

EDS

Engineering,
GM DAEWOO Auto & Technology.
Standards

TENSILE TEST OF METALLIC MATERIALS

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1. PURPOSE

This standard aims at helping test personnel perform the test in an appropriate method by describing the measuring method of tensile strength, yield point, yield strength, yield elongation, fracture elongation, and reduction of area of metallic materials with tensile loads applied to the test piece.

2. SCOPE

This standard specifies the method for tensile testing of metallic materials.

3. DEFINITIONS

3.1. NOMINAL STRESS

Nominal Stress is the Tensile Load applied to a test piece divided by Initial Cross-section area. In general, stress refers to nominal stress.

$$\text{NOMINAL STRESS (N/mm}^2\text{)} = \text{LOAD (N)} / \text{INITIAL CROSS-SECTION AREA (mm}^2\text{)}$$

3.2. NOMINAL STRAIN

The difference between the length between two marked positions extended during an tensile testing and the original distance between the marked positions is called 'deformation.' Deformation divided by the Initial Marked Distance is called Nominal Strain (called 'Strain,' in general). Nominal Strain is expressed in percentage in general.

3.3. YIELD POINT PHENOMENON

The phenomenon where load increases, rapidly decreases, then maintains uniform load on the average while deformation increases during a tensile testing. (Portion A of Fig. 1)

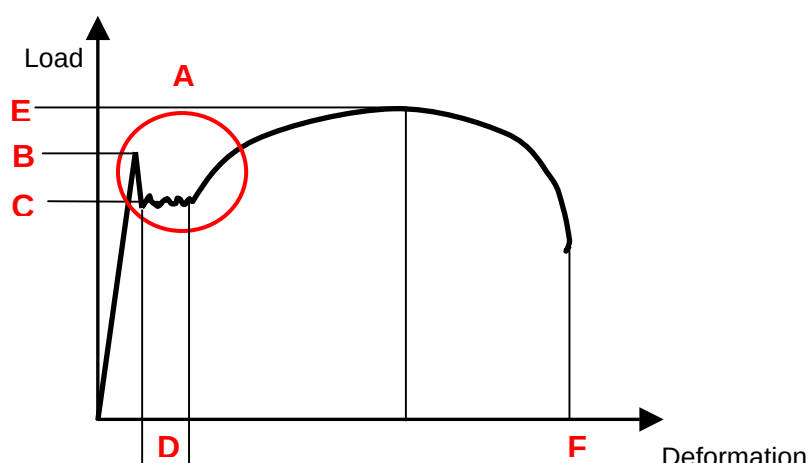


Fig. 1. Load vs Deformation curve of a material where Yield Point Phenomenon occurs

3.3.1. UPPER YIELD POINT, UPPER YIELD STRESS

The max load immediately before a Parallel Section of the test piece begins to yield, divided by Initial Cross-

section area. (B of Fig. 1)

3.3.2. LOWER YIELD POINT, LOWER YIELD STRESS

The minimum load under almost uniform load condition after yield point of test piece, divided by Initial Cross-section area in a tensile testing. (C in Fig. 1)

3.3.3. YIELD POINT ELONGATION

The change in the gauge length from yield point of a Parallel Section of sample followed by deformation increase under almost uniform stress condition and a stress increase afterwards, expressed in percentage of the marked point distance. (D in Fig. 1)

3.4. YIELD STRESS

The point where a Parallel Section of a test piece begins plastic deformation after tensile deformation is called Yield Point. The load at Yield Point divided by the initial cross-section area is called Yield Stress. In reality, it is very difficult to accurately measure the yield point. Therefore, yield stress is obtained using Offset Method, Permanent Elongation Method or Total Elongation Method.

3.5. ULTIMATE TENSILE STRESS

Max Tensile Load divided by the initial cross-section area of Parallel Section. (E in Fig. 1)

3.6. FRACTURE STRAIN

The permanent strain of the gauge length after fracture. It is called generally "strain".(Fig 1. F)

3.7. REDUCTION RATE OF AREA

The ratio of the difference between the least cross-sectional area of the test piece after fracture and the original cross-sectional area to the latter, expressed in a percentage.

4. TEST PIECE

Refer to Appendix 1 "Metal Material Tensile Test Piece."

5. TESTING MACHINE

5.1. The testing machine used for tensile test shall conform to DIN 51221, ASTM E4 or KS B 5521 and shall be composed of load moving device, load measuring device, test piece grip holders and strain measuring device.

