SLOVENSKI STANDARD
SIST EN 4632-006:2014

01-februar-2014

Aeronavtika - Varilnost in spajkalnost letalskih in vesoljskih konstrukcij - 006. del: Homogeni sestavi titanovih zlitin

Aerospace series - Weldability and brazeability of materials in aerospace constructions - Part 006: Homogeneous assemblies of titanium alloys

Luft- und Raumfahrt - Schweißbarkeit und Lötbarkeit von Werkstoffen im Luft- und Raumfahrzeugbau - Teil 006: Gleichartige Verbindungen aus Titanbasislegierungen

Série aérospatiale - Soudabilité et brasabilité des matériaux pour constructions aérospatiales - Partie 006: Assemblages homogènes des alliages de titane

Ta slovenski standard je istoveten z: EN 4632-006:2013

ICS:

25.160.01	Varjenje, trdo in mehko spajkanje na splošno	Welding, brazing and soldering in general
49.025.30	Titan	Titanium

SIST EN 4632-006:2014 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 4632-006

March 2013

ICS 49.025.01

English Version

Aerospace series - Weldability and brazeability of materials in aerospace constructions - Part 006: Homogeneous assemblies of titanium alloys

Série aérospatiale - Soudabilité et brasabilité des matériaux pour constructions aérospatiales - Partie 006 : Assemblages homogènes des alliages de titane

Luft- und Raumfahrt - Schweißbarkeit und Lötbarkeit von Werkstoffen im Luft- und Raumfahrzeugbau - Teil 006: Gleichartige Verbindungen aus Titanbasislegierungen

This European Standard was approved by CEN on 19 January 2013.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 4632-006:2013: E

Contents

Page

Foreword

This document (EN 4632-006:2013) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2013, and conflicting national standards shall be withdrawn at the latest by September 2013.

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

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

This standard is part 6 of a series of 8 standards, with:

— EN 4632-001, *Aerospace series — Welded and brazed assemblies for aerospace constructions — Weldability and brazeability of materials — Part 001: General requirements*

— EN 4632-002, *Aerospace series — Welded and brazed assemblies for aerospace constructions — Weldability and brazeability of materials — Part 002: Homogeneous assemblies aluminium and aluminium alloys*

— EN 4632-003, *Aerospace series — Weldability and brazeability of materials in aerospace constructions — Part 003: Welding and brazing of homogeneous assemblies of unalloyed and low alloy steels*

— EN 4632-004, *Aerospace series — Welded and brazed assemblies for aerospace constructions — Weldability and brazeability of materials — Part 004: Homogeneous assemblies highly alloyed steels*

— EN 4632-005, *Aerospace series — Weldability and brazeability of materials in aerospace constructions — Part 005: Homogeneous assemblies of heat resisting Ni or Co base alloys*

— *EN* 4632-007, *Aerospace series — Weldability and brazeability of materials in aerospace constructions — Part 007: Homogeneous assemblies of miscellaneous alloys*

1 Scope

This European Standard defines degrees of weldability and brazeability for materials or families of materials used in the aerospace applications.

It comprises a series of sheets, by materials or by material family, which:

— indicate the main titles, the typical chemical composition and the main characteristics,

— contain recommendations for welding and brazing,

— indicate a degree of weldability or brazeability for a given process under defined conditions.

It is applicable without restriction for the manufacturing of new parts or for repair.

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.

EN 3120, *Aerospace series — Titanium alloy TI-P64003 — Cold worked and stress relieved — Seamless tube for pressure systems — 4 mm ≤ D ≤ 51 mm — 690 MPa ≤ R_m ≤ 1 030 MPa*

EN 3310, *Aerospace series — Titanium alloy TI-P64001 (Ti-6Al-4V) — Not heat treated — Forging stock, for annealed forgings — D_e ≤ 360 mm*

EN 3311, *Aerospace series — Titanium alloy TI-P64001 (Ti-6Al-4V) — Annealed — Bar for machining — D < 110 mm*

EN 3312, *Aerospace series — Titanium alloy Ti-6Al-4V — Annealed — Forgings — D_e ≤ 150 mm*

EN 3313, *Aerospace series — Titanium alloy TI-P64001 — Not heat treated — Grade 2 forging stock, for solution treated and aged forgings — a or D ≤ 360 mm* [1)]

