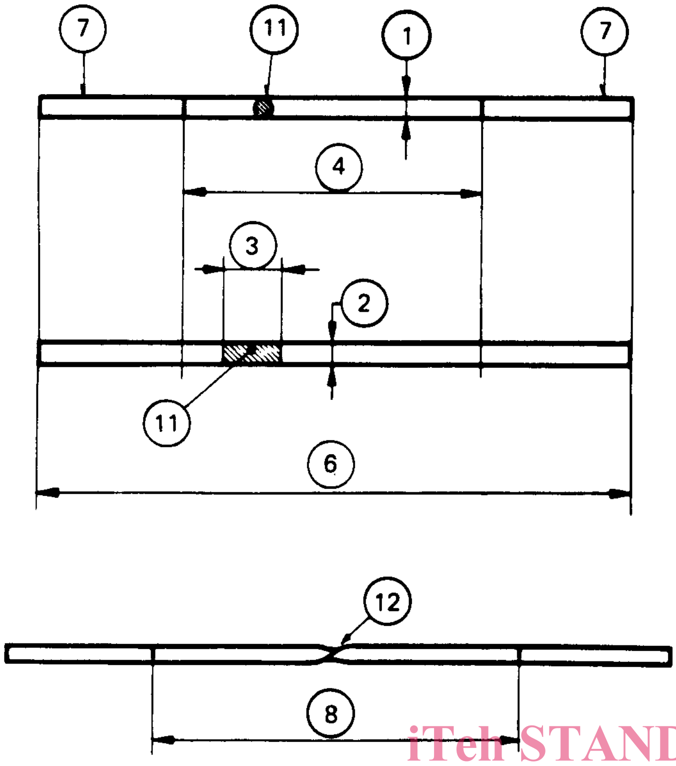


FIGURE 1

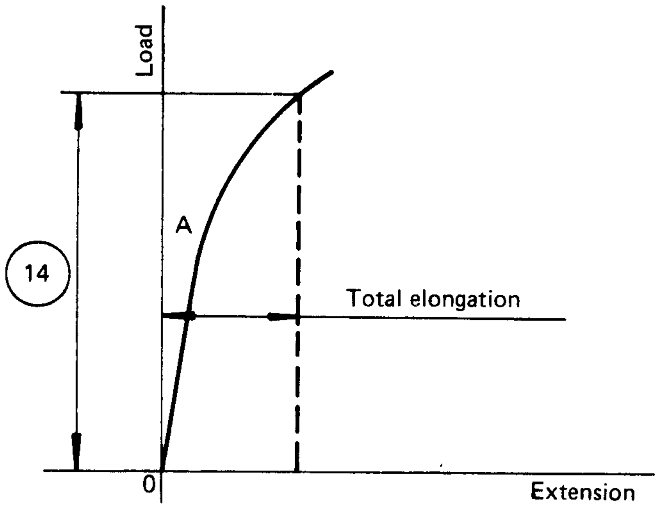


FIGURE 3

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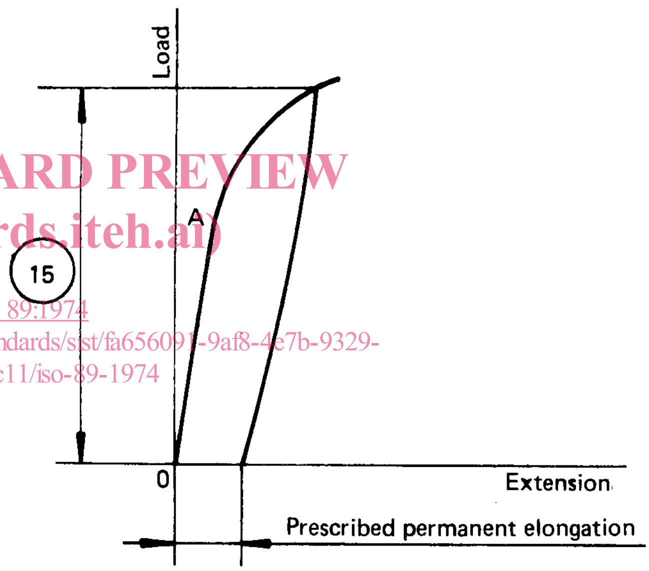


