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Welding consumables — Covered electrodes for manual metal arc welding of nickel and nickel alloys — Classification

Produits consommables pour le soudage — Électrodes enrobées pour le soudage manuel à l'arc 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 document 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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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 fourth edition cancels and replaces the third edition (ISO 14172:2015), which has been technically revised.

The main changes are as follows:

— updated to latest style including foreword;

— aligned with ISO 18274 where possible;

— updated references;

— rounding procedure is now Clause 8;

— revised the chemical compositions for a number of chemical compositions in Table 1;

— added new alloys in Table 1;

— updated corresponding entries in other parts of the document;

— new Example 2 added;

— added Chinese alloys to Table C.1

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.

Welding consumables — Covered electrodes for manual metal arc welding of nickel and nickel alloys — Classification

1 Scope

This document prescribes requirements for the classification of nickel and nickel-alloy covered electrodes for manual metal arc welding and overlaying. The classification of the covered electrodes is based on the chemical composition of their deposited all-weld metal. 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 14344, *Welding consumables — Procurement of filler materials and fluxes*

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

ISO 80000-1:2022, *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

A covered electrode shall be classified in accordance with the chemical composition of the all-weld metal as given in Table 1. The required mechanical properties for the classification's all-weld metal are listed in Table 2.

The symbol for the classification is divided into two parts:

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

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

5 Symbols and requirements

5.1 Symbol for the product or process

The symbol for covered electrodes used for manual metal arc welding shall be the letter “E”.

NOTE Corresponding national classifications are shown in Annex C.

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 digit is an indicator of the class of alloy deposited, where:

1 indicates significant molybdenum addition without significant chromium addition (nickel-molybdenum alloys);

2 indicates no significant alloy addition;

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

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

8 indicates significant chromium addition, with iron more than 25 % (nickel-iron-chromium alloys).

The remaining digits indicate the particular alloy deposited. The basis of the system of designation is described in Annex A.

NOTE In addition, the chemical symbol can be used.

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 can be used; however, in case of dispute, reference shall be made to established published methods.

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 covered electrodes in accordance with Table 1, shall be determined using a test assembly type 1,3 in accordance with ISO 15792-1:2020, with 4,0 mm electrodes. The minimum tensile properties shall be in accordance with Table 2.

8 Rounding procedure

Actual test values obtained shall be subject to ISO 80000-1:2022, B.3, 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 to the requirements of this document, rounding shall be done only after calculating the average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

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

Alloy symbol [a]		Chemical composition % (by mass)[b]														
Numerical symbol	Chemical symbol	C	Mn	Fe	Si	Cu	Ni [c]	Co	Al	Ti	Cr	Nb [d]	Mo	V	W	Notes [e, f]
Nickel																
Ni 2061	NiTi3	0,10	0,7	0,7	1,2	0,2	min. 92,0	—	1,0	1,0 to 4,0	—	—	—	—	—	—
Nickel-copper																
Ni 4060	NiCu30Mn3Ti	0,15	4,0	2,5	1,5	27,0 to 34,0	min. 62,0	—	0,75	1,0	—	—	—	—	—	—
Ni 4061	NiCu27Mn3NbTi	0,15	4,0	2,5	1,3	24,0 to 31,0	min. 62,0	—	1,0	1,5	—	3,0	—	—	—	—
Nickel-chromium																
Ni 6056	NiCr27Nb3	0,05	2,5 to 4,5	2,0 to 3,0	0,50	0,3	59,0 min.	0,10	0,6	0,40	26,0 to 28,0	2,0 to 3,6	—	—	—	0,02 P
Ni 6082	NiCr20Mn3Nb	0,10	2,0 to 6,0	4,0	0,8	0,5	min. 63,0	—	—	0,5	18,0 to 22,0	1,5 to 3,0	2,0	—	—	—
Ni 6172	NiCr50Nb	0,10	1,5	1,0	1,0	0,25	min. 41,0	—	—	—	48,0 to 52,0	1,0 to 2,5	—	—	—	0,02 P 0,02 S
Ni 6231	NiCr22W14Mo	0,05 to 0,10	0,3 to 1,0	3,0	0,3 to 0,7	0,5	min. 45,0	5,0	0,5	0,1	20,0 to 24,0	—	1,0 to 3,0	—	13,0 to 15,0	—
Nickel-chromium-iron																
Ni 6025	NiCr25Fe10AlY	0,10 to 0,25	1,0	8,0 to 11,0	1,0	—	min. 55,0	1,0	1,5 to 2,2	0,4	24,0 to 26,0	—	—	—	—	0,15 Y
Ni 6045	NiCr27Fe23Si	0,05 to 0,20	2,5	21,0 to 25,0	2,5 to 3,0	0,30	min. 38,0	1,0	0,30	—	26,0 to 29,0	—	—	—	—	0,04 P 0,03 S
Ni 6055	NiCr30Mo4Nb3	0,05	1,0	rem	0,7	0,30	52,0 to 62,0	0,10	0,50	0,50	28,5 to 31,0	2,1 to 4,0	3,0 to 5,0	—	—	—