EN 3314, *Aerospace series — Titanium alloy TI-P64001 — Solution treated and aged — Bar for machining — D ≤ 75 mm* [1)]

EN 3315, *Aerospace series — Titanium alloy TI-P64001 — Solution treated and aged — Forgings — D_e ≤ 75 mm* [1)]

EN 3321, *Aerospace series — Titanium alloy TI-P65001 — As forged — Grade 1 forging stock, for solution treated and aged forgings — a or D ≤ 360 mm* [1)]

EN 3322, *Aerospace series — Titanium alloy TI-P65001 — Solution treated and aged — Grade 1 — Forgings — D_e ≤ 75 mm* [1)]

EN 3354, *Aerospace series — Titanium alloy TI-P64001 (Ti-6Al-4V) — Annealed — Sheet for superplastic forming — a ≤ 6 mm* [1)]

1) Published as ASD-STAN Prestandard at the date of publication of this standard (www.asd-stan.org).

EN 3355, *Aerospace series — Titanium alloy TI-P64001 (Ti-6Al-4V) — Annealed — Extruded section — D_e ≤ 150 mm — 900 MPa ≤ R_m ≤ 1 160 MPa*

EN 3442, *Aerospace series — Titanium TI-P99002 — Annealed — Sheet and strip, hot rolled — a ≤ 6 mm — 390 MPa ≤ R_m ≤ 540 MPa* [1)]

EN 3443, *Aerospace series — Titanium TI-P99003 — Annealed — Sheet and strip, hot rolled — a ≤ 6 mm — 570 MPa ≤ R_m ≤ 730 MPa* [1)]

EN 3451, *Aerospace series — Titanium TI-P99002 — Not heat treated — Grade 2 forging stock, for annealed forgings — a or D ≤ 300 mm* [1)]

EN 3453, *Aerospace series — Titanium TI-P99003 — Not heat treated — Grade 2 forging stock, for annealed forgings — a or D ≤ 300 mm* [1)]

EN 3454, *Aerospace series — Titanium alloy TI-P19001 — Not heat treated — Grade 2 forging stock, for annealed forgings — a or D ≤ 300 mm* [1)]

EN 3455, *Aerospace series — Titanium alloy TI-P19001 — Not heat treated — Grade 2 forging stocks, for solution treated and aged forgings — a or D ≤ 300 mm* [1)]

EN 3456, *Aerospace series — Titanium alloy TI-P64001 (Ti-6Al-4V) — Annealed — Sheet and strip, hot rolled — a ≤ 6 mm*

EN 3460, *Aerospace series — Titanium TI-P99002 — Annealed — Bar for machining — a or D ≤ 150 mm — R_m ≥ 390 MPa* [1)]

EN 3461, *Aerospace series — Titanium TI-P99003 — Annealed — Bar for machining — D ≤ 150 mm — 540 MPa ≤ R_m ≤ 740 MPa* [1)]

EN 3462, *Aerospace series — Titanium alloy TI-P19001 — Annealed — Bar for machining — D ≤ 150 mm* [1)]

EN 3463, *Aerospace series — Titanium alloy TI-P19001 — Solution treated and aged — Bar for machining — D ≤ 75 mm* [1)]

EN 3464, *Aerospace series — Titanium alloy TI-P64001 (Ti-6Al-4V) — Annealed — Plate — 6 mm < a ≤ 100 mm*

EN 3494, *Aerospace series — Titanium alloy TI-P19001 — Grade 2 — Solution treated and aged — Forgings — D_e ≤ 75 mm* [1)]

EN 3495, *Aerospace series — Titanium alloy TI-P19001 — Grade 2 — Annealed — Forgings — D_e ≤ 150 mm* [1)]

EN 3496, *Aerospace series — Titanium TI-P99003 — Grade 2 — Annealed — Forgings — D_e ≤ 150 mm* [1)]

EN 3498, *Aerospace series — Titanium TI-P99002 — Annealed — Sheet and strip, cold rolled — a ≤ 6 mm — 390 MPa ≤ R_m ≤ 540 MPa* [1)]

EN 3499, *Aerospace series — Titanium TI-P99003 — Annealed — Sheet and strip, cold rolled — a ≤ 6 mm — 570 MPa ≤ R_m ≤ 730 MPa* [1)]

