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Light metals and their alloys — Titanium and titanium alloys — Vocabulary

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Foreword

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This document was prepared by Technical Committee ISO/TC 79, *Light metals and their alloys*, Subcommittee SC 11, *Titanium*.

This second edition cancels and replaces the first edition (ISO 28401:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the title was changed from “Classification and terminology” to “Vocabulary”;

— new terms were added;

— some sentences were revised for clarity;

— the notations alpha and beta were changed from English to Greek;

— some abbreviated terms were removed;

— Annex A was revised and tables were added as additional normative text;

— Annex B was removed.

A list of all parts in the ISO 28401 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

There are many technical terms related to titanium used in national standards.

Unifying and interpreting these technical terms worldwide, so that specifications can be understood accurately around the world, is essential for international trade in common titanium products.

There is a need to classify technical terms related to titanium and establish a common interpretation of each term.

Light metals and their alloys — Titanium and titanium alloys — Vocabulary

1 Scope

This document defines terms and definitions related to titanium and titanium alloys.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Material

3.1.1
titanium sponge
products of metallic titanium in a porous and sponge-like form, which are applied as titanium metal melting stock

Note 1 to entry: To produce titanium sponge, oxidized titanium ore is chlorinated to tetrachloride and is condensed and purified. Then the product is reduced with magnesium or sodium under an inert atmosphere.

3.1.2
alloy
metallic substance consisting of a mixture of the basic metallic element and other elements, such as alloying elements and impurities

Note 1 to entry: In this document, the most predominant element by mass fraction is titanium.

3.1.3
alloying element
metallic or non-metallic elements intentionally added to, or retained by, base metal to give special properties

3.1.4
impurity
metallic or non-metallic elements which are present but not intentionally added to, or retained by, a metal

3.1.5
wrought alloy
alloy primarily intended for the production of wrought products by hot and/or cold plastic forming

3.1.6
casting alloy
alloy primarily intended for the production of castings

3.1.7
master alloy
alloy intended for alloying elements added to molten or compacted titanium by controlling physical properties such as melting point, densities and dissolvability

3.1.8
heat-treatable alloy
alloy capable of being strengthened by a suitable thermal treatment

3.1.9
non-heat-treatable alloy
alloy capable of being strengthened only by cold working rather than by thermal treatment

3.2 Classification of phases and related terms

3.2.1
α phase
solid solution at low temperature with a hexagonal closed packed crystal structure

3.2.2
α phase stabilisers
alloy elements such as aluminium, oxygen, nitrogen and carbon that expand the α phase, which is the low temperature phase of titanium alloy, to high temperature and enhance the stability of the α structure

3.2.3
β phase
solid solution at high temperature with a body centred cubic crystal structure

3.2.4
β phase stabilisers
alloy elements such as iron, manganese, molybdenum and vanadium that expand the β phase, which is the high temperature phase of titanium alloy, to low temperature and enhance the stability of the β structure

3.2.5
α plus β phase
mixture of the α and β phases

3.2.6
β-transus temperature
temperature above which the crystal structure turns to the β phase

3.3 Classification of microstructure by morphology and related terms

3.3.1
microstructure by morphology
microstructure observed by an optical and/or a scanning microscope characterized by composition, processing and heat treating

Note 1 to entry: See Reference [2] for detailed classifications of titanium and titanium alloy microstructures, including microstructure photographs.

3.3.2
equiaxed α structure
polygonal or globular α structure with approximately equal dimensions in all directions

Note 1 to entry: In some types of α-β titanium alloys, most α structures are observed in a globular rather than equiaxed form. Therefore, this structure is sometimes called the globular α structure.

3.3.3
acicular α structure
microstructure in which β transforms the selected crystal planes by nucleation and growth or martensitically

Note 1 to entry: This microstructure is also called the Widmansttäten α structure.

Note 2 to entry: Depending on the aspect ratio and the existence state in the colonies, other names for this microstructure are platelet α structure, blocky α structure, basketweave α structure and lamellar α structure.

3.3.4
grain boundary α structure
α structure formed at prior β grain boundaries during cooling from the single β phase region

3.3.5
elongated α structure
grain microstructure in which the length of one of the three axial directions of the crystal grains is remarkably elongated

Note 1 to entry: The structure shows that the influence of plastic working remains strong or that it has failed to become equiaxed and remained elongated.