[a] Symbols with B generally have more restrictive chemical compositions and are typically used in Pacific Rim countries.

[b] Single values for all elements except nickel are maxima. Two values shown indicate minimum and maximum limits for a range.

[c] Up to 1 % of the nickel content can be cobalt unless otherwise specified. For certain applications, lower cobalt levels can be required and should be agreed between contracting parties.

[d] Up to 20 % of the niobium content can be tantalum.

[e] The total of unspecified elements shall not exceed 0,5 %, excluding cobalt and tantalum.

[f] Phosphorus 0,020 max., sulfur 0,015 max. unless otherwise stated.

[g] Boron 0,005 % max., Zr 0,020 %.

[h] Consumables for which the chemical composition is not listed in the table may be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore two electrodes with the same Z-classification may not be interchangeable.

Table 1 *(continued)*

Alloy symbol [a]		Chemical composition % (by mass)[b]														
Numerical symbol	**Chemical symbol**	C	Mn	Fe	Si	Cu	Ni [c]	Co	Al	Ti	Cr	Nb [d]	Mo	V	W	Notes [e, f]
Ni 6062	NiCr15Fe8NbMo	0,08	3,5	11,0	0,7	0,5	min. 62,0	—	—	—	13,0 to 17,0	1,5 to 4,0	—	—	—	—
Ni 6093	NiCr15Fe8NbMo	0,20	1,0 to 5,0	12,0	1,0	0,5	min. 60,0	—	—	—	13,0 to 17,0	1,0 to 3,5	1,0 to 3,5	—	—	—
Ni 6093B	NiCr15Fe8NbMo	0,20	1,0 to 3,5	12,0	1,0	0,5	min. 60,0	—	—	—	13,0 to 17,0	1,0 to 3,5	1,0 to 3,5	—	—	—
Ni 6094	NiCr14Fe4NbMo	0,15	1,0 to 4,5	12,0	0,7	0,5	min. 55,0	—	—	—	12,0 to 17,0	0,5 to 3,0	2,5 to 5,5	—	1,5	—
Ni 6095	NiCr15Fe8NbMoW	0,20	1,0 to 3,5	12,0	0,7	0,5	min. 55,0	—	—	—	13,0 to 17,0	1,0 to 3,5	1,0 to 3,5	—	1,5 to 3,5	—
Ni 6132	NiCr15Fe9Nb	0,08	3,5	11,0	0,75	0,50	min. 62,0	—	—	—	13,0 to 17,0	1,5 to 4,0	—	—	—	0,03 P
Ni 6133	NiCr16Fe12NbMo	0,10	1,0 to 3,5	12,0	0,8	0,5	min. 62,0	—	—	—	13,0 to 17,0	0,5 to 3,0	0,5 to 2,5	—	—	—
Ni 6133B	NiCr16Fe12NbMo	0,10	1,0 to 3,5	12,0	0,7	0,5	min. 62,0	—	—	—	13,0 to 17,0	0,5 to 3,0	0,5 to 2,5	—	—	0,03 P 0,02 S
Ni 6152	NiCr30Fe9Nb	0,05	5,0	7,0 to 12,0	0,7	0,5	min. 50,0	—	0,5	0,5	28,0 to 31,5	1,0 to 2,5	0,5	—	—	g
Ni 6182	NiCr15Fe6Mn	0,10	5,0 to 10,5	10,0	1,0	0,5	min. 60,0	—	—	1,0	13,0 to 17,0	1,0 to 3,5	—	—	—	*0,3 max. Ta where specified

[a] Symbols with B generally have more restrictive chemical compositions and are typically used in Pacific Rim countries.

