11 Determination of the upper yield strength

R_{eH} may be determined from the force-extension curve or peak load indicator and is defined as the maximum value of stress prior to the first decrease in force. The latter is obtained by dividing this force by the original cross-sectional area of the test piece, S_o (see Figure 2).

12 Determination of the lower yield strength

R_{eL} is determined from the force-extension curve and is defined as the lowest value of stress during plastic yielding, ignoring any initial transient effects. The latter is obtained by dividing this force by the original cross-sectional area of the test piece, S_o (see Figure 2).

For productivity of testing, R_{eL} may be reported as the lowest stress within the first 0,25 % strain after R_{eH}, not taking into account any initial transient effect. After determining R_{eL} by this procedure, the test rate may be increased as per 10.3.4. Use of this shorter procedure should be recorded on the test report.

NOTE This clause only applies to materials having yield phenomena and when A_e is not to be determined.

13 Determination of proof strength, plastic extension

13.1 R_p is determined from the force-extension curve by drawing a line parallel to the linear portion of the curve and at a distance from it equivalent to the prescribed plastic percentage extension, e.g. 0,2 %. The point at which this line intersects the curve gives the force corresponding to the desired proof strength plastic extension. The latter is obtained by dividing this force by the original cross-sectional area of the test piece, S_o (see Figure 3).

If the straight portion of the force-extension curve is not clearly defined, thereby preventing drawing the parallel line with sufficient precision, the following procedure is recommended (see Figure 6).

When the presumed proof strength has been exceeded, the force is reduced to a value equal to about 10 % of the force obtained. The force is then increased again until it exceeds the value obtained originally. To determine the desired proof strength, a line is drawn through the hysteresis loop. A line is then drawn parallel to this line, at a distance from the corrected origin of the curve, measured along the abscissa, equal to the prescribed plastic percentage extension. The intersection of this parallel line and the force-extension curve gives the force corresponding to the proof strength. The latter is obtained by dividing this force by the original cross-sectional area of the test piece, S_o (see Figure 6).

NOTE 1 Several methods can be used to define the corrected origin of the force-extension curve. One of these is to construct a line parallel to that determined by the hysteresis loop so that it is tangential to the force-extension curve. The point where this line crosses the abscissa is the corrected origin of the force-extension curve (see Figure 6).

NOTE 2 The plastic strain at the starting point of force reduction is only slightly higher than the specified plastic extension of R_p. Starting points at much higher strain values reduce the slope of the line through the hysteresis loop.

NOTE 3 If not specified in product standards or agreed by the customer, it is inappropriate to determine proof strength during and after discontinuous yielding.

13.2 The property may be obtained without plotting the force-extension curve by using automatic devices (microprocessor, etc.), see Annex A.

NOTE Another available method is described in GB/T 228[12].

14 Determination of proof strength, total extension

14.1 R_t is determined on the force-extension curve, taking 10.2 into consideration, by drawing a line parallel to the ordinate axis (force axis) and at a distance from this equivalent to the prescribed total percentage extension. The point at which this line intersects the curve gives the force corresponding to the desired proof strength. The latter is obtained by dividing this force by the original cross-sectional area of the test piece, S_o (see Figure 4).

14.2 The property may be obtained without plotting the force-extension curve by using automatic devices (see Annex A).

20 Determination of percentage elongation after fracture

20.1 Percentage elongation after fracture shall be determined in accordance with the definition given in 3.4.2.

For this purpose, the two broken pieces of the test piece shall be carefully fitted back together so that their axes lie in a straight line.

Special precautions shall be taken to ensure proper contact between the broken parts of the test piece when measuring the final gauge length. This is particularly important for test pieces of small cross-section and test pieces having low elongation values.

