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Through-thickness characteristics for steel products

Caractéristiques garanties dans le sens de l'épaisseur pour produits en acier

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 3, *Steels for structural purposes*.

This second edition cancels and replaces the first edition (ISO 7778:1983), which has been technically revised.

Introduction

Steel products as normally manufactured generally exhibit deformation properties in the direction perpendicular to the surface of the product, which are different from those obtained in the direction of the surface. It is, however, possible to improve these deformation properties by taking particular precautions when the steel is manufactured. Experience has shown that measurement of the value for reduction of area, measured by means of a tensile test piece sampled in the direction of thickness of the product perpendicular to its surface, is the best way to characterize these properties.

However, the choice of one quality of steel exhibiting properties of this nature does not necessarily ensure the safety of a structure of which certain components are stressed perpendicular to their surface. Precautions should be taken both at the design and fabrication stage, and more particularly during welding, so as to minimize stresses in the through-thickness direction.

Through-thickness characteristics for steel products

1 Scope

This International Standard specifies the criteria for through-thickness reduction of area properties specified in the direction of thickness perpendicular to the surface. This International Standard also specifies the test conditions by which conformance to the specified criteria is evaluated.

This International Standard applies to fully killed steel with a specified minimum yield strength or proof strength ≤960 MPa and supplied as plates, wide flats, or sections of thickness from 15 mm to 400 mm.

The application of this International Standard to products <15 mm or >400 mm or having minimum specified yield strengths or proof strengths >960 MPa will be the subject of agreement when ordering.

The requirements of this International Standard supplement other International Standards that specify the qualities of products (plate, wide flats, and sections).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 404, *Steel and steel products — General technical delivery requirements*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 17577:2006, *Steel — Ultrasonic testing for steel flat products of thickness equal to or greater than 6 mm*

3 Requirements

Table 1 gives the minimum average values and the minimum individual values for the reduction of area, which the products shall satisfy according to their class.

Table 1 — Minimum average and individual values

Class	Minimum average value[a]	Minimum individual value
Z15	15 %	10 %
Z25	25 %	15 %
Z35	35 %	25 %

[a] Average of three tests.

NOTE Products delivered in accordance with this International Standard can be subject to ultrasonic testing according to published standards (e.g. ASTM, JIS, EN, ISO, etc.) upon agreement (see, for example, ISO 630-1).

4 Designation

The qualities of steel with specified through-thickness properties shall be marked by adding a plus sign and the class number after the designation of the steel.

EXAMPLE S355D+Z35.

5 Number and selection of test pieces

5.1 Test unit for flat products

See Table 2.

— for sulfur >0,005 %: testing shall be per rolled unit (R) in the same heat treatment condition (parent plate or wide flat);

— for sulfur ≤0,005 %: at the option of the manufacturer, the test unit shall be type 1 or type 2.

  — Type 1 testing: per test unit consisting of products from the same heat (H) which have undergone the same heat treatment and have nominal thicknesses which do not differ by more than 20 % compared with the minimum thickness of the test unit.

    Ultrasonic testing in accordance to ISO 17577:2006, Table 4, class B2, is mandatory for all the products of the test unit.

  — Type 2 testing: per test unit consisting of products from the same heat which have undergone the same heat treatment and have a total mass of ≤ 40 t (L) and have nominal thicknesses which do not differ by more than 20 % compared with the minimum thickness of the test unit.

Table 2 — Test unit

	Sulfur >0,005 %	**Sulfur ≤0,005 %**	
Frequency		Type 1	Type 2
	R	H	L
Ultrasonic testing	–	Mandatory	–

5.2 Test unit for sections

The tests shall be carried out, unless otherwise agreed, per test unit consisting of products from the same heat, which have undergone the same heat treatment, and have a total mass of ≤ 40 t and have nominal thicknesses which do not differ by more than 20 % compared with the minimum thickness of the test unit.

5.3 Sampling

5.3.1 Flat products

For each test unit, three tensile test pieces shall be taken from the thickest product, from one end. In case of continuous cast, the sample shall be taken from the centre of width or nearby or from the 1/4 width or nearby (see Figure 1). In case of ingot cast, the sample shall be taken from the centre of width or nearby.

5.3.2 Sections

For each test unit, three tensile test pieces shall be taken from the thickest product, from one end. The sampling position shall be the flange unless otherwise agreed at the time of the order. The location of the sample shall be in accordance with ISO 377.

6 Test methods

6.1 Test pieces

6.1.1 The reduction of area shall be measured using a cylindrical test piece. The diameter of the test piece, which depends on the thickness of the product, is given in Table 3.

The effective length, L_c, of the cylindrical part of the test piece shall be ≥ 1,5 times its diameter.