FIGURE 4

**Load/extension diagrams :**

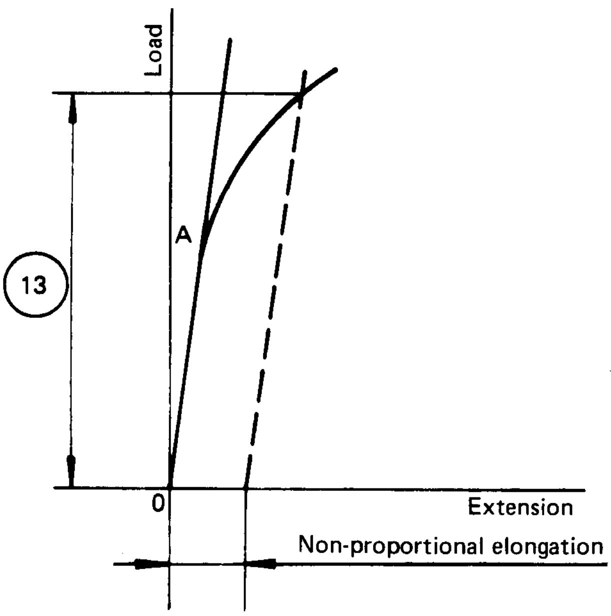


FIGURE 2

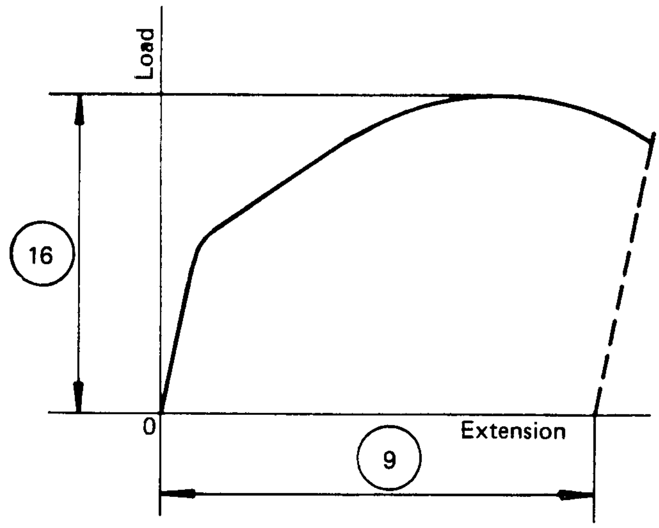


FIGURE 5

A = Elastic limit

## 6 TEST PIECES

**6.1** The cross-section of the test piece is to be that of the wire.

**6.2** As proportional test pieces are not generally appropriate for tests on wire, the usual gauge length is 100 mm or 200 mm and preference should be given to the latter. For diameters of 4 mm and greater, the minimum practical gauge length is usually 10 *d*. As an interim measure, gauge lengths of 50 mm and 250 mm are permitted.

**6.3** The distance between grips is to be at least 50 mm greater than the gauge length.

**6.4** If possible, the test piece should not be straightened before testing. If straightening is necessary, it shall be done by hand or, if this is not practicable, by using a hammer having a head of wood, plastics or other suitable material, the wire being supported on a flat surface of wood or other suitable material.

## 7 DETERMINATION OF CROSS-SECTIONAL AREA

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**7.1** The cross-sectional area shall be calculated from measurements of the appropriate dimensions with an error on each dimension of not more than ± 0,5 % for wire of 3 mm and larger, and ± 1,0 % for wire of less than 3 mm.

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**7.2** By agreement between the parties concerned, for wires having dimensions complying with the tolerances of a material specification, the nominal dimensions may be used in calculations.

**7.3** By agreement between the parties concerned, for wires of special shape the cross-sectional area may be determined from the mass of a known length and its density.

## 8 MARKING THE ORIGINAL GAUGE LENGTH

**8.1** When the elongation is to be determined, the test piece shall be marked throughout the length between grips, except for a distance of at least 2 *d*, with gauge marks spaced at intervals equal to half the gauge length to an accuracy of ± 0,5 mm.

**8.2** The test piece shall be straight before it is marked with either fine ink lines or superficial scribed lines. The latter may be made more easily visible by first painting the wire with a quick-drying ink or dye.

## 9 METHOD OF GRIPPING

**9.1** Test pieces are to be held by wedge grips having serrations which will produce the minimum depth of notch in the wire commensurate with effective grip. Soft metal inserts coated with carborundum may be used with very sensitive materials or small wires. Capstans or similar means are preferable for holding the smallest diameter wires.

**9.2** Every endeavour must be made to ensure that test pieces are held in such a way that the load is applied as axially as posssible. This is of particular importance when testing brittle material or when determining proof stress or yield stress.

## 10 ACCURACY OF TESTING EQUIPMENT

**10.1** The testing machine shall be calibrated in accordance with ISO/R 147, and should be maintained to grade 1,0 except when grade 0,5 is required by the standard for the material.

**10.2** Where appropriate (see also 12.2), the apparent elastic compliance (*K*) of the tensile testing system shall be determined in accordance with ISO 2573.

**10.3** The instrument error of an extensometer or proof stress indicator shall not exceed 5 % of the value of the elongation for which the stress value is obtained.

