
**Aeronavtika - Varilnost in spajkalnost letalskih in vesoljskih konstrukcij - 004. del:
Varjenje in spajkanje homogenih sestavov iz istovrstnih močno legiranih jekel**

Aerospace series - Weldability and brazeability of materials in aerospace constructions -
Part 004: Welding and brazing of homogeneous assemblies of high alloyed steels

Luft- und Raumfahrt - Schweißbarkeit und Lötbarkeit von Werkstoffen im Luft- und
Raumfahrzeugbau - Teil 004: Schweißen und Löten gleichartiger Verbindungen aus
hochlegierten Stählen

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Série aérospatiale - Soudabilité et brasabilité des matériaux pour constructions
aérospatiales - Partie 004: Assemblages soudés et brasés homogènes d'aciers
fortement alliés

Ta slovenski standard je istoveten z: EN 4632-004:2012

ICS:

25.160.01	Varjenje, trdo in mehko spajkanje na splošno	Welding, brazing and soldering in general
49.025.10	Jekla	Steels

SIST EN 4632-004:2014**en**

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EUROPEAN STANDARD

EN 4632-004

NORME EUROPÉENNE

EUROPÄISCHE NORM

September 2012

ICS 49.025.01

English Version

Aerospace series - Weldability and brazeability of materials in aerospace constructions - Part 004: Welding and brazing of homogeneous assemblies of high alloyed steels

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This European Standard was approved by CEN on 23 March 2012.

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Foreword

This document (EN 4632-004:2012) 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of an identical text or by endorsement, at the latest by March 2013, and conflicting national standards shall be withdrawn at the latest by March 2013.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.

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EN 4632-004:2012 (E)**1 Scope**

This European Standard specifies the weldability and brazeability of materials or material families used in the aerospace industry.

It comprises a series of sheets, by materials or 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,
- indicate a value for the welded joint mechanical resistance coefficient for each welding process when extracted from relevant bibliographical references. Joint coefficient is the ratio of stress resistance transversally to welded joint over tensile strength of parent alloy.

It recommends ISO/TR 17671-3 and EN 1011-3 for pre-heating conditions specially for the welding of martensitic steels. These conditions depend on the line energy of welding, thickness, arc welding process and of hydrogen rate in filler metal.

It applies unreservedly to 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 1011-3, *Welding — Recommendations for welding of metallic materials — Part 3: Arc welding of stainless steels*

EN 1045, *Brazing — Fluxes for brazing — Classification and technical delivery conditions*

EN 2174, *Aerospace series — Heat resisting alloy FE-PA2602 (X4NiCrTiMoV26-15) — Solution treated and precipitation treated — Forgings — $D_e \leq 100$ mm — $R_m \geq 850$ MPa¹⁾*

EN 2175, *Aerospace series — Heat resisting alloy FE-PA2602 (X4NiCrTiMoV26-15) — Solution treated and precipitation treated — Sheet strip and plate — $0,5$ mm $\leq a \leq 10$ mm — $R_m \geq 850$ MPa¹⁾*

EN 2177, *Aerospace series — Heat resisting alloy FE-PA2501 (X4NiCrMoTi43-13) — Solution treated and precipitation treated — Forgings — $D_e \leq 100$ mm¹⁾*

EN 2178, *Aerospace series — Heat resisting alloy FE-PA2501 (X4NiCrMoTi43-13) — Solution treated and precipitation treated — Bar and section — $D_e \leq 200$ mm¹⁾*

EN 2278, *Steel FE-PM37 — 900 MPa $\leq R_m \leq 1$ 100 MPa — Bars $D_e \leq 150$ mm — Aerospace series²⁾*

EN 2279, *Steel FE-PM37 — 900 MPa $\leq R_m \leq 1$ 100 MPa — Forgings $D_e \leq 150$ mm — Aerospace series²⁾*

EN 2280, *Steel FE-PM37 — 900 MPa $\leq R_m \leq 1$ 100 MPa — Sheets $a \leq 6$ mm — Aerospace series²⁾*

