
Aeronavtika - Varivost in spajkljivost materialov v aeronavtičnih konstrukcijah - 003. del: Varjenje in spajkanje homogenih sestavov iz nelegiranega in malo legiranega jekla

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

Luft- und Raumfahrt - Schweißbarkeit und Lötbarkeit von Werkstoffen im Luft und Raumfahrzeugbau - Teil 003: Schweißen und Löten gleichartiger Verbindungen aus unlegierten und niedriglegierten Stählen

[SIST EN 4632-003:2010](https://standards.iteh.ai/catalog/standards/sist/55645b99-18c5-4f0a-b0b7-)

Série aérospatiale - Soudabilité et brasabilité des matériaux pour constructions aérospatiales - Partie 003: Assemblages homogènes des aciers non alliés et faiblement alliés

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Foreword

This document (EN 4632-003:2010) 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of an identical text or by endorsement, at the latest by September 2010, and conflicting national standards shall be withdrawn at the latest by September 2010.

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EN 4632-003:2010 (E)**1 Scope**

This 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 families, which:

- a) indicate the main titles, the typical chemical composition and the main characteristics;
- b) contain recommendations for welding and brazing;
- c) indicate a degree of weldability or brazeability for a given process under defined conditions;
- d) 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 define preheating conditions, it recommends EN 1011-2 recommendations. These conditions depend on the calculation of carbon equivalent, welding energy per unit length, thickness, arc welding process and hydrogen rate in filler metal.

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 1011-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels* SIST EN 4632-003:2010
a6c631921e34/sist-en-4632-003-2010

EN 2135, *Aerospace series — Steel FE-PL61 — Carburized, hardened and tempered — Bar $D_e \leq 40$ mm* ¹⁾

EN 2213, *Steel FE-PL52 S — 980 MPa $\leq R_m \leq 1$ 180 MPa — Bars $D_e \leq 16$ mm — Aerospace series* ²⁾

EN 2218, *Steel FE-PL52 S — 980 MPa $\leq R_m \leq 1$ 180 MPa — Tubes for structures $a \leq 4$ mm — $d \geq 5$ a — Aerospace series* ²⁾

EN 2220, *Steel FE-PL52 S — 1 080 MPa $\leq R_m \leq 1$ 250 MPa — Tubes for structures — 2 mm $\leq a \leq 20$ mm — $d \geq 5$ a — Aerospace series* ²⁾

EN 2767, *Aerospace series — Steel FE-PL79 — Carburized, hardened and tempered — 1 180 MPa $\leq R_m \leq 1$ 550 MPa — Bar for machining — $D_e \leq 150$ mm* ¹⁾

EN 2768, *Aerospace series — Steel FE-PL79 — Carburized, hardened and tempered — 1 180 MPa $\leq R_m \leq 1$ 550 MPa — Forgings — $D_e \leq 150$ mm* ¹⁾

EN 2779, *Aerospace series — Steel FE-PL56 — Hardened and tempered — 1 250 MPa $\leq R_m \leq 1$ 400 MPa — Bars — $D_e \leq 70$ mm* ¹⁾

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

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

- EN 2780, Aerospace series — Steel FE-PL56 — Hardened and tempered — $1\,250\text{ MPa} \leq R_m \leq 1\,400\text{ MPa}$ — Forgings — $D_e \leq 70\text{ mm}$ ³⁾
- EN 3522, Aerospace series — Steel FE-PL79 — Softened — Reference heat treatment: carburized, hardened and tempered — Forging stock — $D_e \leq 200\text{ mm}$ ³⁾
- EN 3523, Aerospace series — Steel FE-PL1505 (15CrMoV6) — Air melted — Hardened and tempered — Bar for machining — $D_e \leq 100\text{ mm}$ — $1\,080\text{ MPa} \leq R_m \leq 1\,280\text{ MPa}$
- EN 3524, Aerospace series — Steel FE-PL1505 (15CrMoV6) — Air melted — Hardened and tempered — Sheet and strip — $2\text{ mm} \leq a \leq 6\text{ mm}$ — $1\,080\text{ MPa} \leq R_m \leq 1\,280\text{ MPa}$
- EN 3525, Aerospace series — Steel FE-PL1505 (15CrMoV6) — Air melted — Hardened and tempered — Plate — $6\text{ mm} < a \leq 20\text{ mm}$ — $1\,080\text{ MPa} \leq R_m \leq 1\,280\text{ MPa}$
- EN 3526, Aerospace series — Steel FE-PL1505 (15CrMoV6) — Air melted — Hardened and tempered — Sheet and strip — $0,5\text{ mm} \leq a \leq 6\text{ mm}$ — $980\text{ MPa} \leq R_m \leq 1\,180\text{ MPa}$
- EN 3969, Aerospace series — Steel FE-PL1507 (40CrMoV12) — Air melted — Annealed — Forging stock — a or $D \leq 350\text{ mm}$
- EN 3971, Aerospace series — Steel FE-PL1507 (40CrMoV12) — Consumable electrode remelted — Annealed — Forging stock — a or $D \leq 350\text{ mm}$
- EN 3972, Aerospace series — Steel FE-PL1507 (40CrMoV12) — Consumable electrode remelted — Hardened and tempered — Bar for machining — $D_e \leq 50\text{ mm}$ — $1\,250\text{ MPa} \leq R_m \leq 1\,400\text{ MPa}$
- EN 4098, Aerospace series — Steel FE-PL1507 (40CrMoV12) — Remelted — Hardened and tempered — Forgings — $D_e \leq 50\text{ mm}$ — $1\,250\text{ MPa} \leq R_m \leq 1\,400\text{ MPa}$
- EN 4331, Aerospace series — Steel FE-WL1804 (25CrMnMo4-2-2) — Filler metal for welding — Wire and rod
- EN 4332, Aerospace series — Steel FE-WL1805 (8CrMnMo12-4-9) — Filler metal for welding — Wire and rod
- EN 4334, Aerospace series — Steel FE-WL1806 (15CrMnMoV5-4-9-3) — Filler metal for welding — Wire and rod
- EN 4632-001:2008, Aerospace series — Welded and brazed assemblies for aerospace constructions — Weldability and brazeability of materials — Part 001: General requirements
- EN 10025 (all parts), Hot rolled products of structural steels
- EN 10027-1, Designation systems for steel — Part 1: Steel names
- EN 10028-1, Flat products made of steels for pressure purposes — Part 1: General requirements
- EN 10028-2, Flat products made of steels for pressure purposes — Part 2: Non-alloy and alloy steels with specified elevated temperature properties
- EN 10028-3, Flat products made of steels for pressure purposes — Part 3: Weldable fine grain steels, normalized
- EN 10052, Vocabulary of heat treatment terms for ferrous products
- EN 10083-1, Steels for quenching and tempering — Part 1: General technical delivery conditions
- EN 10084, Case hardening steels — Technical delivery conditions