Table 3 — Diameter of test pieces

Dimensions in millimetres

Product thickness	Diameter of test piece
$t \leq 25$	$d_0 = 6$ or 10
$t > 25$	$d_0 = 10$

6.1.2 When it is not possible to machine a test piece in the thickness of the product, the extension pieces may be attached by welding. Welding may be carried out in accordance with any suitable method (e.g. friction welding), but shall be chosen in a way which results in a minimum heat-affected zone. The effective length, L_c, shall be outside the heat-affected zones.

6.1.3 Unless otherwise agreed when ordering, the manufacturer may use either a test piece with extension pieces attached by welding or a test piece machined in the whole thickness of the product (see Figure 2). The use of test pieces of type b or c is recommended when it is necessary to examine the surface properties of the product.

6.1.4 For products thicker than 80 mm, when it is not possible to machine a test piece in the whole thickness, the length of the test piece shall be such that the effective length, L_c, contains the 1/4 thickness position of the product (see Figure 2, type d).

NOTE Upon request, an additional test piece can be machined containing the 1/2 thickness position of the product.

6.2 Tensile test

6.2.1 Measurement of reduction of area

The tensile test shall be carried out in accordance with the requirements of ISO 6892-1.

The assessment of results is based on a sequential method (as defined in ISO 404).

The reduction of area Z is defined by Formula (1):

$$Z = \frac{S_0 - S}{S_0} \times 100 \quad (1)$$

where

S_0 is the original cross-sectional area of the test piece,

$$S_0 = \frac{\pi d_0^2}{4};$$

S is the final cross-sectional area of the test piece after fracture,

$$S = \frac{\pi}{4}\left(\frac{d_1 + d_2}{2}\right)^2;$$

d_1 and d_2 are the measurements of two perpendicular diameters (where the fracture is elliptical in shape, d_1 and d_2 correspond to the axes of the ellipse).

6.2.2 Assessment of results

6.2.2.1 The average value of a set of three test pieces (see 6.1.1) shall meet the specified requirement (see Table 1). One individual value may be below the specified minimum average value, provided that it is not less than the specified minimum individual value.

6.2.2.2 If the conditions in 6.2.2.1 are not satisfied, then an additional set of three test pieces shall be taken from the same sample and tested. The test unit is conformed, after testing the second set and after the following conditions being satisfied simultaneously:

— the average value of six tests shall be equal to or greater than the specified minimum average value;

— not more than two of six individual values may be lower than the specified minimum average value;

— not more than one of six individual values may be lower than the specified minimum individual value.

6.2.2.3 If the conditions in 6.2.2.2 are not satisfied, the sample product is rejected and retests are carried out on the remainder of the test unit, if applicable (see 5.1 and 5.2).

6.2.3 Retest

Except in cases where the test unit is the rolled unit, a new set of three tests shall be carried out on each of two different products from the remainder of the test unit; those two series of tests shall meet the requirements. In this case, 6.2.2.2 and 6.2.2.3 no longer apply.

Each rolled unit on which the tests do not meet the requirements shall be rejected.

6.2.4 Invalid tests

A test is invalid if

— the test piece was defectively machined,

— the test piece was incorrectly mounted in the test machine,

— the test machine malfunctioned, or

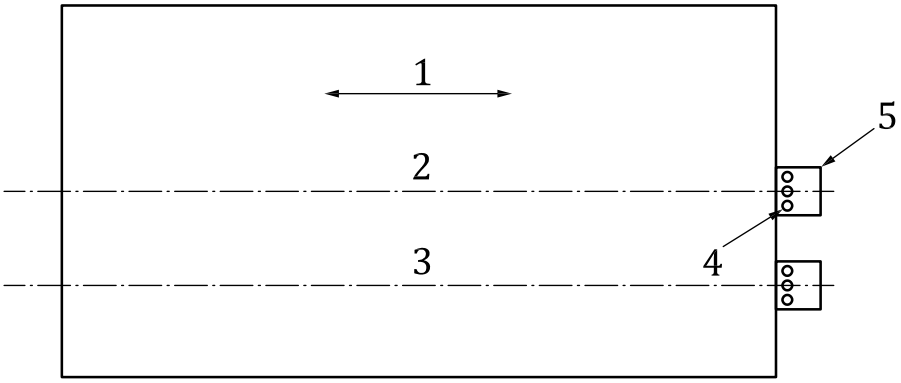
— the test piece fractured in the weld metal or in the heat-affected zone when using extension pieces.

Results from invalid tests shall not be considered.

6.2.5 Sorting and reprocessing

Sorting and reprocessing shall be in accordance with ISO 404.

The manufacturer has the right to carry out sorting or reprocessing (e.g. heat treatment, machining, rolling, drawing, etc.) of non-conforming products, either before or after retests, and to submit these products as a new test unit in accordance with 5.1 and 5.2. Where no reprocessing, only sorting, has been applied, the new inspection procedure shall only apply to the requirements which were not complied with during the first inspection and testing. The manufacturer shall inform the inspection representative which method of sorting or reprocessing was used.

