
Aeronavtika - Varivost in spajkljivost materialov v aeronavtičnih konstrukcijah - 005. del: Varjenje in spajkanje homogenih sestavov iz nikljeve ali kobaltove osnovne zlitine, odporne proti vročini

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

Luft- und Raumfahrt - Schweißbarkeit und Lötbarkeit von Werkstoffen im Luft und Raumfahrzeugbau - Teil 005: Schweißen und Löten gleichartiger Verbindungen aus hitzebeständigen Nickel- oder Kobaltbasislegierungen

Série aérospatiale - Soudabilité et brasabilité des matériaux pour constructions aérospatiales - Partie 005: Assemblages homogènes des alliages base Ni ou Co résistant à haute température

Ta slovenski standard je istoveten z: EN 4632-005:2009

ICS:

25.160.01	Varjenje, trdo in mehko spajkanje na splošno	Welding, brazing and soldering in general
49.025.15	Neželezove zlitine na splošno	Non-ferrous alloys in general

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EUROPEAN STANDARD

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

Série aérospatiale - Assemblages soudés et brasés pour constructions aérospatiales - Soudabilité et brasabilité des matériaux - Partie 005: assemblage homogènes des alliages base Ni ou Co résistant à haute température

Luft- und Raumfahrt - Schweißbarkeit und Lötbarkeit von Werkstoffen im Luft und Raumfahrzeugbau - Teil 005: Schweißen und Löten gleichartiger Verbindungen aus hitzebeständigen Nickel- oder Kobaltbasislegierungen

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Foreword

This document (EN 4632-005:2009) 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of an identical text or by endorsement, at the latest by June 2010, and conflicting national standards shall be withdrawn at the latest by June 2010.

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 4632-005:2009 (E)**1 Scope**

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

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

- indicate the main titles, the 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 of the mechanical strength coefficient of the welded joint for each welding process, when it could be extracted from bibliographic references referring to it. The joint coefficient is expressed as a ratio of the tensile strength of the welded joint to the tensile strength of the base alloy (to be in accordance with EN 4632-002).

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

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 2161, *Aerospace series — Heat resisting alloy CO-CH1401 (CoCr26Ni11W) — Not heat treated — Precision castings*¹⁾

EN 2183, *Aerospace series — Heat resisting alloy NI-PH2301 (NiCr21Fe18Mo9) — Solution treated — Forging — $D_e \leq 200$ mm*¹⁾

EN 2184, *Aerospace series — Heat resisting alloy NI-PH2301 (NiCr21Fe18Mo9) — Solution treated — Bar and section — $D_e \leq 200$ mm*¹⁾

EN 2185, *Aerospace series — Heat resisting alloy NI-PH2301 (NiCr21Fe18Mo9) — Solution treated — Sheet, strip and plate — $0,2$ mm $\leq a \leq 10$ mm*¹⁾

EN 2199, *Aerospace series — Heat resisting alloy NI-PH1303 (NiCo20Cr20Mo5Ti2Al) — Solution treated and precipitation treated — Bar and section — $D_e \leq 200$ mm*¹⁾

EN 2203, *Aerospace series — Heat resisting alloy NI-PH1303 (NiCo20Cr20Mo5Ti2Al) — Solution treated — Sheet, strip and plate — $0,2$ mm $\leq a \leq 10$ mm*¹⁾

EN 2204, *Aerospace series — Heat resisting alloy NI-CH1303 (NiCo20Cr20Mo5Ti2Al) — Vacuum melted — Solution treated and precipitation treated — Precision casting — $D_e \leq 50$ mm*¹⁾

EN 2403, *Aerospace series — Heat resisting alloy NI-CH2601 (NiCr19Fe19Nb5Mo3) — Vacuum melted — Solution treated and precipitation treated — Precision casting — a or $D \leq 50$ mm*¹⁾

EN 2405, *Aerospace series — Heat resisting alloy NI-PH2601 (NiCr19Fe19Nb5Mo3) — Solution treated and precipitation treated — Forgings — $D_e \leq 200$ mm*¹⁾

1) Published as ASD-STAN Prestandard at the date of publication of this standard.