EN 3735, *Aerospace series — Titanium alloy TI-P65002 — Solution treated and aged — Bar for machining — D ≤ 75 mm* [1)]

EN 3736, *Aerospace series — Titanium alloy TI-P65002 — Grade 2 — Solution treated and aged — Forgings — D_e ≤ 75 mm* [1)]

EN 3737, *Aerospace series — Titanium alloy TI-P65002 — Not heat treated — Grade 2 forging stock, for solution treated and aged forgings — a or D ≤ 360 mm* [1)]

EN 3859, *Aerospace series — Titanium alloy TI-P19001 — Annealed — Sheet and strip, hot rolled — a ≤ 6 mm* [1)]

EN 3860, *Aerospace series — Titanium alloy TI-P19001 — Annealed — Sheet and strip, cold rolled — a ≤ 6 mm* [1)]

EN 3870, *Aerospace series — Titanium alloy TI-P19001 — Solution treated and aged — Sheet and strip, hot rolled — a ≤ 6 mm* [1)]

EN 3871, *Aerospace series — Titanium alloy TI-P19001 — Solution treated and aged — Sheet and strip, cold rolled — a ≤ 6 mm* [1)]

EN 3892, *Aerospace series — Titanium alloy TI-W64001 — Filler metal for welding*

EN 3965, *Aerospace series — Titanium alloy TI-B17001 — Filler metal for brazing — Rolled foil*

EN 4632-001:2008, *Aerospace series — Welded and brazed assemblies for aerospace constructions — Weldability and brazeability of materials — Part 001: General requirements*

EN 4632-007, *Aerospace series — Weldability and brazeability of materials in aerospace constructions — Part 007: Homogeneous assemblies of miscellaneous alloys* [2)]

EN 10052, *Vocabulary of heat treatment terms for ferrous products*

EN ISO 4063:2009, *Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063:2009)*

EN ISO 24034, *Welding consumables — Solid wires and rods for fusion welding of titanium and titanium alloys — Classification (ISO 24034:2010)*

AMS 4897, *Titanium alloy, sheet, strip, and plate 77 Ti — 15Mo - 3.0Al - 2.8Cb - 0.20Si* [3)]

AMS 4911, *Titanium alloy, sheet, strip, and plate 6Al - 4V annealed* [3)]

AMS 4920, *Titanium alloy, forgings 6Al - 4V alpha-beta or beta processed, annealed* [3)]

AMS 4928, *Titanium alloy bars, wire, forgings, rings, and drawn shapes, 6Al - 4V, annealed* [3)]

AMS 4930, *Titanium alloy bars, wire, forgings, and rings, 6Al - 4V, extra low interstitial, annealed* [3)]

AMS 4934, *Titanium alloy, extrusions and flash welded rings, 6Al - 4V, solution heat treated and aged* [3)]

AMS 4935, *Titanium alloy, extrusions and flash welded rings 6Al - 4V annealed beta processed* [3)]

AMS 4965, *Titanium alloy, bars, wire, forgings, and rings 6.0Al - 4.0V solution heat treated and aged* [3)]

AMS 4966, *Titanium alloy, forgings 5Al - 2.5Sn annealed, 110 ksi (758 MPa) yield strength* [3)]

AMS 4967, *Titanium alloy, bars, wire, forgings, and rings, 6.0Al - 4.0V, annealed, heat treatable* [3)]

---

2) In preparation at the date of publication.

3) Published by: SAE National (US) Society of Automotive Engineers http://www.sae.org/.

AMS 4981, *Titanium alloy bars, wire, and forgings — 6.0Al - 2.0Sn - 4.0Zr - 6.0Mo — solution and precipitation heat treated* [3)]

AMS 4985, *Titanium alloy, investment castings 6Al 4V 130 Uts, 120 Ys, 6 % El hot isostatically pressed anneal optional or when specified* [3)]

AMS 4991, *Titanium alloy castings, investment 6Al - 4V hot isostatic pressed, annealed optional* [3)]

AMS 4995, *Billets and preforms 5Al - 2Sn - 2Zr - 4Cr - 4M - 0.100 premium quality, powder-metallurgy product* [3)]

ASTM B 265, *Standard specification for titanium and titanium alloy strip, sheet, and plate* [4)]

AWS A5.16, *Specification for titanium and titanium alloy welding electrodes and rods* [5)]

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the terms, definitions, symbols and abbreviations given in EN 4632-001:2008 and EN ISO 4063:2009 apply.

