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Welding consumables — Tubular-cored electrodes for gas-shielded and non-gas-shielded metal arc welding of nickel and nickel alloys — Classification

Produits consommables pour le soudage — Fils-électrodes fourrés pour soudage à l'arc avec ou sans gaz de protection du nickel et des alliages de nickel — Classification

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 12153:2011), which has been technically revised.

The main changes are as follows:

— dated references updated to the latest editions;

— the chemistries of a number of classifications revised in Table 1;

— a new alloy symbol, Ni 6023 (numerical), NiCr13Mo13W3 (chemical) added in Table 1, Table 2 and Table A.1;

— a restricted numerical alloy symbol Ni 6117R and chemistry added to Table 1;

— the minimum elongation for Ni 1013 revised in Table 2;

— Table A.1 updated to reflect the above changes and provide missing data.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

Welding consumables — Tubular-cored electrodes for gas-shielded and non-gas-shielded metal arc welding of nickel and nickel alloys — Classification

1 Scope

This document specifies requirements for the classification of tubular-cored electrodes for metal arc welding with or without a gas shield of nickel and nickel alloys. It includes those compositions in which the nickel content exceeds that of any other element.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

ISO 6847, *Welding consumables — Deposition of a weld metal pad for chemical analysis*

ISO 6947, *Welding and allied processes — Welding positions*

ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

ISO 14344, *Welding consumables — Procurement of filler materials and fluxes*

ISO 15792-1:2020, *Welding consumables — Test methods — Part 1: Preparation of all-weld metal test pieces and specimens in steel, nickel and nickel alloys*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Classification

Tubular-cored electrodes shall be classified according to the chemical composition of the all-weld metal as given in Table 1 and the mechanical properties of the all-weld metal listed in Table 2.

The classification designation is divided into five parts:

a) the first part gives a symbol indicating the product or process to be identified;

b) the second part gives a symbol indicating the chemical composition of the all-weld metal;

c) the third part gives a symbol indicating the type of electrode core;

d) the fourth part gives a symbol indicating the type of shielding gas;

e) the fifth part gives a symbol indicating the welding position.

5 Symbols and requirements

5.1 Symbol for the product or process

The symbol for the tubular-cored electrode used in the metal arc welding process shall be the letter "T".

NOTE Corresponding national classifications are shown in Annex A.

5.2 Symbol for the chemical composition of the all-weld metal

The symbol for the chemical composition of the all-weld metal shall comprise "Ni" plus four digits, as shown in Table 1. The first digits are an indicator of the class of alloy deposited, as follows:

— 4 indicates significant copper addition (nickel-copper alloys);

— 6 indicates significant chromium addition, with iron less than 25 % (by mass) (nickel-chromium-iron and nickel-chromium-molybdenum alloys);

— 10 indicates significant molybdenum addition without significant chromium addition (nickel-molybdenum alloys).

The remaining digits indicate the particular alloy deposited.

The tubular-cored electrode classified in accordance with Table 1 and produced as described in Clause 5 and Clause 6 shall also fulfil the requirements of Table 2.

NOTE In addition, the chemical symbol can be used.

5.3 Symbol for the type of electrode core

The third part of the designation indicates the type of electrode core and the slag characteristics (see Table 3).

5.4 Symbol for the shielding gas

The symbols for shielding gases shall be in accordance with ISO 14175, except that the symbol NO shall be used for tubular-cored electrodes without a gas shield.

5.5 Symbol for the welding position

The fifth part of the designation (see Table 4) describes the welding position in which the tubular-cored electrode can be welded. The symbols for welding positions shall be in accordance with ISO 6947, as shown in Table 4.

6 Chemical analysis

Chemical analysis shall be performed on any suitable all-weld metal test specimen. In case of dispute, the test specimen specified in ISO 6847 shall be used. The test results shall meet the requirements of Table 1 for the classification under test. Any analytical technique may be used, but in cases of dispute, reference shall be made to established published methods.

