INTERNATIONAL STANDARD

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Second edition
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Metallic materials — Designation of test specimen axes in relation to product texture

Matériaux métalliques — Désignation des axes des éprouvettes en relation avec la texture du produit

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 3785 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 4, *Toughness testing — Fracture (F), Pendulum (P), Tear (T)*.

This second edition cancels and replaces the first edition (ISO 3785:1976), which has been technically revised.

Introduction

The measured mechanical properties of a metallic product, especially those characterizing ductility and toughness, such as elongation, reduction of area, fracture toughness and impact resistance, are dependent on the test specimen location within the product and orientation with respect to the product's principal directions of metal working, grain flow or otherwise-produced texture. This International Standard specifies a method for designating specimen orientation in relation to product texture.

Metallic materials — Designation of test specimen axes in relation to product texture

1 Scope

This International Standard specifies a method for designating test specimen axes in relation to product texture by means of an X-Y-Z orthogonal coordinate system.

The system applies equally to unnotched and notched (or precracked) test specimens.

The method is intended only for metallic materials with uniform texture that can be unambiguously determined.

Test specimen orientation is decided before specimen machining, identified in accordance with the designation system specified in this International Standard, and recorded.

2 Designation system

2.1 General

The method for relating specimen axes to the characteristic directions of the product makes use of an X-Y-Z orthogonal coordinate system for wrought metals:

— the letter X always denotes the direction of principal deformation (maximum grain flow in the product);

— the letter Y denotes the direction of least deformation;

— the letter Z denotes the direction normal to the X-Y plane.

2.2 Exception — not aligned

When the specimen direction does not coincide with the product's characteristic grain-flow directions, two letters are used as described for unnotched specimens in 3.2.2 and 3.2.4, and for notched specimens in 4.3.

2.3 Exception — no grain flow

When there is no grain-flow direction as in a casting, specimen location and orientation shall be defined on a part drawing and the test result shall carry no orientation designation.

3 Designation of unnotched specimens

3.1 General

The designations of unnotched specimens variously aligned with respect to the product's characteristic grain-flow directions are depicted in Figure 1. Only specimens fully aligned with, or lying midway between, the product's characteristic grain-flow directions are shown.

3.2 Sheet, plate, bar (flat rolled products)

3.2.1 Aligned, grain flow different in all three orthogonal directions

For products of non-circular cross-section and grain flow differing in the three orthogonal directions, specimens aligned with the product's characteristic grain-flow directions are designated as either X-, Y- or Z-direction specimens as depicted in Figure 1 a).

3.2.2 Not aligned, grain flow different in all three orthogonal directions

For products of non-circular cross-section and grain flow differing in the three orthogonal directions, specimens lying midway between the product's characteristic grain-flow directions are designated as XY-, XZ- or YZ-direction specimens as depicted in Figure 1 f). When the specimen lies neither in alignment with the product's characteristic grain-flow directions nor midway between them, but rather at some other angle to them, then that angle shall be stated between the two designation letters, the first letter denoting the direction toward which the specimen axis is inclined, and the second letter the direction from which the specimen axis is inclined. This designation scheme is restricted to direction vectors that lie within any of the three planes described by the orthogonal X, Y and Z directions. When the direction vector lies outside those planes, specimen location and orientation hall be defined on a drawing of the product or part and the test result shall carry no orientation designation.

3.2.3 Aligned, equal cross-sectional grain flow

For products of non-circular cross-section with equal Y- and Z-direction grain flow, specimens oriented normal to the X-direction (principal direction of) grain flow may be designated as either Y- or Z-direction specimens, as depicted in Figure 1 a).