- EN 2407, Aerospace series — Heat resisting alloy NI-PH2601 (NiCr19Fe19Nb5Mo3) — Solution treated and precipitation treated — Sheet, strip and plate — $0,2 \text{ mm} \leq a \leq 10 \text{ mm}^2$)
- EN 2657, Aerospace series — Heat resisting alloy CO-PH1402 — Consumable electrode remelted — Solution treated — Bar — $a \text{ or } D \leq 150 \text{ mm} — R_m \geq 860 \text{ MPa}^2$)
- EN 2658, Aerospace series — Heat resisting alloy CO-PH1402 — Consumable electrode remelted — As forged — Forging stock — $D_e \leq 360 \text{ mm}^2$)
- EN 2659, Aerospace series — Heat resisting alloy CO-PH1402 — Consumable electrode remelted — Solution treated — Forgings — $D_e \leq 100 \text{ mm} — R_m \geq 860 \text{ MPa}^2$)
- EN 2661, Aerospace series — Heat resisting alloy CO-PH1402 — Consumable electrode remelted — Solution treated — Sheet and strip — $a \leq 3 \text{ mm} — R_m \geq 860 \text{ MPa}^2$)
- EN 2662, Aerospace series — Heat resisting alloy NI-PH3601 (NiCr22Mo9Nb) — Annealed — Sheet, strip and plate — $0,2 \text{ mm} \leq a \leq 10 \text{ mm}^2$)
- EN 2663, Aerospace series — Heat resisting alloy NI-PH3601 (NiCr22Mo9Nb) — Solution treated — Sheet, strip and plate — $0,2 \text{ mm} \leq a \leq 10 \text{ mm}^2$)
- EN 2959, Aerospace series — Heat resisting alloy NI-PH1302 (NiCr20Co13Mo4Ti3Al) — Solution treated and cold worked — Bar for forged fasteners — $3 \text{ mm} \leq D \leq 30 \text{ mm}^2$)
- EN 3668, Aerospace series — Heat resisting alloy NI-PH2301 (NiCr21Fe18Mo9) — Non heat treated — Forging stock — $a \text{ or } D \leq 250 \text{ mm}$
- EN 3671, Aerospace series — Heat resisting alloy NI-PH3601 (NiCr22Mo9Nb) — Non heat treated — Forging stock — $a \text{ or } D \leq 250 \text{ mm}$
- EN 3884, Aerospace series — Heat resisting alloy NI-WH2601 (NiCr19Nb5Mo3Ti) — Filler metal for welding
- EN 3887, Aerospace series — Heat resisting alloy CO-WH4101 (CoCr20W15Ni) — Filler metal for welding
- EN 3888, Aerospace series — Heat resisting alloy CO-WH1402 (CoCr22Ni22W15) — Filler metal for welding
- EN 4095, Aerospace series — Heat resisting alloy NI-CH1305 (NiCr16Co10Mo8Al4Ti4) — Vacuum melted — Non heat treated — Precision castings²⁾
- EN 4222, Aerospace series — Heat resisting alloy NI-PH1305 (NiCr22Co13Mo9Al1) — Air melted and vacuum refined — Annealed — Sheet and strip — $0,25 \text{ mm} \leq a \leq 3 \text{ mm}^2$)
- EN 4327, Aerospace series — Heat resisting alloy CO-WH1401 (CoCr26Ni11W8) — Filler metal for welding — Wire and rod
- EN 4329, Aerospace series — Heat resisting alloy NI-WH0001 (NiCr20) — Filler metal for welding — Wire and rod
- EN 4376, Aerospace series — Heat resisting alloy NI-PH2601 (NiCr19Fe19Nb5Mo3) — Solution treated and precipitation treated — Bar and section — $D_e \leq 200 \text{ mm}^2$)
- EN 4377, Aerospace series — Heat resisting alloy NI-PH2601 (NiCr19Fe19Nb5Mo3) — Non heat treated — Forging stock — $a \text{ or } D \leq 300 \text{ mm}^2$)

2) Published as ASD-STAN Prestandard at the date of publication of this standard.

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EN 4379, Aerospace series — Heat resisting alloy NI-PH3601 (NiCr22Mo9Nb) — Solution treated — Forging — $D_e \leq 200$ mm

EN 4380, Aerospace series — Heat resisting alloy NI-PH3601 (NiCr22Mo9Nb) — Solution treated — Bar and section — $D_e \leq 200$ mm³⁾

EN 4381, Aerospace series — Heat resisting alloy NI-PH3601 (NiCr22Mo9Nb) — Solution treated — Seamless tubes — For structural application — $D \leq 50$ mm, $a \leq 3$ mm³⁾

EN 4382, Aerospace series — Heat resisting alloy NI-PH3601 (NiCr22Mo9Nb) — Solution treated — Seamless tubes — For hydraulic application — $D \leq 50$ mm, $a \leq 3$ mm