Table 1 — Symbols and all-weld metal chemical composition requirements

Alloy symbols		Chemical composition (% by mass)[a,b]														
Numerical	Chemical	C	Mn	Fe	Si	Cu	Ni	Co	Al	Ti	Cr	Nb[c]	Mo	V	W	Others[d]
Nickel-copper																
Ni 4060	NiCu30Mn3Ti	0,15	4,0	2,5	1,5	27,0 to 34,0	≥62,0	—	1,0	1,0	—	—	—	—	—	—
Ni 4061	NiCu27Mn3NbTi	0,15	4,0	2,5	1,3	24,0 to 31,0	≥62,0	—	1,0	1,5	—	3,0	—	—	—	—
Nickel-chromium																
Ni 6082	NiCr20Mn3Nb	0,10	2,5 to 3,5	3,0	0.50	0,5	≥67,0	—	—	0,75	18,0 to 22,0	2,0 to 3,0	—	—	—	P 0,03
Ni 6083	NiCr20Mn6Fe4Nb	0,10	4,0 to 8,0	4,0	0,8	0,5	≥60,0	—	—	0,5	18,0 to 22,0	1,5 to 3,0	2,0	—	—	—
Nickel-molybdenum																
Ni 1013	NiMo17Cr7W	0,10	2,0 to 3,0	10,0	0,75	0,5	≥58,0	—	—	—	4,0 to 8,0	—	16,0 to 19,0	—	2,0 to 4,0	—
Nickel-chromium-iron																
Ni 6062	NiCr15Fe8Nb	0,08	3,5	11,0	0,75	0,5	≥62,0	—	—	—	13,0 to 17,0	1,5 to 4,0	—	—	—	P 0,03
Ni 6133	NiCr16Fe12NbMo	0,10	1,0 to 3,5	12,0	0,75	0,5	≥62,0	—	—	—	13,0 to 17,0	0,5 to 3,0	0,5 to 2,5	—	—	P 0,03 S 0,02
Ni 6182	NiCr15Fe6Mn	0,10	5,0 to 9,5	10,0	1,0	0,5	≥59,0	—	—	1,0	13,0 to 17,0	1,0 to 2,5	—	—	—	P 0,03
Ni 6152	NiCr30Fe9Nb	0,05	5,0	7,0 to 12,0	0,8	0,5	≥50,0	—	0,5	0,5	28,0 to 31,5	1,0 to 2,5	0,5	—	—	—
Nickel-chromium-molybdenum																

[a] Unless otherwise stated, single values are maxima.

[b] Phosphorus 0,020 % (by mass) max., sulfur 0,015 % (by mass) max. unless otherwise stated.

[c] Up to 20 % (by mass) of the amount of Nb can be replaced by Ta.

[d] Total unspecified elements shall not exceed 0,5 % (by mass).

[e] Symbols with R have more restricted chemical compositions than symbols without R. Symbols with R meet the requirements of symbols without R but not vice versa.

[f] Consumables for which the chemical composition is not listed shall be symbolized similarly and prefixed by the letter "Z". The chemical composition ranges are not specified and it is possible that two electrodes with the same Z classification are not interchangeable.