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

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EN 10222-1, *Steel forgings for pressure purposes — Part 1: General requirements for open die forgings*

EN 10222-2, *Steel forgings for pressure purposes — Part 2: Ferritic and martensitic steels with specified elevated temperature properties*

EN 10222-3, *Steel forgings for pressure purposes — Part 3: Nickel steels with specified low temperature properties*

EN 10222-4, *Steel forgings for pressure purposes — Part 4: Weldable fine grain steels with high proof strength*

EN ISO 636, *Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels — Classification*

EN ISO 2560, *Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification (ISO 2560:2009)*

EN ISO 3580, *Welding consumables — Covered electrodes for manual metal arc welding of creep-resisting steels — Classification (ISO 3580:2004)*

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

EN ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes (ISO 14175:2008)*

EN ISO 14341, *Welding consumables — Wire electrodes and deposits for gas shielded metal arc welding of non alloy and fine grain steels — Classification (ISO 14341:2002)*

EN ISO 17632, *Welding consumables — Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels — Classification (ISO 17632:2004)*

ISO/TR 17671-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels*

ANSI/AWS A5.28, *Specification for low-alloy steel electrodes and rods for gas shielded arc welding* ⁴⁾

ANSI/AWS 5.5, *Specification for low alloy steel covered arc welding electrodes* ⁴⁾

ASTM A516, *Standard specification for pressure vessel plates, carbon steel, for moderate and lower-temperature service* ⁵⁾

3 Terms and definitions

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

In addition for the purposes of this document, the five following terms apply as well:

F : foil

tp : transfer tape

4) Published by: Society of Automotive Engineers, Inc. (SAE), 400 Commonwealth Drive, Warrendale, PA 15096-0001, USA.

5) Published by: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, USA.

w	:	wire
PJHT	:	post joining heat treatment
PWHT	:	post-weld heat treatment

Table 1 — Commonly used US acronyms and abbreviation

Reference number according to EN ISO 4063	Welding/brazing process	US-acronym
21	Resistance spot welding	RSW
22	Resistance seam welding	RSEW
24	Flash welding	FW
42	Friction welding	FRW
51	Electron beam welding	EBW
91	Brazing with local heating	—
97	Braze welding	—
111	Shielded metal arc welding	SMAW
131	Gas metal arc welding using inert gas and solid wire electrode	—
135	Gas metal arc welding using active gas with solid wire electrode	—
136	Gas metal arc welding using active gas and flux cored electrode	—
141	Gas tungsten arc welding using inert gas and solid filler material (wire/rod)	—
311	Oxy acetylene welding	OAW
422	Inertia friction welding	FRW-I
522	Gas laser welding	—

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 choose thermal states that give the lowest degree (for better weldability or brazeability).

5 Updating

See EN 4632-001.