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

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

- EN 2465, Aerospace series — Steel FE-PA3901 (X2CrNi18-9) — Softened — $450 \text{ MPa} \leq R_m \leq 680 \text{ MPa}$ — Bar for machining — $4 \text{ mm} \leq D_e \leq 100 \text{ mm}$
- EN 2466, Aerospace series — Steel FE-PA3901 (X2CrNi19-11) — Softened — Forgings — $D_e \leq 100 \text{ mm}$
- EN 2467, Aerospace series — Steel FE-PA3901 (X2CrNi18-9) — Air melted — Softened — Plate, sheet and strip — $0,4 \text{ mm} \leq a \leq 20 \text{ mm}$ — $520 \text{ MPa} \leq R_m \leq 670 \text{ MPa}$
- EN 2468, Steel FE-PA11 — Softened — Tubes $0,5 \text{ mm} \leq a \leq 5 \text{ mm}$ — Aerospace series ²⁾
- EN 2469, Aerospace series — Steel FE-PA3901 (X1CrNi18-10) — Air melted — Softened — Wires — $0,4 \text{ mm} \leq D \leq 12,5 \text{ mm}$ — $450 \text{ MPa} \leq R_m \leq 650 \text{ MPa}$
- EN 2815, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted — Solution treated and precipitation treated — Bar for machining — a or $D \leq 200 \text{ mm}$ — $R_m \geq 965 \text{ MPa}$
- EN 2816, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 200 \text{ mm}$ — $R_m \geq 965 \text{ MPa}$ ¹⁾
- EN 2817, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted — Solution treated and precipitation treated — Bar for machining — a or $D \leq 200 \text{ mm}$ — $R_m \geq 1\,070 \text{ MPa}$
- EN 2818, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 200 \text{ mm}$ — $R_m \geq 1\,070 \text{ MPa}$
- EN 2821, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted — Solution treated and precipitation treated — Bar for machining — a or $D \leq 200 \text{ mm}$ — $R_m \geq 1\,310 \text{ MPa}$
- EN 3160, Aerospace series — Steel FE-PM3801 (X5CrNiCu17-4) — Air melted, solution treated and precipitation treated — Bar — a or $D \leq 200 \text{ mm}$ — $R_m \geq 1\,310 \text{ MPa}$
- EN 3161, Aerospace series — Steel FE-PM3801 (X5CrNiCu17-4) — Air melted, solution treated and precipitation treated — Bar — a or $D \leq 200 \text{ mm}$ — $R_m \geq 930 \text{ MPa}$
- EN 3162, Aerospace series — Steel FE-PM3801 (X5CrNiCu17-4) — Air melted, solution treated and precipitation treated — Sheet and strip, $a \leq 6 \text{ mm}$ — $R_m \geq 930 \text{ MPa}$
- EN 3357, Aerospace series — Steel FE-PM1503 (X3CrNiMoAl13-8-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Bar for machining — a or $D \leq 150 \text{ mm}$ — $1\,200 \text{ MPa} \leq R_m \leq 1\,400 \text{ MPa}$ ¹⁾
- EN 3358, Aerospace series — Steel FE-PM1503 (X3CrNiMoAl13-8-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Bar for machining — a or $D \leq 150 \text{ mm}$ — $R_m \geq 1\,400 \text{ MPa}$ ¹⁾
- EN 3359, Aerospace series — Steel FE-PM1503 (X3CrNiMoAl13-8-2) — Vacuum induction melted and consumable electrode remelted, softened, forging stock — a or $D \leq 300 \text{ mm}$
- EN 3361, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted, solution treated and precipitation treated, sheet and strip — $a \leq 6 \text{ mm}$ — $1\,070 \text{ MPa} \leq R_m \leq 1\,220 \text{ MPa}$
- EN 3365, Aerospace series — Steel FE-PM3901 (X15CrNi17-3) — Air melted, softened, forging stock — a or $D \leq 300 \text{ mm}$

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EN 3468, Aerospace series — Steel FE-PA13 — Softened — $500 \leq R_m \leq 700$ MPa — Forgings — $D_e \leq 100$ mm ¹⁾

EN 3469, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 200$ mm — $R_m \geq 1\ 310$ MPa ¹⁾