Table 1 *(continued)*

Alloy symbols		Chemical composition (% by mass)[a,b]														
Numerical	Chemical	C	Mn	Fe	Si	Cu	Ni	Co	Al	Ti	Cr	Nb[c]	Mo	V	W	Others[d]
Ni 6002	NiCr22Fe18Mo	0,05 to 0,15	1,0	17,0 to 20,0	1,0	0,5	≥45,0	0,5 to 2,5	—	—	20,5 to 23,0	—	8,0 to 10,0	—	0,2 to 1,0	P 0,04 S 0,03
Ni 6012	NiCr22Mo9	0,03	1,0	3,5	0,7	0,5	≥58,0	—	0,4	0,4	20,0 to 23,0	1,5	8,5 to 10,5	—	—	—
Ni 6022	NiCr21Mo13W3	0,02	1,0	2,0 to 6,0	0,2	0,5	≥49,0	2,5	—	—	20,0 to 22,5	—	12,5 to 14,5	0,35	2,5 to 3,5	P 0,03
Ni 6023	NiCr13Mo13W3	0,10	1,0 to 3,0	4,0 to 7,0	0,50	0,5	≥58,0	1,0	—	—	12,0 to 14,5	1,0	12,0 to 14,0	0,35	2,0 to 3,5	P 0,03 S 0,03
Ni 6059	NiCr23Mo16	0,02	1,0	1,5	0,2	0,5	≥56,0	—	—	—	22,0 to 24,0	—	15,0 to 16,5	—	—	—
Ni 6275	NiCr15Mo16Fe5W3	0,10	1,0	4,0 to 7,0	1,0	0,5	≥50,0	2,5	—	—	14,5 to 16,5	—	15,0 to 18,0	0,4	3,0 to 4,5	—
Ni 6276	NiCr15Mo15Fe6W4	0,02	1,0	4,0 to 7,0	0,2	0,5	≥50,0	2,5	—	—	14,5 to 16,5	—	15,0 to 17,0	0,35	3,0 to 4,5	P 0,03 S 0,03
Ni 6455	NiCr16Mo15Ti	0,02	1,5	3,0	0,2	0,5	≥56,0	2,0	—	0,7	14,0 to 18,0	—	14,0 to 17,0	—	0,5	—
Ni 6456	NiCr16Mo10Nb	0,10	5,0 to 8,0	10,0	0,8	0,5	≥58,0	—	—	1,0	15,0 to 18,0	1,5 to 3,0	9,0 to 11,0	—	—	—
Ni 6625	NiCr22Mo9Nb	0,10	0,50	5,0	0,50	0,5	≥58,0	—	—	0,40	20,0 to 23,0	3,15 to 4,15	8,0 to 10,0	—	—	—
Ni 6686	NiCr21Mo16W4	0,02	1,0	5,0	0,3	0,5	≥49,0	—	—	0,3	19,0 to 23,0	—	15,0 to 17,0	—	3,0 to 4,4	—
Nickel-chromium-cobalt-molybdenum																

[a] Unless otherwise stated, single values are maxima.

[b] Phosphorus 0,020 % (by mass) max., sulfur 0,015 % (by mass) max. unless otherwise stated.

[c] Up to 20 % (by mass) of the amount of Nb can be replaced by Ta.

[d] Total unspecified elements shall not exceed 0,5 % (by mass).

[e] Symbols with R have more restricted chemical compositions than symbols without R. Symbols with R meet the requirements of symbols without R but not vice versa.

[f] Consumables for which the chemical composition is not listed shall be symbolized similarly and prefixed by the letter "Z". The chemical composition ranges are not specified and it is possible that two electrodes with the same Z classification are not interchangeable.

Table 1 *(continued)*

Alloy symbols		Chemical composition (% by mass)[a,b]														
Numerical	**Chemical**	**C**	**Mn**	**Fe**	**Si**	**Cu**	**Ni**	**Co**	**Al**	**Ti**	**Cr**	**Nb[c]**	**Mo**	**V**	**W**	**Others[d]**
Ni 6117	NiCr22Co12Mo	0,05 to 0,15	2,5	5,0	0,75	0,5	≥45,0	9,0 to 15,0	—	—	21,0 to 26,0	1,0	8,0 to 10,0	—	—	P 0,03
Ni 6117R[e]	NiCr22Co12Mo	0,05 to 0,15	0,3 to 2,5	5,0	0,75	0,5	≥45,0	9,0 to 15,0	—	—	21,0 to 26,0	1,0	8,0 to 10,0	—	—	P 0,03
Ni 6617	NiCr22Co12MoAlTi	0,05 to 0,15	2,5	5,0	0,75	0,5	≥45,0	9,0 to 15,0	1,5	0,6	21,0 to 26,0	1,0	8,0 to 10,0	—	—	—
Z[f]		Any other agreed composition														

[a] Unless otherwise stated, single values are maxima.

[b] Phosphorus 0,020 % (by mass) max., sulfur 0,015 % (by mass) max. unless otherwise stated.

[c] Up to 20 % (by mass) of the amount of Nb can be replaced by Ta.

[d] Total unspecified elements shall not exceed 0,5 % (by mass).

[e] Symbols with R have more restricted chemical compositions than symbols without R. Symbols with R meet the requirements of symbols without R but not vice versa.

[f] Consumables for which the chemical composition is not listed shall be symbolized similarly and prefixed by the letter "Z". The chemical composition ranges are not specified and it is possible that two electrodes with the same Z classification are not interchangeable.

