
**Welding consumables — Solid wire
electrodes, solid wires and rods
for fusion welding of titanium and
titanium alloys — Classification**

*Produits consommables pour le soudage — Fils-électrodes pleins, fils
pleins et baguettes pleines pour le soudage par fusion du titane et des
alliages de titane — Classification*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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.

Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: <https://committee.iso.org/sites/tc44/home/interpretation.html>.

This third edition cancels and replaces the second edition (ISO 24034:2010), which has been technically revised. The main changes compared to the previous edition are as follows:

- a number of alloys in [Table 1](#) have been updated;
- a number of typographical errors in [Table 1](#) and [Table B.1](#) have been corrected;
- [Clause 8](#) has been updated to reflect the current agreed wording;
- in [Clause 11](#), the words “Solid wire” have been deleted from each example designation;
- the last sentence of the second paragraph of [A.1](#) has been deleted to align with [A.15](#);
- a number of dated references in [Annex B](#) and the bibliography have been updated.

Introduction

This document proposes a classification in order to designate solid wire electrodes, solid wires and rods in terms of their chemical composition.

There is no unique relationship between the product form (solid wire electrodes, solid wires or rods) and the welding process used (gas-shielded metal arc welding, tungsten inert gas arc welding, plasma arc welding or laser beam welding). For this reason, solid wire electrodes, solid wires and rods can be classified in terms of their chemical composition.

In this document, the symbol of the welding process is not used, because:

- a) different joining processes are performed with the same chemical component consumable;
- b) the producer is not able to determine the process symbol before shipping.

Also, it should be noted that the mechanical properties of all-weld metal test specimens or welded joints produced by welding consumables can vary from those obtained in production joints because of differences in welding procedure and the base-metal alloy. For this reason, the mechanical properties of all-weld metal or welded joints for titanium-welding consumables are not specified in this classification.

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Welding consumables — Solid wire electrodes, solid wires and rods for fusion welding of titanium and titanium alloys — Classification

1 Scope

This document specifies requirements for the classification of solid wire electrodes, solid wires and rods for fusion welding of titanium and titanium alloys. The classification is based on their chemical composition.

The compositions of solid wire electrodes for metal inert gas (MIG) welding are the same as solid wire electrodes, solid wires and rods for tungsten inert gas (TIG) arc welding, plasma arc welding, laser beam welding, and other fusion welding processes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 544, *Welding consumables — Technical delivery conditions for filler materials and fluxes — Type of product, dimensions, tolerances and markings*

ISO 14344, *Welding consumables — Procurement of filler materials and fluxes*

ISO 80000-1:2009, *Quantities and units — Part 1: General*, Corrected by ISO 80000-1:2009/Cor 1:2011

3 Terms and definitions

No terms and definitions are listed in this document.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Classification

The classification is divided into two parts:

- a) the first part gives a symbol indicating the product to be identified, see [5.1](#);
- b) the second part gives a symbol indicating the chemical composition of the solid wire electrodes, solid wires and rods, see [Table 1](#).

5 Symbols and requirements

5.1 Symbol for the product

The symbol for the solid wire electrodes, solid wires and rods shall be S.

5.2 Symbol for the chemical composition

The numerical symbols in [Table 1](#) indicate the chemical composition of a solid wire or rod, determined under the conditions given in [Clause 7](#). The first two digits indicate the alloy group. See [Annex A](#) for an explanation of the numerical symbols.

The optional additional chemical symbols in [Table 1](#) indicate the chemical composition and include an indication of the characteristic alloying elements.

6 Mechanical properties

Mechanical properties of all-weld metal or welded joints are not part of this classification.

7 Chemical analysis

Chemical analysis shall be performed on specimens of the product or the stock from which it is made. See also footnote c to [Table 1](#). Any analytical technique may be used but, in cases of dispute, reference shall be made to established published methods, agreed between the contracting parties.

8 Rounding procedure

Actual test values obtained shall be subject to ISO 80000-1:2009, B.3, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this document, the measured values shall be converted to the units of this document before rounding. If an average value is to be compared to the requirements of this document, rounding shall be done only after calculating the average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

9 Retests

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If any test fails to meet the requirement(s), that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original test assembly or sample or from one or two new test assemblies. For chemical analysis, retests need only be for those specific elements that failed to meet the requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this document for that classification.

In the event that during preparation, or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test assembly or sample(s) or test specimen(s), or in conducting the tests, the test shall be considered invalid. This determination is made without regard to whether the test was actually completed, or whether the test results met, or failed to meet, the requirements. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

10 Technical delivery conditions

Technical delivery conditions shall meet the requirements of ISO 544 and ISO 14344.