EN 3470, Aerospace series — Steel FE-PM1503 (X3CrNiMoAl13-8-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 150$ mm — $1\ 200$ MPa $\leq R_m \leq 1\ 400$ MPa ¹⁾

EN 3479, Aerospace series — Steel FE-PM1802 (X5CrNiCu15-5) — Consumable electrode remelted — Solution treated and precipitation treated — Plate — 6 mm $< a \leq 20$ mm — $1\ 070$ MPa $\leq R_m \leq 1\ 220$ MPa

EN 3480, Aerospace series — Steel FE-PA3601 (X6CrNiTi18-10) — Air melted — Softened — Plate — 6 mm $< a \leq 50$ mm — 500 MPa $\leq R_m \leq 700$ MPa

EN 3481, Aerospace series — Steel FE-PA13 — Annealed — Reference heat treatment: softened — Hollow bars — $5 \leq a \leq 12$ mm ¹⁾

EN 3486, Aerospace series — Steel FE-PM67 — Solution annealed and precipitation hardened — $1\ 400 \leq R_m \leq 1\ 550$ MPa — Forgings — $D_e \leq 100$ mm ¹⁾

EN 3487, Aerospace series — Steel FE-PA3601 (X6CrNiTi18-10) — Air melted — Softened — Bar for machining — a or $D \leq 250$ mm — 500 MPa $\leq R_m \leq 700$ MPa

EN 3488, Aerospace series — Steel FE-PA3601 (X6CrNiTi18-10) — Air melted — Softened — Sheet and strip — $a \leq 6$ mm — 500 MPa $\leq R_m \leq 700$ MPa

EN 3489, Aerospace series — Steel FE-PA13 — Softened — $500 \leq R_m \leq 750$ MPa — Tubes for structures — $0,5 \leq a \leq 5$ mm ¹⁾

EN 3490, Aerospace series — Steel FE-PM3901 (X15CrNi17-3) — Air melted — Hardened and tempered — Bar for machining — $D_e \leq 200$ mm — 900 MPa $\leq R_m \leq 1\ 100$ MPa

EN 3491, Aerospace series — Steel FE-PM3901 (X15CrNi17-3) — Air melted — Hardened and tempered — Forgings — $D_e \leq 100$ mm — 900 MPa $\leq R_m \leq 1\ 100$ MPa

EN 3510, Aerospace series — Heat resisting alloy FE-PA2602 (X4NiCrTiMoV26-15) — Solution treated and precipitation treated — Bar and section — $D_e \leq 100$ mm ¹⁾

EN 3529, Aerospace series — Steel FE-PM2701 (X2NiCoMo18-8-5) — Vacuum induction melted and vacuum arc remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 150$ mm — $1\ 750$ MPa $\leq R_m \leq 2\ 000$ MPa ¹⁾

EN 3531, Aerospace series — Steel FE-PM2701 (X2NiCoMo18-8-5) — Vacuum induction melted and vacuum arc remelted — Solution treated and precipitation treated — Sheet and strip — $a \leq 6$ mm — $1\ 750$ MPa $\leq R_m \leq 2\ 000$ MPa

EN 3532, Aerospace series — Steel FE-PM-2701 (X2NiCoMo18-8-5) — Vacuum induction melted and vacuum arc remelted — Solution treated and precipitation treated — Plate — 6 mm $< a \leq 40$ mm — $1\ 750$ MPa $\leq R_m \leq 2\ 000$ MPa

EN 3677, Aerospace series — Steel FE-PM3801 (X5CrNiCu17-4) — Air melted — Solution treated and precipitation treated — Forgings — a or $D \leq 200$ mm — $R_m \geq 1\ 310$ MPa

EN 3678, Aerospace series — Steel FE-PM3801 (X5CrNiCu17-4) — Air melted — Solution treated and precipitation treated — Forgings — a or $D \leq 200$ mm — $R_m \geq 930$ MPa

EN 3889, Aerospace series — Steel FE-WM3801 (X5CrNiCu17-4) — Filler metal for welding

EN 3890, Aerospace series — Steel FE-WM1502 (X11CrNiMoVN12-3) — Filler metal for welding

