
**Thermal spraying — Wires, rods and
cords for flame and arc spraying —
Classification — Technical supply
conditions**

*Projection thermique — Fils, baguettes et cordons pour projection
thermique à l'arc et au pistolet dans une flamme — Classification —
Conditions techniques d'approvisionnement*



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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Classification	1
3.1 Classification according to the manufacturing process and resulting structure	1
3.2 Classification according to material groups and chemical composition	1
3.2.1 Tin and tin alloys	2
3.2.2 Zinc and zinc alloys	3
3.2.3 Aluminium and aluminium alloys	4
3.2.4 Copper and copper alloys	5
3.2.5 Iron and iron alloys	6
3.2.6 Nickel and nickel alloys	8
3.2.7 Molybdenum	9
3.2.8 Ceramics	9
4 Sizes and tolerances	10
5 Properties	11
5.1 Mechanical properties	11
5.2 Surface properties	11
5.3 Workability: Winding of wires	12
6 Designation	12
7 Technical supply conditions	12
7.1 Forms of delivery	12
7.2 Identification	14
7.3 Packaging and storage	14
8 Inspection documents	14

Foreword

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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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ISO 14919 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 240, *Thermal spraying and thermally sprayed coatings*, in collaboration with ISO Technical Committee ISO/TC 107, *Metallic and other inorganic coatings*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 14919:2001), which has been technically revised.

Introduction

Requests for official interpretations of any aspect of this standard should be directed to the secretariat of ISO/TC 107/WG 1 via your national standards body; a complete listing can be found at www.iso.org.

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Thermal spraying — Wires, rods and cords for flame and arc spraying — Classification — Technical supply conditions

1 Scope

This International Standard specifies requirements for classification of metal and non-metal wires (solid and cored), rods, cords processed by means of thermal spraying, especially by arc and flame spraying.

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.

ISO 10474:2013, *Steel and steel products — Inspection documents*

ISO 544:2011, *Welding consumables — Technical delivery conditions for filler materials and fluxes — Type of product, dimensions, tolerances and markings*

3 Classification

3.1 Classification according to the manufacturing process and resulting structure

The thermal spray materials are classified according to the manufacturing process and the resulting structure, as given in [Table 1](#).

Table 1 — Classification of thermal spraying material and resulting structure

Number	Term	Manufacturing process	Structure
1	solid wire/rod	metallurgical manufacturing and forming	homogeneous composition
2	solid wire/rod	powder metallurgical manufacturing and forming	homogeneous composition
3	cored wire (tube shaped wire)	filling up a metal tube and compressed by means of forming	seamless metal shell with powder filling
4	cored wire (folded wire)	forming a metal sheet with powder filling, binder and compressed by means of drawing	metal shell with powder filling
5	cords	simultaneous extruding of powder, binder and organic sheath	plastic shell with powder filling
6	oxide ceramic rods	extruding and sintering respectively drying of ceramic material	porous rod consisting of bonded ceramic particles

3.2 Classification according to material groups and chemical composition

The material groups are given in [Table 2](#), and the chemical composition shall comply with [Tables 3](#) to [10](#).

Table 2 — Classification according to material groups

Code Number	Term
1	tin and tin alloys
2	zinc and zinc alloys
3	aluminium and aluminium alloys
4	copper and copper alloys
5	iron and iron alloys
6	nickel and nickel alloys
7	molybdenum
8	oxide ceramics

3.2.1 Tin and tin alloys**Table 3 — Tin and tin alloys**

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
1.1	Sn99	Sn $\geq 99,95$	total $\leq 0,05$ Sb $\leq 0,02$ Ag $\leq 0,01$ Bi $\leq 0,002$ Cu $\leq 0,01$ Fe $\leq 0,01$ Pb $\leq 0,02$ Al+Cd+Zn $\leq 0,002$	1
1.2	SnSbCu84	Sb 7 to 8 Cu 3 to 4 remainder Sn	Pb $\leq 0,35$ As $\leq 0,1$ Bi $\leq 0,08$ Fe $\leq 0,1$ Al $\leq 0,01$ Zn $\leq 0,01$ other: $\leq 0,2$ total	1