EN 4384, Aerospace series — Heat resisting alloy NI-CH1303 (NiCo20Cr20Mo5Ti2Al) — Non heat treated — Remelting stock

EN 4566, Aerospace series — Heat resisting alloy CO-PH4101 (CoCr20W15Ni) — Vacuum melted — Solution treated — Forgings — $D_e \leq 100$ mm³⁾

EN 4567, Aerospace series — Heat resisting alloy CO-PH4101 (CoCr20W15Ni) — Vacuum melted — Solution treated — Bar and section — a or $D \leq 100$ mm³⁾

EN 4568, Aerospace series — Heat resisting alloy CO-PH4101 (CoCr20W15Ni) — Vacuum melted — Solution treated — Sheet and strip — $a \leq 6$ mm³⁾

EN 4569, Aerospace series — Heat resisting alloy CO-PH4101 (CoCr20W15Ni) — Vacuum melted — Solution treated — Wire — $D \leq 4$ mm³⁾

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

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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 10095, Heat resisting steels and nickel alloys

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

EN ISO 18274, Welding consumables — Wire and strips electrodes, wires and rods for fusion welding of nickel and nickel alloys — Classification (ISO 18274:2004)

ISO 9722, Nickel and nickel alloys — Composition and forms of wrought products

AMS 5390, Nickel alloy, corrosion and heat resistant, investment castings 47.5Ni - 22Cr - 1.5Co - 9Mo - 0.60W - 18.5Fe (N-12mv) as cast⁴⁾

AMS 5399, Nickel alloy, corrosion and heat resistant, investment castings 52Ni - 19Cr - 11Co - 9.8Mo - 3.2Ti - 1.6Al - 0.006B vacuum-melted, vacuum-cast, solution heat treated⁴⁾

AMS 5402, Nickel alloy, corrosion and heat-resistant, investment castings 62Ni - 21.5Cr - 9.0Mo - 3.6Cb (Nb) as cast⁴⁾

3) Published as ASD-STAN Prestandard at the date of publication of this standard.

4) Published by: SAE, 400 Commonwealth Drive - Warrendale, PA 15096-0001 USA.

AMS 5540, *Nickel alloy, corrosion and heat resistant, sheet, strip, and plate 74Ni - 15.5Cr - 8.0Fe annealed*⁵⁾

AMS 5580, *Nickel alloy, corrosion and heat resistant, seamless tubing 74Ni - 15.5Cr - 8.0Fe annealed*⁵⁾

AMS 5665, *Nickel alloy, corrosion and heat resistant, bars, forgings, and rings 74Ni - 15.5Cr - 8.0Fe*⁵⁾

AMS 5687, *Nickel alloy, corrosion and heat resistant, wire 74Ni - 15.5Cr - 8.0Fe annealed*⁵⁾

AWS A5.14, *Specification for Nickel and Nickel Alloy Bare Welding Electrodes and Rods*⁶⁾

AWS A5.8-92, *Specification for filler metals for brazing and braze welding*⁶⁾

3 Terms, definitions, symbols and abbreviations

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

F : Foil

p : Powder

PJHT : Post joining heat treatment

PWHT : Post-weld heat treatment

w : Wire

15 : Plasma arc welding

21 : Resistance spot welding

22 : Resistance seam welding

24 : Flash welding

42 : Friction welding

51 : Electron beam welding

52 : Laser welding

91 : Brazing with local heating

111 : Shielded metal arc welding

141 : Gas tungsten arc welding

522 : Gas laser welding

521 : Solid state laser welding

922 : Vacuum brazing

5) Published by: SAE, 400 Commonwealth Drive - Warrendale, PA 15096-0001 USA.

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

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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.

The degree of weldability or brazeability (see EN 4632-001) 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 shall select the degree that is most appropriate for the definition of the assembly.

5 Updating this standard

See EN 4632-001.

6 List of heat resisting Ni or Co base alloys

Table 1

Sheet	Material
7.1	NiCr15Fe
7.2	NiCr16Co10Mo8Al4Ti4
7.3	NiCr19Fe19Nb5Mo3
7.4	NiCr19Fe19Nb5Mo3
7.5	NiCr19Co11Mo10Ti3
7.6	NiCr20Co13Mo4Ti3Al
7.7	NiCr20Nb
7.8	NiCr20Ti
7.9	NiCr22Mo9Nb
7.10	NiCr22Mo9Nb
7.11	NiCr21Fe18Mo9
7.12	NiCr21Fe18Mo9
7.13	NiCr22Co13Mo9Al1
7.14	NiCo20Cr20Mo5Ti2Al
7.15	NiCo20Cr20Mo5Ti2Al
7.16	CoCr20W15Ni
7.17	CoCr26Ni11W
7.18	CoCr22Ni22W15