3.2.4 Not aligned, equal cross-sectional grain flow

For products of non-circular cross-section with equal Y- and Z-direction grain flow, specimens lying midway between the product's characteristic grain-flow directions are designated as XY-, XZ-, or YZ-direction specimens, as depicted in Figure 1 f). When the specimen lies neither in alignment with the product's characteristic grain-flow directions nor midway between them, but rather at some other angle to them, then that angle shall be stated between the two letters, the first letter denoting the direction toward which the specimen axis is inclined, and the second letter the direction from which the specimen axis is inclined. This designation scheme is restricted to direction vectors the lie within any of the three planes described by the orthogonal X, Y and Z directions. When the direction vector lies outside those planes, specimen location and orientation shall be defined on a drawing of the product or part and the test result shall carry no orientation designation.

3.3 Cylinders and thick-walled tubes

Specimen depictions in Figures 1 b) and 1 c) pertain to solid cylinders; those in Figure 1 d) apply to hollow cylinders (thick-walled tubes).

3.4 Thin-walled tubes, helical grain flow

Specimen depictions in Figure 1 e) pertain to products with helical grain flow, typically thin-walled tubing.

3.5 Castings

When there is no grain-flow direction as in a casting, specimen location and direction shall be defined on a part drawing and the test result shall carry no orientation designation.

4 Designation of notched (or precracked) specimens

4.1 General

Designating the plane and direction of crack extension for notched (or precracked) specimens, in relation to the product's characteristic grain-flow directions, is done using a hyphenated code wherein the letter(s) preceding the hyphen represent the direction normal to the crack plane and the letter(s) following the hyphen represent the anticipated direction of crack extension.

4.2 Aligned

When the specimen direction is aligned with the product's characteristic grain-flow directions, a single letter for each case is used to denote the direction perpendicular to the crack plane and the direction of intended crack extension, as depicted in Figure 2 a), 2 c) and 2 d).

4.3 Not aligned

When the specimen orientation directions lie midway between the product's characteristic grain-flow directions, two letters shall be used to denote the normal to the crack plane or the crack propagation direction, as depicted in Figure 2 b). When the specimen orientation directions lie neither in alignment with the product's characteristic grain-flow directions nor midway between them, but rather at some other angle to them, then that angle shall be stated between the two letters, the first letter denoting the direction toward which the crack plane normal or propagation direction is inclined, and the second letter the direction from which the crack plane normal or crack propagation direction is inclined. This designation scheme is restricted to direction vectors that lie within any of the three planes described by the orthogonal X, Y and Z directions. When the direction vector lies outside those planes, the specimen crack plane orientation and propagation direction shall be defined on a drawing of the product or part, and the test result shall carry no orientation designation.

4.4 No grain flow

When there is no grain-flow direction as in a casting, specimen location and crack plane orientation shall be defined on a part drawing and the test result shall carry no orientation designation.

4.5 Welds

A futur International Standard, which is being developed, contains a method of test for welds, including a unique scheme for designating specimen location and orientation. When that test method is adopted as an International Standard, its specimen location and orientation scheme will be incorporated into this International Standard.

5 Application of designation system in material specification

5.1 General

The designation of specimen location and orientation with respect to the product characteristic directions is straightforward for regular structural configurations like plate and rod. It is more difficult for complex structural shapes, in which case knowledge of production and processing plays an essential role.

5.2 Non-uniform grain flow

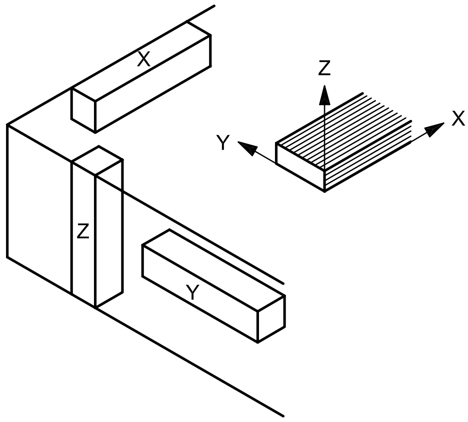
In cases where grain flow is not uniform, specimen location and orientation shall reference component geometry and be noted on component drawings along with a description of component production and processing.