Note 2 to entry: The string-like elongated structure is sometimes called stringy α structure.

3.3.6
bimodal structure
microstructure composed of equiaxed or elongated α structure embedded in transformed β matrix

3.4 Unwrought products

3.4.1
unwrought product
general term for products obtained by either melting, casting or powder metallurgy processes or a combination thereof

EXAMPLE Ingots for rolling, ingots for extruding, ingots for forging and ingots for remelting.

3.4.2
electrode for remelting
cylindrical or rectangular semi-product formed from titanium sponge and alloying elements or consolidated from recycled and processed scrap, to be remelted once or multiple cycles in a vacuum or in inert gas for at least the final melting

3.4.3
ingot for rolling, extruding and forging
titanium and titanium alloy ingot melted mostly using the vacuum arc remelting (VAR) method applied for at least the final cycle in a vacuum or in inert gas, suitable for rolling, extruding and forging

Note 1 to entry: The melting method is not necessarily limited to VAR. It also includes cases that involve electron beam melting (EBM), plasma arc melting (PAM) and others.

Note 2 to entry: The VAR method is the typical method used for melting titanium and titanium alloys. In this method, the titanium or titanium alloy electrode is dissolved while being consumed itself by an arc generated between a consumable electrode and a water-cooled copper crucible in a vacuum or in an inert gas environment.

Note 3 to entry: The EBM method is also called electron beam cold hearth melting. In this method, charged titanium or titanium alloy is melted in a water-cooled copper hearth using an electron gun and then poured into a mould in a vacuum or in an inert gas chamber.

Note 4 to entry: The PAM method is the method for melting metal using arc discharge generated between the electrode of a plasma torch and the metal, and by using a gas such as argon or helium as the plasma gas. In this method, metal can be melted in an inert gas atmosphere under the environment close to atmospheric pressure.

3.4.4
ingot for remelting
titanium and titanium alloy ingot in a form suitable for remelting after having been processed metallurgically for composition, melted by electron beam melting, vacuum arc remelting and plasma arc melting and other methods applied for at least the final cycle in a vacuum or in inert gas

3.4.5
additive manufacturing product
articles manufactured by 3D metal printing

3.5 Wrought products

3.5.1
wrought product
general term for products obtained by hot and/or cold plastic deformation processes, such as extruding, forging, hot rolling, cold rolling or drawing, either solely or in combination

EXAMPLE Rod/bar, billets, wire, tube, shape/profile, sheet, plate, strip, foils, die forgings, open die forgings.

3.5.2
billet
solid wrought product of uniform cross-section that is above 10 000 mm^2 along its whole length, supplied in straight lengths

Note 1 to entry: The cross-sections are in the shape of circles, ovals, squares, rectangles, equilateral triangles or regular polygons. Products with a square, rectangular, triangular or polygonal cross-section can have corners rounded along their whole length.

3.5.3
rod/bar
solid wrought product of uniform cross-section that is under 10 000 mm^2 along its whole length, supplied in straight lengths.

Note 1 to entry: The cross-sections are in the shape of circles, ovals, squares, rectangles, equilateral triangles or regular polygons. Products with a square, rectangular, triangular or polygonal cross-section can have corners rounded along their whole length.

Note 2 to entry: For rectangular bars:

— the thickness exceeds one-third of the width;

— the term "rectangular bar" includes "flattened circles" and "modified rectangles", of which two opposite sides are convex arcs, the other two sides being straight, of equal length and parallel.

3.5.4
wire
solid wrought product of uniform cross-section along its whole length, supplied in coiled form

Note 1 to entry: The cross-sections are in the shape of circles, ovals, squares, rectangles, equilateral triangles or regular polygons. Products with a square, rectangular, triangular, or polygonal cross-section can have corners rounded along their whole length.

Note 2 to entry: For rectangular wires:

— the thickness exceeds one-third of the width;

— the term "rectangular wire" includes "flattened circles" and "modified rectangles", of which two opposite sides are convex arcs, the other two sides being straight, of equal length and parallel.

3.5.5
wire rod
intermediate unwrought or wrought product for wire