3.2.2 Zinc and zinc alloys

Table 4 — Zinc and zinc alloys

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
2.1	Zn99,99	Zn $\geq 99,99$	total $\leq 0,010$ Pb $\leq 0,007$ Cd $\leq 0,004$ Pb+Cd $\leq 0,011$ Sn $\leq 0,001$ Fe $\leq 0,005$ Cu $\leq 0,002$ other: $\leq 0,12$ total	1
2.2	Zn99	Zn ≥ 99	total $\leq 1,0$ Pb $\leq 0,05$ Cd $\leq 0,005$ Pb+Cd $\leq 0,06$ Sn $\leq 0,001$ Fe $\leq 0,01$ Cu $\leq 0,7$ Mo $\leq 0,01$ Ti $\leq 0,16$ Mg $\leq 0,01$ Al $\leq 0,01$ other: $\leq 0,12$ total	1
2.3	ZnAl15	Zn 84 to 86 Al 14 to 16	total $\leq 0,17$ Pb $\leq 0,007$ Cd $\leq 0,004$ Pb+Cd $\leq 0,011$ Sn $\leq 0,001$ Fe $\leq 0,02$ Cu $\leq 0,01$ Si $\leq 0,12$	1

3.2.3 Aluminium and aluminium alloys

Table 5 — Aluminium and aluminium alloys

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
3.2	Al99,5	Al ≥ 99,5	total ≤ 0,3 Si ≤ 0,25 Fe ≤ 0,40 Ti ≤ 0,02 Cu ≤ 0,02 Zn ≤ 0,07 Mn ≤ 0,02 other: ≤ 0,03 particular	1
3.3	AlMg5	Mg 4,5 to 5,6 Mn 0,05 to 0,20 Cr 0,05 to 0,20 Ti 0,06 to 0,20 remainder Al	total ≤ 0,9 Si ≤ 0,30 Fe ≤ 0,40 Cu ≤ 0,10 Zn ≤ 0,10 other: ≤ 0,15 particular	1
3.4	AlZn5	Zn 4,5 to 5,1 remainder Al	total ≤ 1 Si ≤ 0,30 Fe ≤ 0,40 Cu ≤ 0,05 Sn ≤ 0,20 other: ≤ 0,05 particular	1
3.5	AlSi5	Si 4,5 to 6,0 remainder Al	total ≤ 1 Si ≤ 0,30 Fe ≤ 0,80 Cu ≤ 0,30 Mn ≤ 0,05 Mg ≤ 0,05 Zn ≤ 0,10 Sn ≤ 0,20 other: ≤ 0,15 particular	1

Table 5 (continued)

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
3.6	AlSi12	Si 11,0 to 13,0 remainder Al	total ≤ 1 Fe ≤ 0,80 Cu ≤ 0,30 Mn ≤ 0,15 Mg ≤ 0,10 Zn ≤ 0,20 Ti ≤ 0,15 other particular: ≤ 0,05 other total: ≤ 0,15	1

3.2.4 Copper and copper alloys

Table 6 — Copper and copper alloys

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
4.1	Cu99	Cu ≥ 99,9	other ≤ 0,01	1
4.2	CuZn37	Cu 62,0 to 64 remainder Zn	Al ≤ 0,03 Fe ≤ 0,1 Mn ≤ 0,1 Ni ≤ 0,3 Pb ≤ 0,1 Sb ≤ 0,01 Sn ≤ 0,1 other: total ≤ 0,5	1
4.3	CuZn39	Cu 56 to 62 Sn 0,5 to 1,5 Si 0,1 to 0,5 remainder Zn	Ni ≤ 1,5 Mn ≤ 1,0 Fe ≤ 0,5 Al ≤ 0,01 Pb ≤ 0,03 other: total ≤ 0,2	1
4.4	CuSn6	Sn 5,0 to 8,0 remainder Cu	Fe ≤ 0,1 Al ≤ 0,01 Zn ≤ 0,1 Pb ≤ 0,02 P 0,01 to 0,4 other: total ≤ 0,4	1

Table 6 (continued)

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
4.6	CuAl8	Al 7,5 to 9,5 remainder Cu	Mn ≤ 1,8 Ni ≤ 0,8 Fe ≤ 0,5 Si ≤ 0,2 Zn ≤ 0,2 other: ≤ 0,5 total	1
4.7	CuAl10	Al 8,5 to 11 Fe 0,5 to 1,5 remainder Cu	Ni+Co ≤ 1,0 Pb ≤ 0,02 Si ≤ 0,1 Mn ≤ 0,03 Zn ≤ 0,02 other: ≤ 0,3 total	1