PJHT : Post joining (brazing or diffusion brazing) heat treatment

PWHT : Post welding heat treatment

FSW : Friction stir welding

15 : Plasma arc welding

21 : Resistance spot welding

22 : Resistance seam welding

24 : Resistance flash welding

42 : Inertia friction welding

45 : Diffusion welding

51 : Electron beam welding

522 : Gas laser welding

91 : Brazing

111 : Shielded metal arc welding

131 : Gas metal arc welding

141 : Gas tungsten arc welding

919 : Diffusion brazing

924 : Vacuum brazing

4) Published by: ASTM National (US) American Society for Testing and Materials http://www.astm.org/.

5) Published by: AWS, 550 N.W. LeJeune Road, Miami, Florida 33126.

4 Use of this standard

The index of material sheets contained in this standard, classified by family based on the main element used in the chemical composition and on the alloy structure, is given in Clause 6 of this standard.

The degree of weldability or brazeability to be used is the value indicated by the material sheet considered for the process chosen. In the operating cycle, preferably select thermal states that give the lowest degree.

If two degrees are indicated, the responsible person must select the degree that is most appropriate for the definition of the assembly.

5 Updating of this standard

See EN 4632-001.

6 List of titanium alloys sheets

See Sheets 7.1 to 7.8.

Sheet	Materials	
	Old designation	Chemical designation
7.1	T40 - T60	Ti Grade 2 - Ti Grade 4
7.2	TU2 - TA5E	Ti-2,5Cu – Ti-5Al -2,5Sn
7.3	TA6V - TA3V2,5	Ti-6Al-4V - Ti-3Al-2,5V
7.4	TA6Zr5D - TA6Zr4DE	Ti-6Al-5Zr-Mo - Ti-6Al-4Zr-4Mo-2Sn
7.5	—	Ti-15Mo-3Nb-3Al
7.6	TAD6Zr4E	Ti-6Al-6Mo-4Zr-2Sn
7.7	TA5CD4	Ti-5Al-4Cr-4Mo-2Sn-2Zr
7.8	TAD4E	Ti-4Al-4Mo-2Sn-0,5Si

7 Material sheets

7.1 Ti Grade 2 - Ti Grade 4

7.1.1 Designation

EN	:	EN 3442, EN 3451, EN 3460, EN 3498	EN 3443, EN 3453, EN 3461, EN 3496, EN 3499
Chemical	:	Ti Grade 2	Ti Grade 4
Current	:	–	–
ASD STAN	:	Ti-P99002	Ti-P99003
Other standards	:	Grade 2 according to ASTM B 265	Grade 4 according to ASTM B 265

7.1.2 Typical chemical composition (w.%)

Grade	Ti	O	N	H	Fe	C
Ti Grade 2	base	— 0,25	— 0,05	— 0,0125	— 0,25	— 0,08

Grade	Ti	O2	N2	H2	Fe	C
Ti Grade 4	base	— 0,40	— 0,05	— 0,0125	— 0,35	— 0,08

7.1.3 Structure

α structure

7.1.4 Particular characteristics

Chemical pickling recommended: welding within 12 hours, otherwise storage under gaseous protection with a neutral gas in a confined environment after chemical pickling.

Chemical pickling may be omitted on mechanical preparations with very good R_a and thorough cleaning.

Improvement of gaseous protection for 141, 15, 52 processes.

For single-run welding without re-start of weld (141, 15, 52) a straw-colouring of the melted zone or/and heat affected zone may be acceptable. For multi-runs welding, this straw-colouring is not permitted between runs.

7.1.5 Forms

Ti-P99002: Hot rolled sheet (EN 3442) – Cold rolled sheet (EN 3498) – Forging stock (EN 3451) – Bars (EN 3460).

Ti-P99003: Hot rolled sheet (EN 3443) – Cold rolled sheet (EN 3499) – Forging stock (EN 3453) – Bar (EN 3461) – Forgings (EN 3496).