
**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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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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Foreword

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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

1 Scope

This International Standard 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 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.

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 6947:2011, *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 15792-1:2000, *Welding consumables — Test methods — Part 1: Test methods for all-weld metal test specimens in steel, nickel and nickel alloys*

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

3 Classification

A tubular cored electrode 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:

- the first part gives a symbol indicating the product/process to be identified;
- the second part gives a symbol indicating the chemical composition of the all-weld metal;
- the third part gives a symbol indicating the type of electrode core;
- the fourth part gives a symbol indicating the type of shielding gas;
- the fifth part gives a symbol indicating the welding position.

4 Symbols and requirements

4.1 Symbol for the product/process

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

4.2 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.

4.3 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).

4.4 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.

4.5 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. PA, PB, PC, PD, PE, PF, and PG are the symbols of the welding positions in accordance with ISO 6947:2011.

5 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) ^{ab}															
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	2,0	—	—	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																	
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 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	—	

Table 1 (continued)

Alloy symbols		Chemical composition (% by mass) ^{ab}														
Numerical	Chemical	C	Mn	Fe	Si	Cu	Ni	Co	Al	Ti	Cr	Nb ^c	Mo	V	W	Others ^d
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																
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 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	—	—	—
Ze		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 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	27
Nickel-Molybdenum				
Ni 1013	NiMo17Cr7W	400	690	27
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 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 positions ^a
1	PA, PB, PC, PD, PE, PF, PG
2	PA, PB, PC, PD, PE, PF
3	PA, PB
4	PA
5	PA, PB, PG
^a 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	

6 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 15792-1:2000, 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.

7 Rounding procedure

For purposes of determining compliance with the requirements of this International Standard, 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 International Standard, the measured values shall be converted to the units of this International Standard before rounding. If an average value is to be compared to the requirements of this International Standard, rounding shall be done only after calculating the average. In the case where the testing standard cited in the normative references of this International Standard contains instructions for rounding that conflict with the instructions of this

International Standard, 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 15792-1:2000 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.				

8 Retest

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retests need be only for those specific elements that failed to meet their test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that, during preparation or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test assembly or test specimen(s), or in conducting the tests, the test shall be considered invalid, without regard to whether the test was actually completed or whether the test results met or failed to meet the requirement. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9 Technical delivery conditions

Technical delivery conditions shall meet the requirements of ISO 544 and ISO 14344.

10 Example of designation

The designation of tubular cored electrodes shall follow the principles given in the example below.

EXAMPLE A basic tubular cored electrode for gas shielded metal arc welding (B) (T) with mixed shielding gas (M21), weldable in all positions except the position PG (2), which gives a nickel-based weld metal (Ni) with the chemical composition: 67 % (by mass) Ni, 15 % (by mass) Cr, 7 % (by mass) Mn, 2 % (by mass) Nb, and all the other requirements for the alloy Ni 6182 in accordance with Tables 1 and 2, is designated:

ISO 12153 — T Ni 6182 B M21 2

or alternatively

ISO 12153 — T Ni 6182 (NiCr15Fe6Mn) B M21 2

where

ISO 12153 is the number of this International Standard;

T indicates tubular cored electrode for metal arc welding (see 4.1);

Ni 6182 indicates the chemical composition of the all-weld metal (see Table 1);

NiCr15Fe6Mn is the optional chemical symbol of the tubular cored electrode (see Table 1);