Table 2 — Mechanical properties of the all-weld metal

Numerical symbol	Chemical symbol	Minimum yield strength $R_{p0,2}$ MPa	Minimum tensile strength R_m MPa	Minimum elongation $5d$ %
Nickel-copper				
Ni 4060	NiCu30Mn3Ti	200	480	27
Ni 4061	NiCu27Mn3NbTi	200	480	27
Nickel-chromium				
Ni 6082	NiCr20Mn3Nb	360	550	22
Ni 6083	NiCr20Mn6Fe4Nb	360	600	20
Nickel-molybdenum				
Ni 1013	NiMo17Cr7W	400	690	22
Nickel-chromium-iron				
Ni 6062	NiCr15Fe8Nb	360	550	22
Ni 6133	NiCr16Fe12NbMo	360	550	22
Ni 6182	NiCr15Fe6Mn	360	550	22
Ni 6152	NiCr30Fe9Nb	360	550	27
Nickel-chromium-molybdenum				
Ni 6002	NiCr22Fe18Mo	380	620	22
Ni 6012	NiCr22Mo9	410	650	22
Ni 6022	NiCr21Mo13W3	350	690	22
Ni 6023	NiCr13Mo13W3	300	690	22
Ni 6059	NiCr23Mo16	350	690	22
Ni 6275	NiCr15Mo16Fe5W3	400	690	22
Ni 6276	NiCr15Mo15Fe6W4	400	690	22
Ni 6455	NiCr16Mo15Ti	300	690	22
Ni 6456	NiCr16Mo10Nb	400	690	27
Ni 6625	NiCr22Mo9Nb	420	690	22
Ni 6686	NiCr21Mo16W4	350	690	27
Nickel-chromium-cobalt-molybdenum				
Ni 6117	NiCr22Co12Mo	400	620	22
Ni 6617	NiCr22Co12MoAlTi	400	620	22

Table 3 — Symbol for the type of electrode core

Symbol	Characteristics
B	Basic
R	Rutile, slow-freezing slag
P	Rutile, fast-freezing slag
M	Metal powder
U	Self-shielding
Z	Other types

Table 4 — Symbol for the welding positions

Symbol	Welding position (in accordance with ISO 6947)
1	PA, PB, PC, PD, PE, PF, PG
2	PA, PB, PC, PD, PE, PF
3	PA, PB
4	PA
5	PA, PB, PG

Key

PA flat position

PB horizontal vertical position

PC horizontal position

PD horizontal overhead position

PE overhead position

PF vertical up position

PG vertical down position

7 Mechanical properties of the all-weld metal

Mechanical properties are not part of the designation, but they are required for classification. The mechanical properties of the all-weld metal, deposited using tubular-cored electrodes in accordance with Table 1, shall be determined using a test assembly in accordance with ISO 15792-1:2020, type 1.3 using 1,2 mm or, if this diameter is not manufactured, the next larger diameter manufactured. The minimum tensile properties shall be in accordance with Table 2.

The total number of runs, the number of runs per layer and the total number of layers shall be as given in Table 5.

8 Rounding procedure

For the purposes of determining conformity with the requirements of this document, the actual test values obtained shall be subjected to the rounding rules of ISO 80000-1:2009, Annex B, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this document, the measured values shall be converted to the units of this document before rounding. If an average value is to be compared with the requirements of this document, rounding shall be done only after calculating the average. In cases where the testing standard cited in Clause 2 contains instructions for rounding that conflict with the instructions of this document, the rounding requirements of the testing standard shall apply. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

Table 5 — Layer sequence

Diameter mm	ISO 15792-1:2020 test assembly type	Passes per layer		Total number of layers
		First layer	Other layers	
< 1,2	1.3	1 to 3	2 to 4[a]	8 to 12
1,2	1.3	1 to 3	2 to 4[a]	5 to 9
1,4; 1,6; 2,0	1.3	1 to 3	2 to 4[a]	5 to 8
2,4; 3,2	1.3	1 or 2	1 to 3[b]	4 to 7

[a] Final layer may have five passes.

[b] Final layer may have four passes.