7 Heat resisting Ni or Co base alloys

7.1 NiCr15Fe

7.1.1 Designation

EN 10095 : NiCr15Fe

ASD STAN : –

Other standards : AMS 5665, AMS 5540, AMS 5580, AMS 5687 and ISO 9722

7.1.2 Chemical composition (w.%)

Table 2

Grade	Ni	Fe	C	Si	Mn	P	S	Cr	Cu	Al	Ti
NiCr15Fe	base	6,0 to 10,0	0,05 to 0,10	≤ 0,5	≤ 1,0	≤ 0,02	≤ 0,015	14,0 to 17,0	≤ 0,5	≤ 0,30	≤ 0,30

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7.1.3 Structure

Austenitic.

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7.1.4 Particular characteristics

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Tensile strength for base metal: $R_m = 550$ MPa (minimum guaranteed in the annealed state).

Continuous use up to 700 °C.

7.1.5 Forms

Bars, forgings and rings (AMS 5665), Sheet, strip and plate (AMS 5540), Tube (AMS 5580) and Wire (AMS 5687).

Table 3 — Recommendations for welding and filling with NiCr15Fe

AWS acronym and corresponding EN ISO 4063 reference number	Thickness range ^a mm	State before welding	PWHT	Degree of weldability ^b	Joint efficiency	Comments and bibliographic references []
141	All	Hardened	None or Stress relieving	1	^c	Filler metal: ERNiCrFe-5 according to AWS A5.14 NiCr16Fe8Nb according to EN ISO 18274 ERNiCr-3 according to AWS A5.14 NiCr20Mn3Nb according to EN ISO 18274 ERNiCr-6 according to AWS A5.14 NiCr20 according to EN ISO 18274 NiCr20 according to EN 4329 [1]
EBW 51	–	Hardened	None or Stress relieving	1	1	–
521	≤ 1	Hardened	None	1	1	–
RSEW 22	–	Hardened	–	1	–	–
RSW 21	–	Hardened	–	1	–	–
FW 24	All	Hardened	Hardened	1	1	–

^a The range of thicknesses in the table concerns single run welding.

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

^c Tensile strength for melted metal and $R_m = 663$ MPa (average value) for ERNiCr-3 filler metal.

Table 4 — Recommendations for brazing and diffusion brazing assemblies

AWS acronym and corresponding EN ISO 4063 reference number	State before assembly	Assembly temperature °C	PJHT	Filler metal		Flux	Degree of brazeability or weldability	Comments
				family	form			
922 (vacuum furnace)	Hardened	1 050	None	Ni	p	None	1	–

7.2 NiCr16Co10Mo8Al4Ti4

7.2.1 Designation

EN 4095 : NiCr16Co10Mo8Al4Ti4

ASD STAN : Ni-CH1305

Other standards : –

7.2.2 Chemical composition (w.%)

Table 5

Grade	Ni	Fe	C	Si	Mn	P	S	Cr	Co	Mo	Al	Ti
NiCr16Co10Mo8Al4Ti4	base	≤ 0,5	0,12 to 0,18	≤ 0,2	≤ 0,2	≤ 0,01	≤ 0,01	14,5 to 16,5	9,0 to 10,5	7,6 to 9,0	3,9 to 4,4	3,4 to 3,8

7.2.3 Structure

Austenitic with structural hardening γ (primary).

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7.2.4 Particular characteristics

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Cast superalloy, stress relieved.

Precision castings with good creep resistance at high temperatures.

Use up to 1 050 °C.

7.2.5 Forms

Castings (EN 4095).

Table 6 — Recommendations for welding and filling with NiCr16Co10Mo8Al4Ti4

AWS acronym and corresponding EN ISO 4063 reference number	Thickness range ^a mm	State before welding	PWHT	Degree of weldability	Joint efficiency	Comments and bibliographic references []
141	≤ 3	Hardened	Hardened ^b	3	–	Filler metal: NiMo24FeCr: ERNiMo-3 according to AWS A5.14 NiMo25Cr5Fe5 according to EN ISO 18274
EBW 51	≤ 3	Hardened	Hardened	2 to 3	–	–

^a The range of thicknesses in the table concerns single run welding.

^b After welding, maintained for 30 min at (1 060 ± 10) °C. Slow cooling to 1 000 °C then cooling at ambient air.