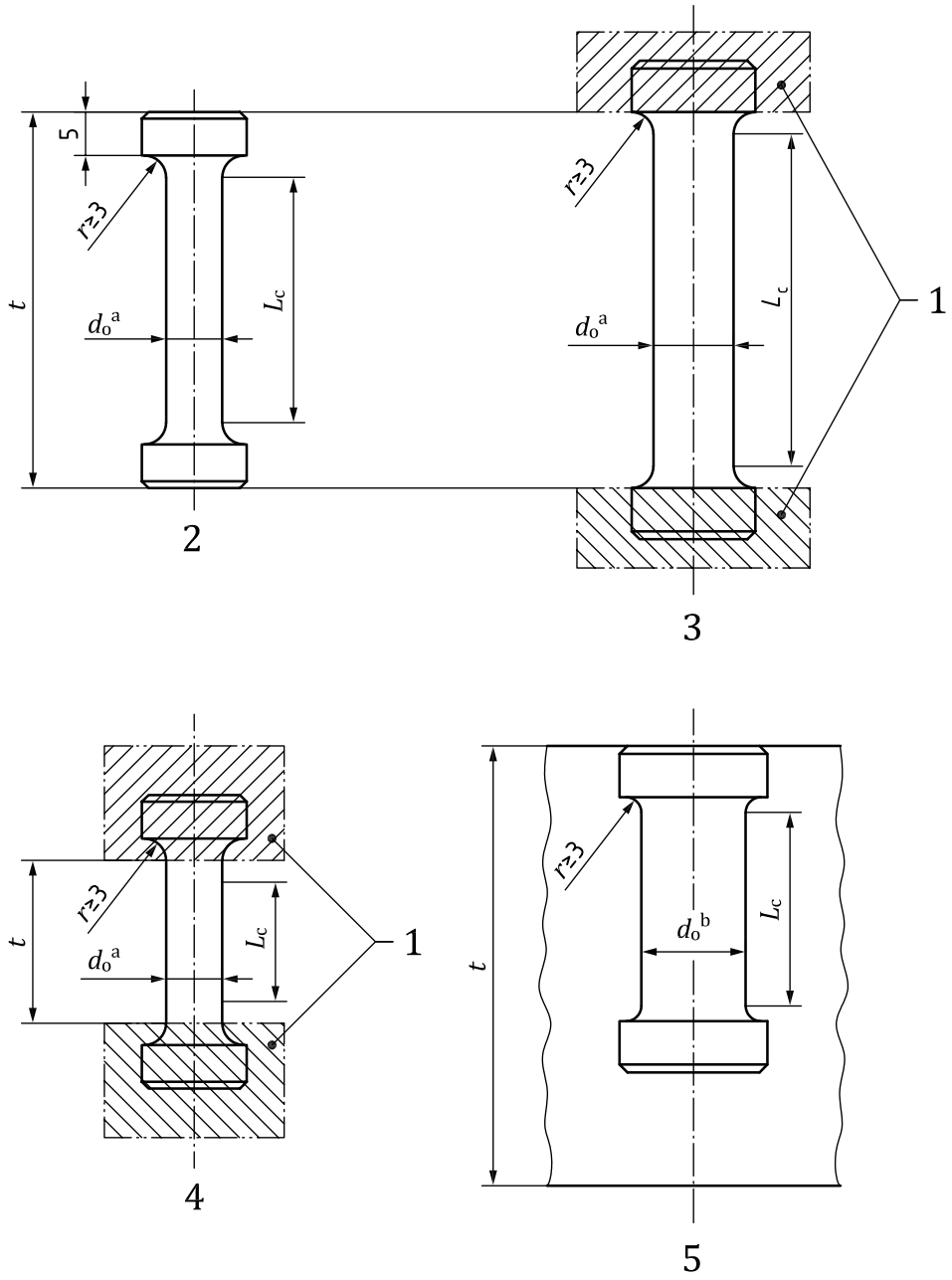


Key

1 rolling direction
2 centre of width
3 1/4 of width
4 test piece
5 sample

NOTE The test coupons are sampled according to 5.3.

Figure 1 — Location of samples for flat products



Key

1 extension pieces attached by welding
2 type a
3 type b
4 type c
5 type d
a d_0 = 6 mm or 10 mm according to Table 3.
b d_0 = 10 mm according to Table 3.

Figure 2 — Sampling and preparation of test pieces

Bibliography

[1] ASTM A435M, *Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates*

[2] ASTM A578M, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

[3] EN 10160, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflexion method)*

[4] EN 10306, *Iron and steel — Ultrasonic testing of H beams with parallel flanges and IPE beams*

[5] JIS G 0801, *Ultrasonic testing of steel plates for pressure vessels*

[6] JIS G 0901, *Classification of structural rolled steel plate and wide flat for building by ultrasonic test*

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