5.2. The testing machine shall be installed on a right foundation and not be shaken.

5.3. In the case where the testing machine has been overhauled and reassembled or subjected to modification of its main part or reinstallation, it shall be used only after being verified in accordance with DIN 51221, ASTM E4 or KS B 5521.

5.4. The machine shall be verified again for accuracy at certain intervals, excepting the case prescribed in 5.3.

6. TEST PROCEDURE

6.1. Preparation of test equipment

Test equipment must be warmed up prior to testing until its temperature reaches normal level. Test shall be conducted in general in the temperature range of 10 ~ 35 °C, where the temperature shall be recorded. For materials that are sensitive to temperature change, test temperature shall be 23 ± 5 °C and the material's specification shall be followed.

6.2. Marking and measurement of gauge length

Gauge length shall be marked on a test piece using a sharp device or pen. Be careful not to make notches when marking gauge length on a material that is sensitive to notches. The gauge length shall be measured to an accuracy of at least 0.4% of the nominal gauge length using a suitable measuring instrument. In the case where a gauge marker or an extensometer having a definite gauge length is used, their gauge lengths shall be calibrated beforehand in accordance with the clause above mentioned. If the error of the extensometer gauge length is found to be not more than 1.0% of the nominal gauge length upon calibration, the nominal gauge length may be taken as the original gauge length.

6.3. Obtaining method of original cross-section area

6.3.1. The original cross-sectional area of parallel portion of test piece (except tubular one) shall be the average of three measurements taken at both ends and the centre of the gauge length. However, for a test piece with taper made for a proper reason, the original cross-sectional area shall be that measured at the thinnest cross section.

For a tubular test piece, the original cross-sectional area shall be measured at the ends of the test piece.

6.3.2. When determining the cross-sectional area of circular section or tubular test piece, the diameter shall be the average of the measurements in two perpendicular directions.

The thickness for determining the cross-sectional area of tubular test piece shall be the average of not less than three measurements taken at the locations equally dividing the circumference of tube ends.

Remark: The average of the differences of inside and outside diameters of a tubular test piece, measured in two perpendicular directions may be substituted by the average of wall thickness at four locations.

6.3.3. For determining the cross-sectional area, the diameters or widths and thickness shall be measured at least to the nearest 0.5% of the specified dimension, but at least to the nearest 0.01 mm for a dimension of not more than 2 mm.

6.3.4. For a test piece of circular or rectangular cross section, where the accuracy of finishing test piece is so satisfactorily controlled that the finished diameter or thickness and width may be uniform over its parallel length and the variation of dimension(the maximum value minus the minimum value) may not exceed the tolerances as given in Table 3, the measurement of the cross-sectional area at one location may be taken, instead of the average of cross-sectional areas at three locations specified in (1), for the original cross-sectional area.

In the case where the differences between the finished dimensions of machined parallel portion and the respective nominal dimensions do not exceed the tolerances as given in Table 3, the original cross-sectional

area may be determined from the nominal dimensions.

Table 1. Tolerances for Nominal Diameter and Width of Test Pieces

Unit: mm

Circular cross section test piece		Rectangular cross section test piece not less than 6 mm thick				Rectangular cross section test piece less than 6 mm thick			
Nominal diameter	Tolerance	Nominal thickness	Tolerance	Nominal width	Tolerance	Nominal thickness	Tolerance	Nominal width	Tolerance
10 to 12 excl.	0.025	6 to 12 excl.	0.02	25 to 40 excl.	0.05	0.6 to 1.2 excl.	0.002	12.5 to 25 excl.	0.02
12 to 16 excl.	0.03	12 to 20 excl.	0.04	40 and over	0.10	1.2 to 2.5 excl.	0.004	25 and over	0.04
16 and over	0.04	20 and over	0.05	-	-	2.5 to 6 excl.	0.01	-	-

6.4. Zero setting of test equipment

Perform zero setting of test equipment so that the load applied to test piece is '0.'

6.5. Test piece installation

Install test piece to sample jig so that the test piece aligns with the axis of the test equipment.

6.6. Test speed

The loading speed should be as uniform as practicable, and any of the following shall be designated:

- * Rate of stressing: Nominal stress increase rate of parallel portion of the test piece per unit hour.
- * Rate of straining: Total elongation increase rate between gauge points of the test piece per unit hour.
- * Elapsed time: Elapsed time in a certain section during the entire process of the tensile test.

6.6.1. For a material whose measured properties are supposed to be affected significantly by loading speed, the loading speed shall be in accordance with the requirements of the standard for a particular material. Unless otherwise specified, the loading speed shall be in accordance with the requirements of 6.6.2 and 6.6.3 and shall be selected so that accurate measurements of load and deformation may be made.