5.3 Specifications

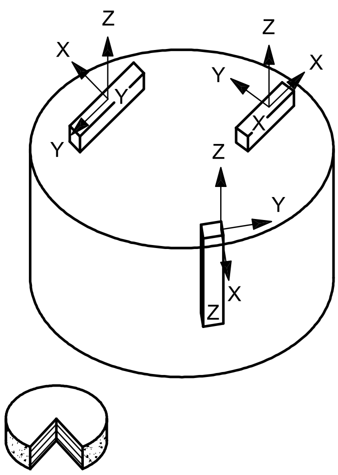
Specimen extraction shall conform to relevant specifications.

5.4 Comparisons

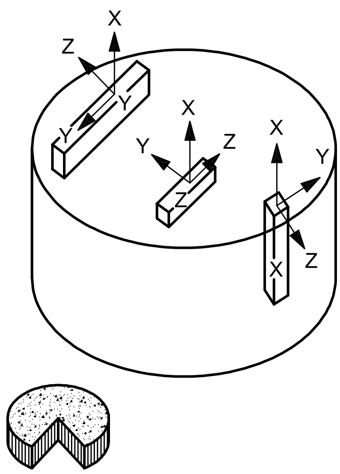
When products are to be compared on the basis of mechanical properties, it is essential that specimen location and orientation with respect to the product's grain-flow directions be comparable and that the results not be generalized beyond these limits.