Table 1 — Chemical composition requirements

Alloy symbols	Chemical composition, % (by mass) ^{a, b, c, d}												
	Numerical	Chemical	C	O	N	H	Fe	Al	V	Sn	Pd	Ru	Other
Ti 0100		Ti99,8	0,03	0,03 to 0,10	0,012	0,005	0,08	—	—	—	—	—	—
Ti 0120		Ti99,6	0,03	0,08 to 0,16	0,015	0,008	0,12	—	—	—	—	—	—
Ti 0125		Ti99,5	0,03	0,13 to 0,20	0,02	0,008	0,16	—	—	—	—	—	—
Ti 0130		Ti99,3	0,03	0,18 to 0,32	0,025	0,008	0,25	—	—	—	—	—	—
Ti 2251		TiPd0,2	0,03	0,03 to 0,10	0,012	0,005	0,08	—	—	0,12 to 0,25	—	—	—
Ti 2253		TiPd0,06	0,03	0,03 to 0,10	0,012	0,005	0,08	—	—	0,04 to 0,08	—	—	—
Ti 2255		TiRu0,1	0,03	0,03 to 0,10	0,012	0,005	0,08	—	—	—	0,08 to 0,14	—	—
Ti 2401		TiPd0,2A	0,03	0,08 to 0,16	0,015	0,008	0,12	—	—	0,12 to 0,25	—	—	—
Ti 2403		TiPd0,06A	0,03	0,08 to 0,16	0,015	0,008	0,12	—	—	0,04 to 0,08	—	—	—
Ti 2405		TiRu0,1A	0,03	0,08 to 0,16	0,015	0,008	0,12	—	—	—	0,08 to 0,14	—	—
Ti 3401		TiNi0,7Mo0,3	0,03	0,08 to 0,16	0,015	0,008	0,15	—	—	—	—	—	Mo: 0,2 to 0,4 Ni: 0,6 to 0,9
Ti 3416		TiRu0,05Ni0,5	0,03	0,13 to 0,20	0,02	0,008	0,16	—	—	—	0,04 to 0,06	—	Ni: 0,4 to 0,6
Ti 3423		TiNi0,5	0,03	0,03 to 0,10	0,012	0,005	0,08	—	—	—	0,04 to 0,06	—	Ni: 0,4 to 0,6
Ti 3424		TiNi0,5A	0,03	0,08 to 0,16	0,015	0,008	0,12	—	—	—	0,04 to 0,06	—	Ni: 0,4 to 0,6
Ti 3443		TiNi0,45Cr0,15	0,03	0,08 to 0,16	0,015	0,008	0,12	—	—	0,01 to 0,02	0,02 to 0,04	—	Cr: 0,1 to 0,2 Ni: 0,35 to 0,55

NOTE Corresponding national classifications are shown in [Annex B](#).

^a Single values are maxima, unless otherwise noted.

^b The remainder of the alloy is titanium.

^c Analysis of the interstitial elements C, O, H and N shall be conducted on samples of rod/wire taken after the rod/wire has been reduced to its final diameter and all processing operations have been completed. Analysis of the other elements may be conducted on the same samples, or it may have been conducted on samples taken from the ingot or the rod stock from which the rod/wire is made. In cases of dispute, samples from the finished rod/wire shall be the referee method.

^d Total residual elements shall not exceed 0,20 % (by mass), with no single such element exceeding 0,05 %, except for yttrium, which shall not exceed 0,005 %. Residual elements need not be reported unless a report is specifically required by the purchaser. Residual elements are those elements other than titanium that are not listed in this table for the particular classification, but which are inherent in the raw material or the manufacturing practice. Residual elements may be present only in trace amounts and they may not be elements that have been intentionally added to the product.

^e Consumables for which the chemical composition is not listed in this table shall be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and it is possible that two electrodes with the same Z-classification are not interchangeable.

Table 1 (continued)

Alloy symbols		Chemical composition, % (by mass) ^{a, b, c, d}										
Numerical	Chemical	C	O	N	H	Fe	Al	V	Sn	Pd	Ru	Other
Ti 3444	TiNi0,45Cr0,15A	0,03	0,13 to 0,20	0,02	0,008	0,16	—	—	—	0,01 to 0,02	0,02 to 0,04	Cr: 0,1 to 0,2 Ni: 0,35 to 0,55
Ti 3531	TiCo0,5	0,03	0,08 to 0,16	0,015	0,008	0,12	—	—	—	0,04 to 0,08	—	Co: 0,20 to 0,80
Ti 3533	TiCo0,5A	0,03	0,13 to 0,20	0,02	0,008	0,16	—	—	—	0,04 to 0,08	—	Co: 0,20 to 0,80
Ti 4251	TiAl4V2Fe	0,05	0,20 to 0,27	0,02	0,010	1,2 to 1,8	3,5 to 4,5	2,0 to 3,0	—	—	—	—
Ti 4621	TiAl6Zr4Mo2Sn2	0,04	0,30	0,015	0,015	0,05	5,50 to 6,50	—	1,80 to 2,20	—	—	Zr: 3,60 to 4,40 Mo: 1,80 to 2,20 Cr: 0,25 max
Ti 5112	TiAl5V1Sn-1Mo1Zr1	0,03	0,05 to 0,10	0,012	0,008	0,20	4,5 to 5,5	0,6 to 1,4	0,6 to 1,4	—	—	Mo: 0,6 to 1,2 Zr: 0,6 to 1,4 Si: 0,06 to 0,14
Ti 6321	TiAl3V2,5A	0,03	0,06 to 0,12	0,012	0,005	0,20	2,5 to 3,5	2,0 to 3,0	—	—	—	—
Ti 6324	TiAl3V2,5Ru	0,03	0,06 to 0,12	0,012	0,005	0,20	2,5 to 3,5	2,0 to 3,0	—	—	0,08 to 0,14	—
Ti 6326	TiAl3V2,5Pd	0,03	0,06 to 0,12	0,012	0,005	0,20	2,5 to 3,5	2,0 to 3,0	—	0,04 to 0,08	—	—
Ti 6402	TiAl6V4B	0,05	0,12 to 0,20	0,030	0,015	0,22	5,50 to 6,75	3,50 to 4,50	—	—	—	—
Ti 6408	TiAl6V4A	0,03	0,03 to 0,11	0,012	0,005	0,20	5,5 to 6,5	3,5 to 4,5	—	—	—	—