[b] Single values for all elements except nickel are maxima. Two values shown indicate minimum and maximum limits for a range.

[c] Up to 1 % of the nickel content can be cobalt unless otherwise specified. For certain applications, lower cobalt levels can be required and should be agreed between contracting parties.

[d] Up to 20 % of the niobium content can be tantalum.

[e] The total of unspecified elements shall not exceed 0,5 %, excluding cobalt and tantalum.

[f] Phosphorus 0,020 max., sulfur 0,015 max. unless otherwise stated.

[g] Boron 0,005 % max., Zr 0,020 %.

[h] Consumables for which the chemical composition is not listed in the table may be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore two electrodes with the same Z-classification may not be interchangeable.

Table 1 *(continued)*

Alloy symbol [a]		Chemical composition % (by mass)[b]														
Numerical symbol	**Chemical symbol**	C	Mn	Fe	Si	Cu	Ni [c]	Co	Al	Ti	Cr	Nb [d]	Mo	V	W	Notes [e, f]
Ni 6182B	NiCr15Fe6Mn	0,10	5,0 to 9,5	10,0	1,0	0,5	min. 59,0	—	—	1,0	13,0 to 17,0	1,0 to 2,5	—	—	—	0,03 P *0,3 max. Ta where specified
Ni 6333	NiCr25Fe16CoMo3W	0,10	1,2 to 2,0	min. 16,0	0,8 to 1,2	0,5	44,0 to 47,0	2,5 to 3,5	—	—	24,0 to 26,0	—	2,5 to 3,5	—	2,5 to 3,5	—
Ni 6701	NiCr36Fe7Nb	0,35 to 0,50	0,5 to 2,0	7,0	0,5 to 2,0		42,0 to 48,0	—	—	—	33,0 to 39,0	0,8 to 1,8	—	—	—	—
Ni 6702	NiCr28Fe6W	0,35 to 0,50	0,5 to 1,5	6,0	0,5 to 2,0	—	47,0 to 50,0	—	—	—	27,0 to 30,0	—	—	—	4,0 to 5,5	—
Ni 6704	NiCr25Fe10Al3YC	0,15 to 0,30	0,5	8,0 to 11,0	0,8	—	min. 55,0	—	1,8 to 2,8	0,3	24,0 to 26,0	—	—	—	—	0,15 Y
Ni 8025	NiCr29Fe26Mo	0,06	1,0 to 3,0	30,0	0,7	1,5 to 3,0	35,0 to 40,0	—	0,1	1,0*	27,0 to 31,0	1,0	2,5 to 4,5	—	—	*or Nb
Ni 8165	NiFe30Cr25Mo	0,03	1,0 to 3,0	30,0	0,7	1,5 to 3,0	37,0 to 42,0	—	0,1	1,0	23,0 to 27,0	—	3,5 to7,5	—	—	—
Nickel-molybdenum																
Ni 1001	NiMo28Fe5	0,07	1,0	4,0 to 7,0	1,0	0,5	min. 55,0	2,5	—	—	1,0	—	26,0 to 30,0	0,6	1,0	—
Ni 1004	NiMo25Cr3Fe5	0,12	1,0	4,0 to 7,0	1,0	0,5	min. 60,0	2,5	—	—	2,5 to 5,5	—	23,0 to 27,0	0,6	1,0	—
Ni 1008	NiMo19WCr	0,10	1,5	10,0	0,7	0,5	min. 60,0	—	—	—	0,5 to 3,5	—	17,0 to 20,0	—	2,0 to 4,0	—

[a] Symbols with B generally have more restrictive chemical compositions and are typically used in Pacific Rim countries.

[b] Single values for all elements except nickel are maxima. Two values shown indicate minimum and maximum limits for a range.