Calculate the percentage elongation after fracture, A, from Equation (5):

$$A = \frac{L_u - L_o}{L_o} \times 100 \tag{5}$$

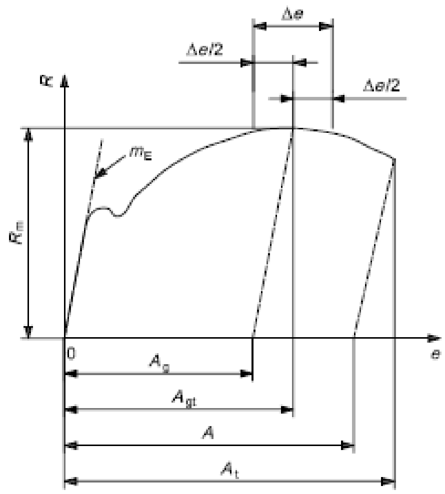
where

L_o is the original gauge length;

L_u is the final gauge length after fracture.

Elongation after fracture, $L_u - L_o$, shall be determined to the nearest 0,25 mm or better using a measuring device with sufficient resolution.

If the specified minimum percentage elongation is less than 5 %, it is recommended that special precautions be taken (see Annex G). The result of this determination is valid only if the distance between the fracture and the nearest gauge mark is not less than $L_o/3$. However, the measurement is valid, irrespective of the position of the fracture, if the percentage elongation after fracture is equal to or greater than the specified value.



Key

A percentage elongation after fracture [determined from the extensometer signal or directly from the test piece (see 20.1)]

A_g percentage plastic extension at maximum force

A_{gt} percentage total extension at maximum force

A_t percentage total extension at maximum fracture

e percentage extension

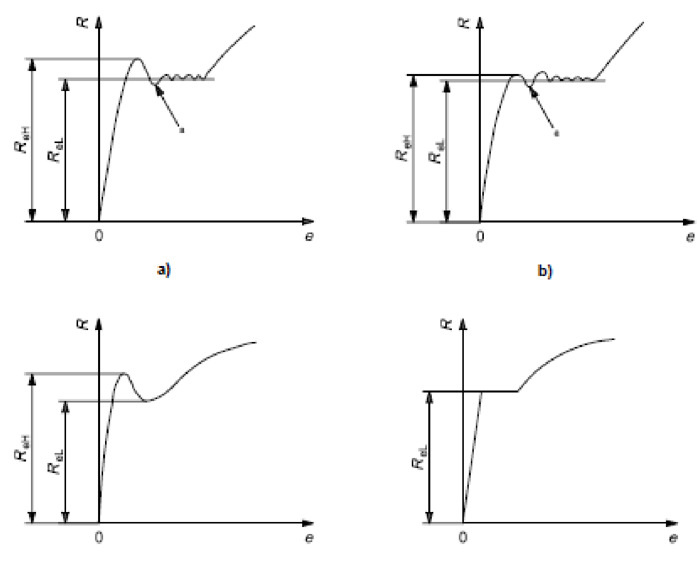
m_E slope of the elastic part of the stress-percentage extension curve

R stress

R_m tensile strength

Δe plateau extent (for determination of A_g, see Clause 17, for determination of A_{gt}, see Clause 18)

Figure 1 — Definitions of extension



Key

e percentage extension

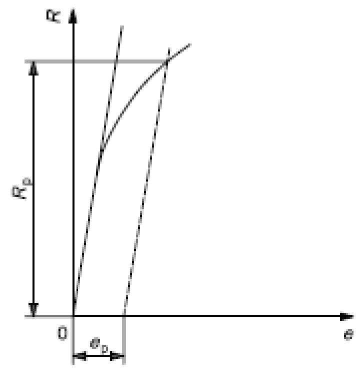
R stress

R_{eH} upper yield strength

R_{eL} lower yield strength

[a] Initial transient effect.

Figure 2 — Examples of upper and lower yield strengths for different types of curve



Key

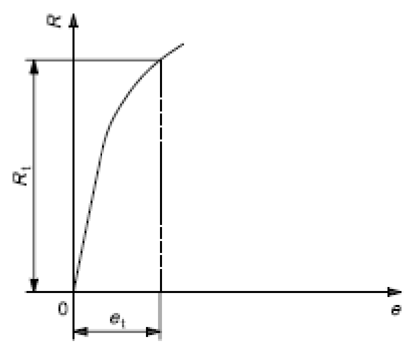
e percentage extension

e_p specified percentage plastic extension

R stress

R_p proof strength, plastic extension

Figure 3 — Proof strength, plastic extension, R_p (see 13.1)