a) Sheet, plate, bar

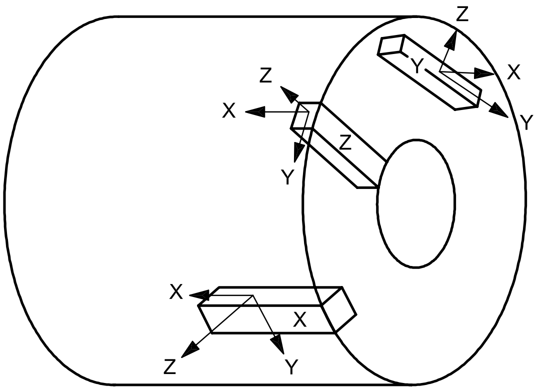


b) Cylinder — Radial grain flow, axial working direction

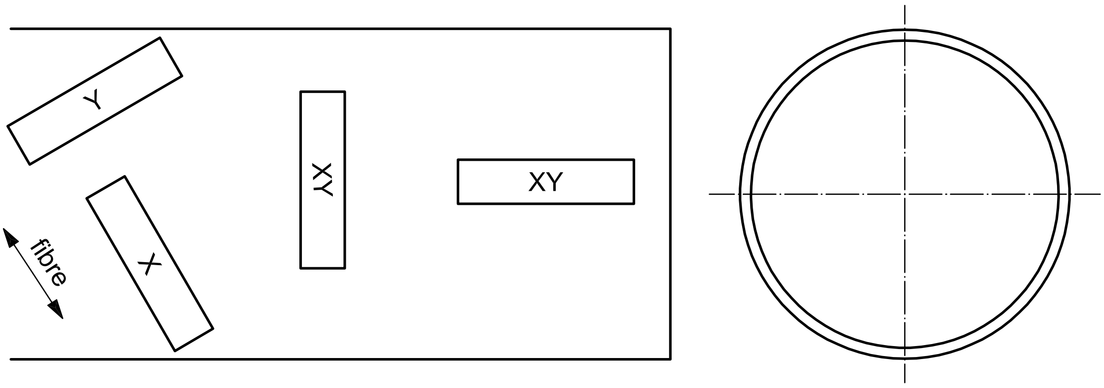


c) Cylinder — Axial grain flow, radial working direction

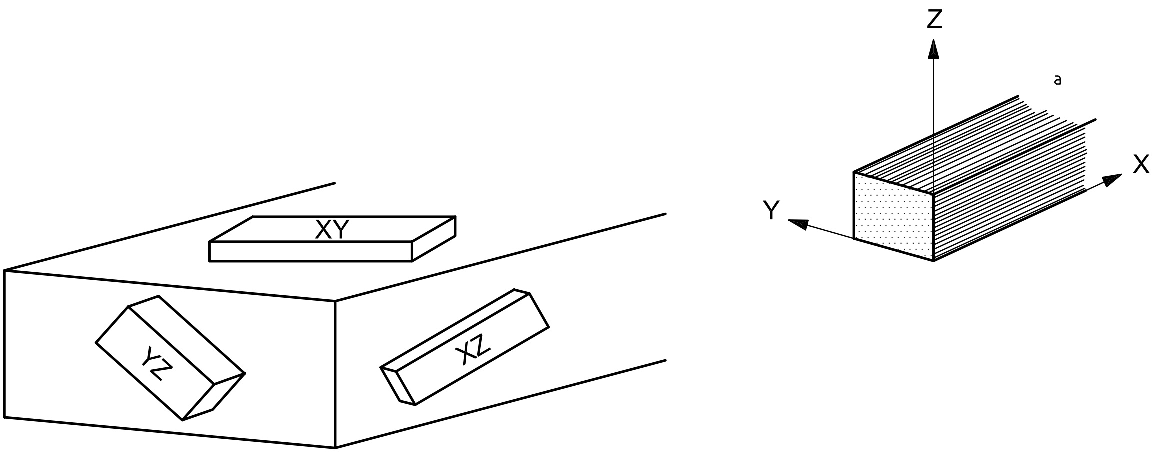
Figure 1 — Designation of unnotched test pieces



d) Tube (axial grain flow)



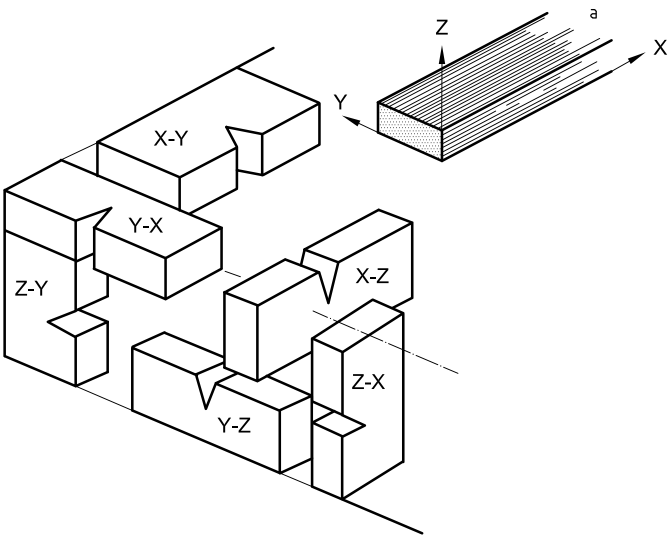
e) Thin-walled tube with helical grain flow



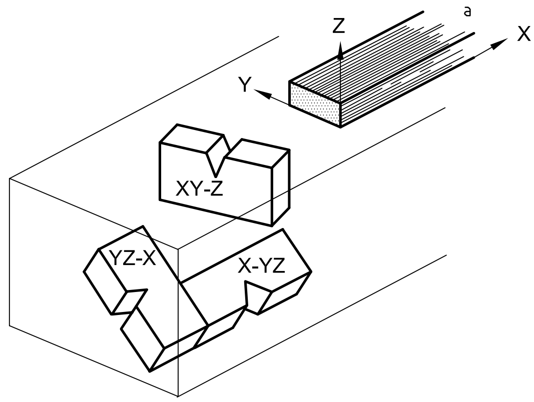
f) Not aligned — sheet, plate, bar

[a] Grain flow.

