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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 main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 12153 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

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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:

a) the first part gives a symbol indicating the product/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.

# 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<br>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<br>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<br>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 | — | — | — |
| Z[e] | | 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); |