[c] Up to 1 % of the nickel content can be cobalt unless otherwise specified. For certain applications, lower cobalt levels can be required and should be agreed between contracting parties.

[d] Up to 20 % of the niobium content can be tantalum.

[e] The total of unspecified elements shall not exceed 0,5 %, excluding cobalt and tantalum.

[f] Phosphorus 0,020 max., sulfur 0,015 max. unless otherwise stated.

[g] Boron 0,005 % max., Zr 0,020 %.

[h] Consumables for which the chemical composition is not listed in the table may be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore two electrodes with the same Z-classification may not be interchangeable.

Table 1 *(continued)*

Alloy symbol [a]		Chemical composition % (by mass)[b]														
Numerical symbol	**Chemical symbol**	C	Mn	Fe	Si	Cu	Ni [c]	Co	Al	Ti	Cr	Nb [d]	Mo	V	W	Notes [e, f]
Ni 1009	NiMo20WCu	0,10	1,5	7,0	0,7	0,3 to 1,3	min. 62,0	—	—	—	—	—	18,0 to 22,0	—	2,0 to 4,0	—
Ni 1062	NiMo24Cr8Fe6	0,02	1,0	4,0 to 7,0	0,7	—	min. 60,0	—	—	—	6,0 to 9,0	—	22,0 to 26,0	—	—	—
Ni 1066	NiMo28	0,02	1,7	2,2	0,2	0,5	min. 64,5	1,0	—	—	1,0	—	26,0 to 30,0	—	1,0	—
Ni 1067	NiMo30Cr	0,02	2,0	1,0 to 3,0	0,2	0,5	min. 62,0	3,0	—	—	1,0 to 3,0	—	27,0 to 32,0	—	3,0	—
Ni 1069	NiMo28Fe4Cr	0,02	1,0	2,0 to 5,0	0,7	—	min. 65,0	1,0	0,5	—	0,5 to 1,5	—	26,0 to 30,0	—	—	—
Ni 1069B	NiMo28Fe4Cr	0,02	2,5	2,0 to 5,0	0,2	0,5	min. 65,0	1,0	0,1 to 0,5	0,3	0,5 to 1,5	0,5	26,0 to 30,0	—	—	
Ni 1362	NiMo22Cr15	0,02	0,60	1,25	0,20	—	58,0 min.	—	0,50	—	13,8 to 15,6	—	21,5 to 23,0	—	—	0,030 P
Nickel-chromium-molybdenum																
Ni 6002	NiCr22Fe18Mo	0,05 to 0,15	1,0	17,0 to 20,0	1,0	0,5	min. 45,0	0,5 to 2,5	—	—	20,5 to 23,0	—	8,0 to 10,0	—	0,2 to 1,0	—
Ni 6007	NiCr22Fe20Mo6 Cu2Nb2Mn	0,05	1,0 to 2,0	18,0 to 21,0	1,0	1,5 to 2,5	min. 37,0	2,5	—	—	21,0 to 23,5	1,75 to 2,50	5,5 to 7,5	—	1,0	0,04 P 0,03 S
Ni 6012	NiCr22Mo9	0,03	1,0	3,5	0,7	0,5	min. 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	0,50	min. 49,0	2,5	—	—	20,0 to 22,5	—	12,5 to 14,5	0,3	2,5 to 3,5	—

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[c] Up to 1 % of the nickel content can be cobalt unless otherwise specified. For certain applications, lower cobalt levels can be required and should be agreed between contracting parties.

[d] Up to 20 % of the niobium content can be tantalum.

[e] The total of unspecified elements shall not exceed 0,5 %, excluding cobalt and tantalum.

[f] Phosphorus 0,020 max., sulfur 0,015 max. unless otherwise stated.

[g] Boron 0,005 % max., Zr 0,020 %.

[h] Consumables for which the chemical composition is not listed in the table may be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore two electrodes with the same Z-classification may not be interchangeable.