EN 4264, Aerospace series — Heat resisting alloy FE-PA2501 (X4NiCrMoTi43-13) — As forged — Forging stock — a or $D \leq 200$ mm ¹⁾

EN 4314, Aerospace series — Heat resisting alloy FE-PA2602 (X4NiCrTiMoV26-15) — Non heat treated, forging stock a or $D \leq 250$ mm

EN 4335, Aerospace series — Steel FE-WA2602 (X4NiCrTiMoV26-15) — Filler metal for welding — Wire and rod

EN 4346, Aerospace series — Steel FE-PM1505 (X1CrNiMoAlTi12-9-2) — Vacuum induction melted and consumable electrode remelted — Softened — Forging stock — a or $D \leq 300$ mm

EN 4467, Aerospace series — Steel FE-PM1505 (X1CrNiMoAlTi12-9-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Bar — a or $D \leq 150$ mm — $R_m \geq 1\,200$ MPa

EN 4468, Aerospace series — Steel FE-PM1505 (X1CrNiMoAlTi12-9-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Bar — a or $D \leq 150$ mm — $R_m \geq 1\,300$ MPa

EN 4469, Aerospace series — Steel FE-PM1505 (X1CrNiMoAlTi12-9-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Bar — a or $D \leq 150$ mm — $R_m \geq 1\,400$ MPa

EN 4470, Aerospace series — Steel FE-PM1505 (X1CrNiMoAlTi12-9-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 150$ mm — $R_m \geq 1\,200$ MPa

EN 4471, Aerospace series — Steel FE-PM1505 (X1CrNiMoAlTi12-9-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 150$ mm — $R_m \geq 1\,300$ MPa

EN 4472, Aerospace series — Steel FE-PM1505 (X1CrNiMoAlTi12-9-2) — Vacuum induction melted and consumable electrode remelted — Solution treated and precipitation treated — Forgings — a or $D \leq 150$ mm — $R_m \geq 1\,400$ MPa

EN 4570, Aerospace series — Heat resisting alloy FE-PA4901 (X12CrNiCoMoW21-20) — Solution treated — Forgings — $D_e \leq 100$ mm ¹⁾

EN 4571, Aerospace series — Heat resisting alloy FE-PA4901 (X12CrNiCoMoW21-20) — Solution treated — Bar and section — $D_e \leq 100$ mm ¹⁾

EN 4572, Aerospace series — Heat resisting alloy FE-PA4901 (X12CrNiCoMoW21-20) — Solution treated — Sheet and strip — $a \leq 3$ mm ¹⁾

EN 4573, Aerospace series — Heat resisting alloy FE-PA4901 (X12CrNiCoMoW21-20) — Solution treated and precipitation treated — Bar and section — $D_e \leq 100$ mm ¹⁾

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EN 4574, Aerospace series — Heat resisting alloy FE-PA4901 (X12CrNiCoMoW21-20) — Solution treated and precipitation treated — Forgings — $D_e \leq 100 \text{ mm}$ ¹⁾

EN 4575, Aerospace series — Heat resisting alloy FE-PA4901 (X12CrNiCoMoW21-20) — Solution treated and descaled — Sheet and plate — $3 \text{ mm} < a \leq 50 \text{ mm}$ ¹⁾

EN 4627, Aerospace series — Steel FE-PM 3504 (X4CrNiMo16-5-1) — Air melted — Hardened and tempered — Forgings — $D_e \leq 150 \text{ mm}$ — $1\ 100 \text{ MPa} \leq R_m \leq 1\ 300 \text{ MPa}$

EN 4628, Aerospace series — Steel FE-PM 3504 (X4CrNiMo16-5-1) — Air melted — Hardened and tempered — Bar — $D_e \leq 150 \text{ mm}$ — $1\ 100 \text{ MPa} \leq R_m \leq 1\ 300 \text{ MPa}$

EN 4629, Aerospace series — Steel FE-PM 3504 (X4CrNiMo16-5-1) — Air melted — Hardened and tempered — Forging stock — $D_e \leq 300 \text{ mm}$