3.2.5 Iron and iron alloys

Table 7 — Iron and iron alloys

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
5.1	10Mn	C 0,04 to 0,12 Mn 0,42 to 0,68 remainder Fe	Si traces Cr ≤ 0,15 Cu ≤ 0,20 Ni ≤ 0,15 P ≤ 0,030 S ≤ 0,030	1
5.3	80MnSi	C 0,8 to 0,85 Si 0,15 to 0,35 Mn 0,50 to 0,70 remainder Fe	P ≤ 0,035 S ≤ 0,035	1
5.6	110MnCrTi5-5	C 0,97 to 1,23 Si 0,12 to 0,38 Mn 1,76 to 2,27 Cr 1,65 to 1,95 remainder Fe	Ti 0,13 to 0,35 P ≤ 0,025 S ≤ 0,025	1
5.7	X45Cr13 a) with Cu plating b) without Cu plating	C 0,3 to 0,50 Si ≤ 1,0 Mn ≤ 1,0 Cr 12 to 14 remainder Fe	P ≤ 0,045 S ≤ 0,030	1
5.8	X20CrMo13-1	C 0,17 to 0,22 Si ≤ 1,0 Mn ≤ 1,0 Cr 12 to 14 Mo 0,9 to 1,3 remainder Fe	Ni ≤ 1,0 P ≤ 0,045 S ≤ 0,030	1

Table 7 (continued)

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
5.9	X 6CrAl22-4	C ≤ 0,055 Si ≤ 0,65 Mn ≤ 0,45 Al 3,5 to 5,5 Cr 21 to 23 remainder Fe	P ≤ 0,040 S ≤ 0,025	1
5.10	X6CrNi19-9	C ≤ 0,06 Si ≤ 1,5 Mn ≤ 2,0 Cr 18 to 20 Ni 8,5 to 10,5 remainder Fe	P ≤ 0,030 S ≤ 0,020	1
5.11	(X5CrNiMo17-12-2) ^a	C ≤ <u>0,08</u> Si ≤ 1,0 Mn ≤ 2,0 Cr 16,5 to 18,5 Mo 2 to 2,5 Ni 10,5 to 13,5 remainder Fe	P ≤ <u>0,045</u> S ≤ 0,030	1, 4
5.12	(X12CrNiMn18-8-6) ^a	C ≤ <u>0,20</u> Si ≤ 1,0 Mn 5,5 to 8,0 Cr 17 to 20 Ni 7,5 to 9,5 remainder Fe	P ≤ 0,040 S ≤ 0,025	1, 4
5.13	X12CrNi25-20	C ≤ 0,15 Si ≤ 1,5 Mn 1,5 to 3,5 Cr 24 to 27 Ni 19 to 22 remainder Fe	P ≤ 0,025 S ≤ 0,020	1
5.14	X25CrCuB26-3-3	C ≤ 0,3 Cr ≤ 26 Mn ≤ 1 Si ≤ 0,3 Cu ≤ 3 B ≤ 3 remainder Fe	other ≤ 1	3, 4
5.15	X25MnAlSi7-5	C ≤ 0,3 Al 4 to 5 Mn 6 to 8 Si ≤ 1,0 remainder Fe	other ≤ 1	3, 4
5.16	X39CrMo17-1 a) with Cu plating b) without Cu plating	C 0,33 to 0,45 Si ≤ 1,0 Mn ≤ 1,5 Cr 15,5 to 17,5 Mo 0,80 to 1,3 remainder Fe	P ≤ 0,040 S ≤ 0,015	1
^a Material is similar to that in brackets. Different limit values are underlined.				