6 Materials

Table 2 — Steel grades

Sheet	Material
6.1.1 6.1.2 6.1.3 6.1.4	P265 GH S235, S275 S355 C22E
6.2.1 6.2.2 6.2.3	12NiCr12, 16NiCrMo17, 16NiCrMo13, 20NiCrMo6-4 15CrMoV6 25CrMo4, 4130 ^a , 16MnCr5
6.2.4 6.2.5 6.2.6	35CrMo4, 4140 ^a 36NiCrMo16, E35NCD16, 4340 ^a 40CrMoV20, 40 CDV 20, E 40 CDV 20

^a According to AISI (American Iron and Steel Institute). Symbolic designations and main symbols mentioned in this table are consistent with EN 10027-1. Heat treatment designations are consistent with EN 10052.

6.1 Unalloyed steels

6.1.1 P265 GH

6.1.1.1 Designation

EN 10028-2	:	P265 GH
Current	:	carbon steel for boilers and pressure devices
ASD STAN	:	— https://standards.iteh.ai/catalog/standards/sist/55645b99-18c5-4f0a-b0b7-6c631921e34/sist-en-4632-003-2010
Other standards	:	ASTM A516 gr. 60

6.1.1.2 Typical chemical composition (w.%)

Table 3 — Chemical composition

Steel grade	Fe	C	Si	Mn	P	S
P265 GH	base	≤ 0,20	≤ 0,40	0,50 to 1,40	≤ 0,030	≤ 0,025

6.1.1.3 Structure

None.

6.1.1.4 Particular characteristics

GH type ensures a guarantee of impact properties at 0 °C.

6.1.1.5 Forms

Sheets (EN 10028-1 to EN 10028-3) – Forging stock (EN 10222-1 to EN 10222-4).

Table 4 — Recommendations for welding and filling of P265 GH steel

Process EN ISO 4063 reference number	Thickness range ^a mm	State before welding	PWHT	Degree of weldability	Joint efficiency	Comments and bibliographic references []
OAW 311	≤ 6	Normalized	none	1	–	Filler metal: G3Si1 according to EN ISO 14341
SMAW 111	≤ 12	Normalized	none	1	1	Rutile covered electrodes E 35...R..
	> 12		Stress relieving if necessary	1	–	Basic covered electrodes E 42...B... according to EN ISO 2560
141	≤ 4	Normalized		1	1	Filler metal: Steel for 141 with Si + Mn (type G3Si1 according to EN ISO 14341)
	> 4 (1 st run)	Normalized	none	1	–	Ditto
135, 136	all	Normalized	none	1	1	Solid welding wire G3Si1 steel grade according to EN ISO 14341 Recommended gas: CO ₂ (C1 according to EN ISO 14175) or CO ₂ + Ar mixture (M2-1 according to EN ISO 14175) Tubular cored electrode according to EN ISO 17632 (T ...)
RSEW 22, RSW 21	all	Normalized	none	1	–	–
FW 24	all	Normalized or as rolled	Normalized	1	–	–

^a The thickness range concerns single run welding.

Table 5 — Recommendations for brazing and assemblies by diffusion

Process EN ISO 4063 reference number	State before joining	Joining temperature °C	PJHT	Filler metal		Flux	Degree of brazeability or weldability	Comments
				family	form			
91	Normalized	≥ 1 083	–	Cu	F, w tp	*	1	* flux: dissociated ammonia
	Normalized	620	–	Ag (40 %)	F, w tp	**	1	** FH10 flux according to EN 1045
	Normalized	750	–	Ag (20 %)	F, w tp	***	1	*** FH10 flux according to EN 1045
97	Normalized	950	–	Cu + Zn	F	****	1	**** covered rods or FH20 flux according to EN 1045 + bare brass rods (B/SB Cu 59 Zn Si 870-890)

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6.1.2 S235, S275

6.1.2.1 Designation

EN 10025 (all parts) : S235, S275

Current : steel for general use in metallic construction

ASD STAN : –

Other standards : –

6.1.2.2 Typical chemical composition (w.%)

Table 6 — Chemical composition

Steel grade	Fe	Si	Mn
S235	base	–	≤ 1,5
S275	base	–	≤ 1,6

6.1.2.3 Structure

None.

6.1.2.4 Particular characteristics

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Table 7 — Analyses on heats for S235 steel grades with thicknesses less than 16 mm

Designation	C %	P %	S %	Minimum impact energy ^a at
S235JRG2	≤ 0,17	≤ 0,045	≤ 0,045	20 °C
S235J0	≤ 0,17	≤ 0,040	≤ 0,040	0 °C
S235J2G3	≤ 0,17	≤ 0,035	≤ 0,030	–20 °C

^a V notch impact.

Table 8 — Analyses on heats for S275 steel grades with thickness less than 16 mm

Designation	C %	P %	S %	Minimum impact energy ^a at
S275JR	≤ 0,21	≤ 0,045	≤ 0,045	20 °C
S275J0	≤ 0,18	≤ 0,040	≤ 0,040	0 °C
S275J2G3	≤ 0,18	≤ 0,035	≤ 0,035	–20 °C

^a V notch impact.

6.1.2.5 Forms

Sheets, commercial rolled, beams, wide flats, foils, hot rolled.

6.1.2.6 Particular comments

Welding of effervescent steel, in particular S235JR, S235JRG1 steels, shall be avoided.