NOTE Corresponding national classifications are shown in Annex B.

^a Single values are maxima, unless otherwise noted.

^b The remainder of the alloy is titanium.

^c Analysis of the interstitial elements C, O, H and N shall be conducted on samples of rod/wire taken after the rod/wire has been reduced to its final diameter and all processing operations have been completed. Analysis of the other elements may be conducted on the same samples, or it may have been conducted on samples taken from the ingot or the rod stock from which the rod/wire is made. In cases of dispute, samples from the finished rod/wire shall be the referee method.

^d Total residual elements shall not exceed 0,20 % (by mass), with no single such element exceeding 0,05 %, except for yttrium, which shall not exceed 0,005 %. Residual elements need not be reported unless a report is specifically required by the purchaser. Residual elements are those elements other than titanium that are not listed in this table for the particular classification, but which are inherent in the raw material or the manufacturing practice. Residual elements may be present only in trace amounts and they may not be elements that have been intentionally added to the product.

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Table 1 (continued)

Alloy symbols		Chemical composition, % (by mass) ^{a, b, c, d}										
Numerical	Chemical	C	O	N	H	Fe	Al	V	Sn	Pd	Ru	Other
Ti 6413	TiAl6V4Ni0,5Pd	0,05	0,12 to 0,20	0,030	0,015	0,22	5,5 to 6,7	3,5 to 4,5	—	0,04 to 0,08	—	Ni: 0,3 to 0,8
Ti 6414	TiAl6V4Ru	0,03	0,03 to 0,11	0,012	0,005	0,20	5,5 to 6,5	3,5 to 4,5	—	—	0,08 to 0,14	—
Ti 6415	TiAl6V4Pd	0,05	0,12 to 0,20	0,030	0,015	0,22	5,5 to 6,7	3,5 to 4,5	—	0,04 to 0,08	—	—
Ti 8211	TiMo15Al3Nb3	0,03	0,10 to 0,15	0,012	0,005	0,20 to 0,40	2,5 to 3,5	—	—	—	—	Mo 14,0 to 16,0 Nb 2,2 to 3,2 Si 0,15 to 0,25
Ti 8451	TiNb45	0,03	0,06 to 0,12	0,02	0,0035	0,03	—	—	—	—	—	Nb 42,0 to 47,0
Ti 8641	TiV8Cr6Mo4Zr4Al3	0,03	0,06 to 0,10	0,015	0,015	0,20	3,0 to 4,0	7,5 to 8,5	—	—	—	Mo 3,5 to 4,5 Cr 5,5 to 6,5 Zr 3,5 to 4,5
Ti 8646	TiV8Cr6Mo4Zr4Al3Pd	0,03	0,06 to 0,10	0,015	0,015	0,20	3,0 to 4,0	7,5 to 8,5	—	0,04 to 0,08	—	Mo 3,5 to 4,5 Cr 5,5 to 6,5 Zr 3,5 to 4,5
	ZTi ^e											

NOTE Corresponding national classifications are shown in Annex B.

^a Single values are maxima, unless otherwise noted.

^b The remainder of the alloy is titanium.

^c Analysis of the interstitial elements C, O, H and N shall be conducted on samples of rod/wire taken after the rod/wire has been reduced to its final diameter and all processing operations have been completed. Analysis of the other elements may be conducted on the same samples, or it may have been conducted on samples taken from the ingot or the rod stock from which the rod/wire is made. In cases of dispute, samples from the finished rod/wire shall be the referee method.

^d Total residual elements shall not exceed 0,20 % (by mass), with no single such element exceeding 0,05 %, except for yttrium, which shall not exceed 0,005 %. Residual elements need not be reported unless a report is specifically required by the purchaser. Residual elements are those elements other than titanium that are not listed in this table for the particular classification, but which are inherent in the raw material or the manufacturing practice. Residual elements may be present only in trace amounts and they may not be elements that have been intentionally added to the product.

^e Consumables for which the chemical composition is not listed in this table shall be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and it is possible that two electrodes with the same Z-classification are not interchangeable.