Key

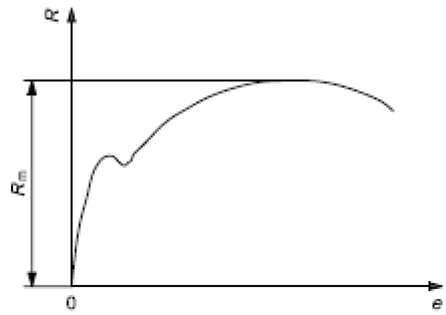
e percentage extension

e_t percentage total extension

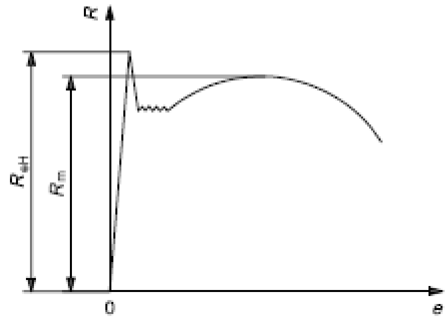
R stress

R_t proof strength, total extension

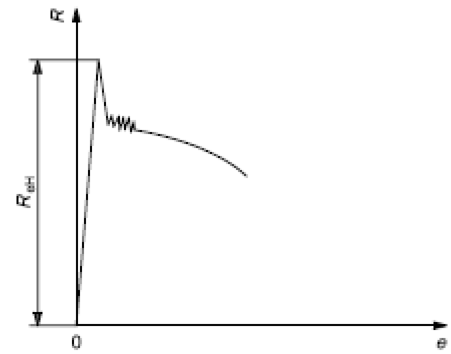
Figure 4 — Proof strength, total extension, R_t



a) $R_{eH} < R_m$



b) $R_{eH} > R_m$



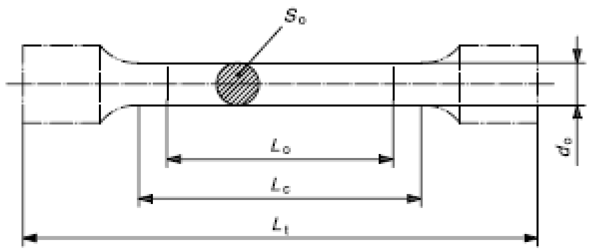
c) Special case of stress-percentage extension behaviour [a]

Key

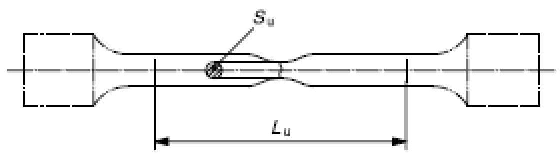
e percentage extension
R stress
R_{eH} upper yield strength
R_m tensile strength

[a] For materials which display this behaviour, no tensile strength is defined according to this part of ISO 6892. If necessary, separate agreements can be made between the parties concerned.

Figure 8 — Different types of stress-extension curve for determination of tensile strength, R_m



a) **Before testing**



b) **After testing**

Key

d_o original diameter of the parallel length of a circular test piece
L_c parallel length
L_o original gauge length
L_t total length of test piece
L_u final gauge length after fracture
S_o original cross-sectional area of the parallel length
S_u minimum cross-sectional area after fracture

NOTE The shape of the test-piece heads is only given as a guide.

Figure 13 — Machined test pieces of round cross-section (see Annex D)

D.2.3 Original gauge length

D.2.3.1 Proportional test pieces

As a general rule, proportional test pieces are used where L_o is related to the original cross-sectional area, S_o, by Equation (D.1):

$$L_o = k\sqrt{S_o} \quad \text{(D.1)}$$

where k is equal to 5,65.

Alternatively 11,3 may be used as the k value.

Test pieces of circular cross-section should preferably have one set of dimensions given in Table D.1.

Table D.1 — Circular cross-section test pieces

Coefficient of proportionality k	Diameter d mm	Original gauge length $L_o = k\sqrt{S_o}$ mm	Minimum parallel length L_c mm
5,65	20	100	110
	14	70	77
	10	50	55
	5	25	28