EN 4630, Aerospace series — Steel FE-PM 3504 (X4CrNiMo16-5-1) — Air melted — Hardened and tempered — Forging — $D_e \leq 200 \text{ mm}$ — $900 \text{ MPa} \leq R_m \leq 1\ 050 \text{ MPa}$

EN 4631, Aerospace series — Steel FE-PM 3504 (X4CrNiMo16-5-1) — Air melted — Hardened and tempered — Bar — $D_e \leq 200 \text{ mm}$ — $900 \text{ MPa} \leq R_m \leq 1\ 050 \text{ MPa}$

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

EN 4642, Aerospace series — Steel FE-PM 3504 (X4CrNiMo16-5-1) — Air melted — Hardened and tempered — Sheet and plate — $0,6 \text{ mm} \leq a \leq 50 \text{ mm}$ — $900 \text{ MPa} \leq R_m \leq 1\ 050 \text{ MPa}$

EN 10088-1, Stainless steels — Part 1: List of stainless steels

EN 10088-2, Stainless steels — Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes

EN 10088-3, Stainless steels — Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes

EN ISO 14343, Welding consumables — Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels — Classification (ISO 14343)

EN ISO 4063:2010, Welding and allied processes — Nomenclature of processes and reference numbers (ISO 4063:2009, Corrected version 2010-03-01)

EN ISO 18265, Metallic materials — Conversion of hardness values (ISO 18265)

ISO/TR 17671-3, Welding — Recommendations for welding of metallic materials — Part 3: Arc welding of stainless steels

AMS 5825, Steel, Corrosion resistant, welding wire, 16.4Cr — 4.8Ni — 0.22 Cb — 3.6Cu ³⁾

AMS 6501, Steel, maraging, welding wire, 18Ni — 8.0Co — 4.9Mo — 0.40Ti — 0.10Al, vacuum induction melted, environment controlled packaging ³⁾

AWS A 5.14, Specification for nickel and nickel-alloy bare welding electrodes and rods ⁴⁾

3) Published by: Society of Automotive Engineers (SAE), (www.sae.org).

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

3 Terms and definitions

For the purposes of this document, the following terms, reference numbers according to EN ISO 4063 and definitions given in EN 4632-001 apply.

4 Abbreviations

See Table 1.

Table 1 — Commonly used US acronyms and abbreviations

Reference number according to EN ISO 4063	Welding process	AWS-acronym
15	Plasma arc welding	PAW
21	Resistance spot welding	RSW
22	Resistance seam welding	RSEW
24	Flash welding	FW
42	Friction welding	FRW
51	Electron beam welding	EBW
111	Manual metal arc welding	SMAW
141	Gas tungsten arc welding using inert gas and solid filler material (wire/rod)	—
131	MIG welding with solid wire electrode	—
311	Oxy-acetylene welding	OAW
521	Solid state laser welding	SLW
522	Gas laser welding	—
912	Flame brazing	TB
913	Laser beam brazing ing	LBBW
922	Vacuum brazing	—
924	Salt-bath brazing	—

PJHT : Post joining heat treatment

PWHT : Post-weld heat treatment

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5 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.

The degree of weldability or brazeability (see EN 4632-001) to be used is the value indicated by the material sheet considered for the chosen process. In the operating cycle, preferably select thermal states that give the lowest degree (for better weldability or brazeability).

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

6 Updating

See EN 4632-001.

7 List of highly alloyed steels

See Table 2.

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Subclause	Material
7.1	X2NiCoMo18-8-5
7.2	X5CrNiCu15-5
	X5CrNiCu17-4
7.3	X15CrNi17-3
7.4	X4CrNiMo16-5-1
7.5	X12CrNiMoV12-3
	X12Cr13
7.6	X2CrNi19-11
	X2CrNiMo17-12-2
	X6CrNiTi18-10
	X6CrNiMoTi17-12-2
	X6CrNiNb18-10
7.7	X12CrNiCoMoW21-20
7.8	X4NiCrMoTi43-13
7.9	X4NiCrTiMoV26-15
7.10	X1CrNiMoAlTi12-9-2
	X3CrNiMoAl13-8-2