3.2.6 Nickel and nickel alloys

Table 8 — Nickel and nickel alloys

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
6.1	NiCu30Mn3Ti (NiCu30)	Ni ≥ 62,0 Cu 27,0 to 35,0 Mn 1,0 to 4,0 Fe 1,0 to 2,5	Al ≤ 0,5 C ≤ 0,15 Si ≤ 1,0 S ≤ 0,02 Ti ≤ 1,0 Nb ≤ 2,5 other: ≤ 0,5 total	1
6.2	Ni99	Ni ≥ 99,2	Cu ≤ 0,1 C ≤ 0,25 Fe ≤ 0,4 Mg ≤ 0,15 Mn ≤ 0,3 S ≤ 0,005 Si ≤ 0,2	1
6.3	NiCrFe15-20	Cr 14 to 19 Fe 19 to 25 Ni ≥ 59	Cu ≤ 0,5 C ≤ 0,15 Mn ≤ 2,5 Si ≤ 2,0	1
6.4	NiCr20	Cr 18 to 21 remainder Ni	Cu ≤ 0,5 C ≤ 0,25 Fe ≤ 0,5 Mn ≤ 1,2 Si ≤ 0,5 S ≤ 0,015	1
6.5	NiAl5	Al 4,5 to 5,5 remainder Ni	Mn ≤ 0,3 Ti ≤ 0,4 Si ≤ 0,5 Fe ≤ 0,3 Cu ≤ 0,08 C ≤ 0,005	1, 3, 4, 5
6.6	NiAl20	Al 18 to 22 remainder Ni	Fe ≤ 0,3 Mn ≤ 0,3 Si ≤ 0,5 Cu ≤ 0,1 C ≤ 0,25	3, 4 ^a
6.7	NiAlMo5-5	Al 4,5 to 5,5 Mo ≤ 5 remainder Ni	other ≤ 1	3, 4

Table 8 (continued)

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
6.8	NiCrAl20-6	Al 6 to 7 Cr 18 to 21 Mo ≤ 5 remainder Ni	other ≤ 1	3, 4
6.9	NiFeAlCr20-14-3	Al 14 to 15 Cr 3 to 5 Fe 17 to 23 remainder Ni	other ≤ 1	3, 4
6.10	NiCrBSi	Cr ≤ 9 Fe ≤ 3 Si ≤ 3,2 B ≤ 1,6 C ≤ 0,3 remainder Ni	other ≤ 1	5
6.11	NiCr22Mo9Nb	Ni ≤ 58,0 Cr 18 to 23 Mo 8 to 10 Nb 3,15 to 4,15	C 0,03 to 0,10 Si ≤ 0,5 Mn ≤ 0,5 TiAl ≤ 0,2 Co ≤ 0,1 Cu 1,5 to 3 P ≤ 0,02 S ≤ 0,015 remainder Fe	1, 4
6.12	NiCu30Mn	Ni ≤ 63,0 Cu 26,5 to 34,0 Fe 1,00 to 2,5	C ≤ 0,15 Si ≤ 0,50 Mn ≤ 2,00 S ≤ 0,020 Ti ≤ 0,30 Al ≤ 0,5	1
^a Filling is typically performed by a solid wire.				

3.2.7 Molybdenum

Table 9 — Molybdenum

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
7.1	Mo	Mo ≥ 99,95	other ≤ 0,05	2

3.2.8 Ceramics

Table 10 — Oxide ceramics

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
8.1	95ZrO ₂ -5CaO	ZrO ₂ ≥ 92 CaO 5 to 7	Al ₂ O ₃ ≤ 0,7 SiO ₂ ≤ 0,4 Fe ₂ O ₃ ≤ 0,04 TiO ₂ ≤ 0,4 Na ₂ O ≤ 0,02 MgO ≤ 0,07	5, 6

Table 10 (continued)