6.6.2. In measuring the upper yield stress, lower yield stress or proof stress, any convenient loading speed may be used up to $\frac{1}{2}$ the load corresponding to the respective specified stress, but above that $\frac{1}{2}$ load, and until the upper yield stress, lower yield stress or proof stress is reached, the average rate of stressing shall be within 3 ~ 30 N/mm² •s for steel, and not more than 30 N/mm² •s for aluminum and its alloys.

Deformation increase rate of yield area shall be less than 15% min.

In measuring the tensile strength without necessity of the measurement of upper yield stress, lower yield stress or proof stress, any convenient loading speed may be used up to $\frac{1}{2}$ the load corresponding to the specified tensile strength, but, above that $\frac{1}{2}$ load, the average rate of straining of the parallel portion of the test piece shall be within 20 to 80 %/min for steel, and not more than 80 %/min for aluminum and its alloys.

6.7. Test conducting

Conduct tensile test of test piece at specified test speed until the test piece is broken or until desired deformation occurs.

6.8. Computation of Yield Stress

The loads for obtaining Upper Yield Point, Lower Yield Point and Yield Stress are read to 0.5% of their magnitudes. Yield Point and Yield Stress values (N/mm^2) are obtained in integers according to KS A 0021.

6.8.1. The upper yield stress and the lower yield stress shall be obtained from the following formula:

$$\text{For upper yield stress (UYS): } = \frac{F_{\text{UYS}}}{A_0}$$

$$\text{For lower yield stress (LYS): } = \frac{F_{\text{LYS}}}{A_0}$$

Where UYS: Upper Yield Stress (N/mm^2)
 LYS: Lower Yield Stress (N/mm^2)
 F_{UYS} : Refer Note 1)
 F_{LYS} : Refer Note 2)
 A_0 : Test sample original cross-sectional area (mm^2)

Note 1) For determining the upper yield stress, the highest load at commencement of yielding of the parallel portion of the test piece under gradual straining, e. g. in a testing machine equipped with a load-indicating dial, the highest load before the load indicating pointer pauses or goes back shall be measured.

Note 2) For determining the lower yield stress, the lowest load while the load is remaining sensibly constant during yielding of the parallel portion of the test piece under gradual straining, e. g. In a testing machine equipped with a load-indicating dial, the load when the load indicating pointer halts or the lowest load when the pointer halts after it has gone back, shall be measured.

6.8.2. Yield Stress of material with no yield point shall be obtained using the following methods.

1) Offset method

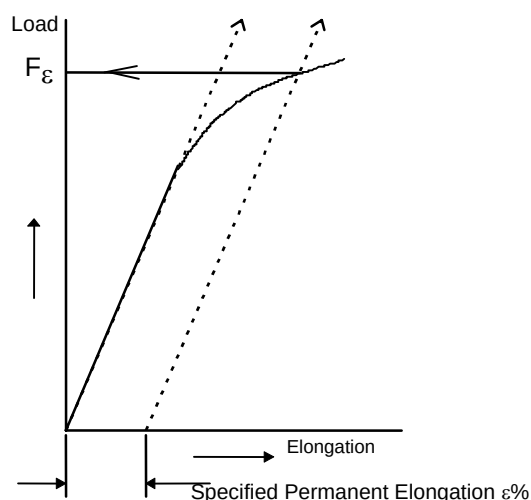


Fig. 2 Offset Method for Yield Stress determination

$$YS_{\epsilon} = \frac{F_{\epsilon}}{A_0}$$

Where YS_{ϵ} : Proof stress determined by offset method (N/mm²)

F_{ϵ} : Using an extensometer, draw a load-elongation diagram. Draw a straight line from a point on the elongation axis representing the specified permanent elongation(ϵ %) parallel to the straight part of the curve for the initial stage of test, and read the load (N) at the intersection of the straight line with the curve

A_0 : Test piece original cross-sectional area (mm²)

In general, when determining Yield Stress with Offset Method, the Permanent Elongation is at 0.2%, for which case the Yield Stress is expressed as follows.

$$YS_{0.2} = \frac{F_{0.2}}{A_0}$$

2) Permanent elongation method

Where only whether a material complies with the standard in proof stress or not is to be verified, the verification may be made by observing whether the permanent elongation of the gauge length is less than the value specified in the standard or not after first applying a load obtained by the multiplication of the specified proof stress by the original cross-sectional area to the test piece for 15 sec. and then removing the load