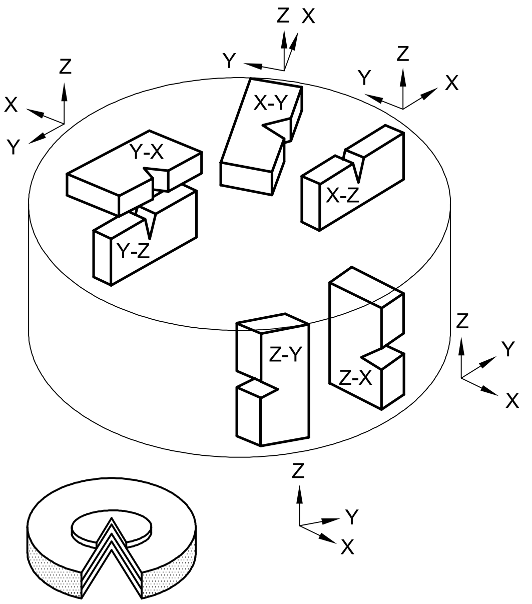
Figure 1 — (*continued*)



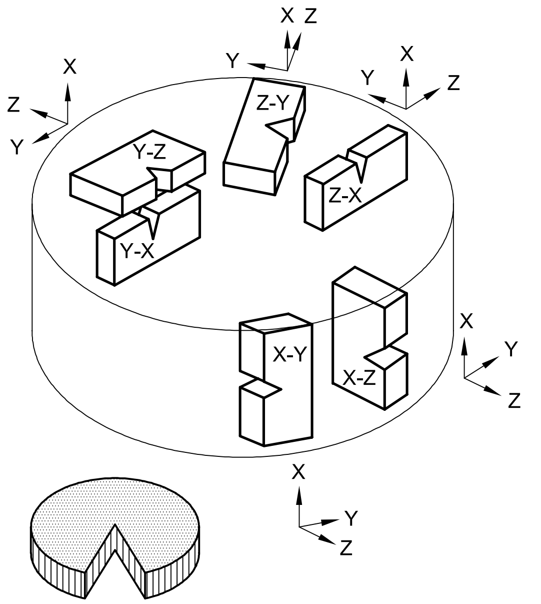
a) **Aligned**



b) **Not aligned**



c) **Radial grain flow, axial working direction**



d) **Axial grain flow, radial working direction**

a Grain flow.

Figure 2 — Designation of notched (or precracked) specimens

Annex A
(informative)

Influence of mechanical working on material structure and properties

A.1 Product production

Steep temperature gradients in the molten metal cause dendritic freezing patterns on cooling, whereas shallow gradients produce more equiaxed grains. Intermetallic compounds of all shapes and nonmetallic particles of usually equiaxed shapes can be distributed throughout.

During hot working, recrystallization occurs and the intermetallic and nonmetallic particles can be affected. All species within the metal are distorted, including the intermetallic and nonmetallic particles if they are sufficiently malleable.

Cold working produces no recrystallization, but rather a continuous elongation of grains and possible further elongation of intermetallics and nonmetallics.

The net processing effect is increased anisotropy. This should be considered in component design and fabrication, and in specimen sampling for the determination of mechanical response of the component.

A.2 Product geometry

In many instances, product geometry is telltale of grain flow. This is especially true of regular product forms such as plate, bar, sheet and rod. Because of the frequent coincidence of grain flow direction with product shape, specimen designation is often referred to in complimentary terms; for example, specimens taken with their long axis aligned with the long axis of the product are referred to as “longitudinal” specimens. The same is true for the transverse and short transverse directions.

Difficulty arises when the direction of principal grain flow is known to differ from the complimentary dimensions of the product; for example, short sheets cut from rolled wide coiled strip. Designations referring to the product geometry, such as tangential, radial, or axial, do not necessarily define the specimen orientation with respect to grain flow. In these instances, the method of production and processing is essential descriptive information. This is particularly so for forgings.

A.3 Product form, composition and processing

Besides the description of location and orientation, other factors are important in characterizing test results. Especially important are product form (bar, sheet, forging, etc.), chemical composition, and processing schedules including heat treatment and chemical or mechanical surface treatments. All of this information is essential to the relevant material specification.

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