Code number	Symbol	Alloying elements mass fraction in %	Other elements mass fraction in %	Manufacturing process
8.2	70ZrO ₂ -30CaO	ZrO ₂ ≥ 68 CaO 28 to 31	Al ₂ O ₃ ≤ 0,7 TiO ₂ ≤ 0,4 Na ₂ O ≤ 0,02 MgO ≤ 0,07	5
8.3	Cr ₂ O ₃	Cr ₂ O ₃ ≥ 90,0	Al ₂ O ₃ ≤ 4 CaO ≤ 0,2 SiO ₂ ≤ 5 Fe ₂ O ₃ ≤ 0,3 TiO ₂ ≤ 0,3 MgO ≤ 0,1	5, 6
8.4	Al ₂ O ₃	Al ₂ O ₃ ≥ 98	CaO ≤ 0,2 SiO ₂ ≤ 0,8 Fe ₂ O ₃ ≤ 0,09 TiO ₂ ≤ 0,03 Na ₂ O ≤ 0,06 MgO ≤ 0,3	5, 6
8.5	97Al ₂ O ₃ -3TiO ₂	Al ₂ O ₃ ≥ 94 TiO ₂ ≥ 3	CaO ≤ 0,2 SiO ₂ ≤ 1,0 Fe ₂ O ₃ ≤ 0,5 Na ₂ O ≤ 0,04 MgO ≤ 0,5 Mn ₃ O ₄ ≤ 0,05	5
8.6	87Al ₂ O ₃ -13TiO ₂	Al ₂ O ₃ 85 to 87 TiO ₂ 13 to 15	CaO ≤ 0,2 SiO ₂ ≤ 0,5 Fe ₂ O ₃ ≤ 0,3 Na ₂ O ≤ 0,2 MgO ≤ 0,3	5, 6
8.7	60Al ₂ O ₃ -40TiO ₂	Al ₂ O ₃ 58 to 60 TiO ₂ 40 to 42	CaO ≤ 0,2 SiO ₂ ≤ 0,5 Fe ₂ O ₃ ≤ 0,3 Na ₂ O ≤ 0,2 MgO ≤ 0,3	5, 6
8.8	70Al ₂ O ₃ -30SiO ₂	Al ₂ O ₃ 72 to 78 SiO ₂ 22 to 28	CaO ≤ 0,2 SiO ₂ ≤ 0,5 Fe ₂ O ₃ ≤ 0,3 Na ₂ O ≤ 0,2 MgO ≤ 0,3	5
8.9	70Al ₂ O ₃ -30MgO	Al ₂ O ₃ 76 to 82 MgO 18 to 24	CaO ≤ 0,2 SiO ₂ ≤ 0,5 Fe ₂ O ₃ ≤ 0,3 Na ₂ O ≤ 0,2 MgO ≤ 0,3	5

4 Sizes and tolerances

Standard sizes and tolerances of diameter in millimetres for thermal spray wires, rods and cords are given in [Tables 11](#), [12](#) and [13](#). If required, smaller ranges of tolerances can be agreed between customer and manufacturer/supplier. The straightness of the rods shall allow the spray material to be fed satisfactorily.

Table 11 — Wire diameters

Size [mm]	Tolerance [mm]
1,6	+ 0; -0,05
1,62	+ 0; -0,05
2,0	+ 0; -0,06
2,3	+ 0; -0,06
2,4	+ 0; -0,06
2,5	+ 0; -0,06
3,0	+ 0; -0,07
3,17	+ 0; -0,07
3,48	+ 0; -0,07
4,76	+ 0; -0,07

Table 12 — Rod diameters

Size [mm]	Tolerance [mm]
4,8	+ 0,05; -0,2
6,3	+ 0,05; -0,2

Table 13 — Cord diameters

Size [mm]	Tolerance [mm]
3,17	±0,1
4,75	±0,1

5 Properties

5.1 Mechanical properties

The mechanical properties of the wires shall be suitable for trouble-free feeding and processing. If required, the mechanical properties should be specified among manufacturer, supplier and customer.

The temper of thermal spray wire should be suitable for uninterrupted feeding on thermal spray equipment.

NOTE Very hard, poorly tempered thermal spray wires are difficult to handle, hard to straighten, and cause excessive wear on vital gun parts such as drive rolls, guides and contact tubes or nozzles. On the other hand, too soft thermal spray wires (e.g. aluminium, tin, zinc) may cause problems with feeding.

5.2 Surface properties

The surface of the thermal spray wire shall be smooth and free of corrosion products, slivers and splits, shrinkholes, splices and scales, damages as well as neckings, welds and laps. Moreover, foreign matter that would adversely affect the thermal spray material's characteristics or properties of the sprayed coating is to be avoided.

For arc spraying, martensitic and ferritic steel thermal spray wire shall be protected with a plating of copper to prevent corrosion during storage. The plating shall cover the whole wire surface without visible defects.

For alloys number 5.7 ([Table 7](#)) two variants are available: 5.7a) with copper plating and 5.7b) with another suitable plating. This condition is also valid for 5.16a) and 5.16b). A very small amount of