## 11 DETERMINATION OF PROPERTIES

The appropriate properties to be determined are to be stated in the specification for the material and determined in accordance with the procedures described in clauses 12 to 17.

NOTE – Attention is drawn to 4.9 and 4.10 regarding the appropriate proof stresses to be stated.

## 12 OBSERVATIONS ON LOAD/EXTENSION DIAGRAMS

**12.1** Observations of extension made at a sequence of increasing loads during a tensile test may be used to derive corresponding values of stress and strain. One of a variety of diagrams may be produced (for example figures 2 to 5).

**12.2** In cases where a yield stress (yield point) determination is required, reference should be made to ISO 82.

## 13 DETERMINATION OF PROOF STRESSES (YIELD STRENGTHS)

**13.1** For the determination of proof stress (non-proportional elongation), $R_p$, or proof stress (total elongation), $R_t$, the rate of application of stress in the elastic range shall not exceed 30 $N/mm^2 \cdot s$ (1.9 $tonf/in^2 \cdot s$) and may be within the range 3 to 30 $N/mm^2 \cdot s$. For both methods an extensometer shall be used.

**13.2** Proof stress (non-proportional elongation) ($R_p$) is determined from a load/extension diagram on which a line is drawn parallel to the straight portion of the curve and distant from it by the required non-proportional amount, for example 0,2 %. The point at which the line cuts the curve represents the required proof stress. (See figure 2.)

**13.2.1** Accurate determination of the load/extension diagram is necessary (see 10.2). The curve may be obtained by either automatic or manual methods. However, the use of a proof stress indicator, without the production of a load/extension diagram, is permitted.

**13.2.2** The required percentage elongation at which a proof stress is to be determined shall be stated in the specification for the material.

**13.3** Proof stress (total elongation) ($R_t$) is illustrated in the load/extension diagram shown in figure 3 on which a line is drawn parallel to the $y$-axis of the diagram and distant from it by the required total elongation. The stress at which the extensometer indicates the total elongation represents the required proof stress.

The required total elongation at which the proof stress is to be determined shall be stated in the specification for the material or agreed between the interested parties.

## 14 PROVING TESTS FOR PERMANENT SET STRESS

**14.1** If a permanent set stress is specified or agreed, the small tensioning stress stated in the specification for the material shall be applied to the test piece. The stress is increased to the specified value and maintained for 10 to 15 s. It is then reduced below the initial tensioning stress and then increased to it.

**14.2** It shall be verified that the gauge length, when measured with an extensometer, has not acquired a permanent extension greater than the specified percentage of the extensometer gauge length.

## 15 DETERMINATION OF TENSILE STRENGTH

**15.1** If values of proof stress are to be determined during the test, the rate of application of stress shall comply with the requirements given in 13.1 until the required proof stress has been determined. Thereafter the rate may be increased, but the maximum rate of application of stress after proof stresses have been determined shall not exceed 100 N/mm$^2$·s (6.35 tonf/in$^2$·s).

**15.2** When the tensile strength only is to be determined, the maximum rate of application of stress throughout the test shall not exceed 100 N/mm$^2$·s (6.35 tonf/in$^2$·s).

**15.3** In all cases, the speed of testing shall be as uniform as possible and the change of speed from one range to the other shall be made without shock.

**15.4** The tensile strength is to be determined in accordance with the definition given in 4.8.

**15.5** When failure occurs at or within the grips, the test piece may be discarded and a further test carried out.

## 16 DETERMINATION OF PERCENTAGE ELONGATION AFTER FRACTURE

**16.1** The percentage elongation after fracture is to be determined in accordance with the definition given in 4.4. The final gauge length shall be measured to an accuracy of ± 0,5 mm.

**16.2** Any statement of the results of a percentage elongation test shall include the gauge length.

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**16.3** The full value of the percentage elongation may not be obtained unless fracture of the test piece has occurred at a section situated between the gauge marks, and at a sufficient distance from the nearest gauge mark. Care must be taken to ensure proper contact between the broken parts of the test piece when measuring the final length between gauge marks. This is of particular importance when measuring test pieces of small cross-section and test pieces having low elongation values. The wire pieces shall be supported against a straight edge and may be conveniently held in position by Plasticine while measurement of the increase in gauge length is made between the two marks on either side of the mark nearest to the fracture. For wires having low elongation values, measurement shall be made with a vernier gauge.

## 17 DETERMINATION OF PERCENTAGE REDUCTION OF AREA

**17.1** Unless otherwise specified, the percentage reduction of area is only to be determined on wires having a diameter of 3 mm and greater.

**17.2** The percentage reduction of area is to be determined in accordance with the definition given in 4.5.