Table 1 *(continued)*

Alloy symbol [a]		Chemical composition % (by mass)[b]														
Numerical symbol	**Chemical symbol**	C	Mn	Fe	Si	Cu	Ni [c]	Co	Al	Ti	Cr	Nb [d]	Mo	V	W	Notes [e, f]
Ni 6024	NiCr26Mo14	0,02	0,5	1,5	0,2	0,5	min. 55,0	—	—	—	25,0 to 27,0	—	13,5 to 15,0	—	—	—
Ni 6030	NiCr29Mo5Fe15W2	0,03	1,5	13,0 to 17,0	1,0	1,0 to 2,4	min. 36,0	5,0	—	—	28,0 to 31,5	0,3 to 1,5	4,0 to 6,0	—	1,5 to 4,0	—
Ni 6035	NiCr33Mo8	0,05	0,50	2,00	0,60	0,30	50,0 min.	1,00	0,40	0,20	32,25 to 34,25	0,50	7,6 to 9,0	0,20	0,60	0,030 P
Ni 6058	NiCr22Mo20	0,02	1,5	1,5	0,2	0,5	min. 51,0	0,3	0,4	—	20,0 to 23,0	—	18,5 to 21,0	—	0,3	0,02 to 0,15 N
Ni 6059	NiCr23Mo16	0,02	1,0	1,5	0,2	—	min. 56,0	—	—	—	22,0 to 24,0	—	15,0 to 16,5	—	—	—
Ni 6059B	NiCr23Mo16	0,02	1,0	1,5	0,2	0,50	min. 56,0	—	—	—	22,0 to 24,0	—	15,0 to 16,5	—	—	0,015 P
Ni 6200	NiCr23Mo16Cu2	0,020	0,5	3,0	0,2	1,3 to 1,9	min. 45,0	2,0	—	—	20,0 to 24,0	—	15,0 to 17,0	—	—	—
Ni 6205	NiCr25Mo16	0,02	0,5	5,0	0,3	2,0	min. 50,0	—	0,4	—	22,0 to 27,0	—	13,5 to 16,5	—	—	—
Ni 6275	NiCr15Mo16Fe5W3	0,10	1,0	4,0 to 7,0	1,0	0,5	min. 50,0	2,5	—	—	14,5 to 16,5	—	15,0 to 17,0	0,3	3,0 to 4,5	—
Ni 6276	NiCr15Mo15Fe6W4	0,02	1,0	4,0 to 7,0	0,2	0,5	min. 50,0	2,5	—	—	14,5 to 16,5	—	15,0 to 17,0	0,4	3,0 to 4,5	—
Ni 6276B	NiCr15Mo15Fe6W4	0,02	1,0	4,0 to 7,0	0,2	0,50	min. 50,0	2,5	—	—	14,5 to 16,5	—	15,0 to 17,0	0,3	3,0 to 4,5	—
Ni 6452	NiCr19Mo15	0,025	2,0	1,5	0,4	0,5	min. 56,0	—	—	—	18,0 to 20,0	0,4	14,0 to 16,0	0,4	—	—

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[b] Single values for all elements except nickel are maxima. Two values shown indicate minimum and maximum limits for a range.

[c] Up to 1 % of the nickel content can be cobalt unless otherwise specified. For certain applications, lower cobalt levels can be required and should be agreed between contracting parties.

[d] Up to 20 % of the niobium content can be tantalum.

[e] The total of unspecified elements shall not exceed 0,5 %, excluding cobalt and tantalum.

[f] Phosphorus 0,020 max., sulfur 0,015 max. unless otherwise stated.

[g] Boron 0,005 % max., Zr 0,020 %.

[h] Consumables for which the chemical composition is not listed in the table may be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore two electrodes with the same Z-classification may not be interchangeable.

Table 1 *(continued)*

Alloy symbol [a]		Chemical composition % (by mass)[b]														
Numerical symbol	**Chemical symbol**	C	Mn	Fe	Si	Cu	Ni [c]	Co	Al	Ti	Cr	Nb [d]	Mo	V	W	Notes [e, f]
Ni 6455	NiCr16Mo15Ti	0,02	1,5	3,0	0,2	0,5	min. 56,0	2,0	—	0,7	14,0 to 18,0	—	14,0 to 17,0	—	0,5	—
Ni 6455B	NiCr16Mo15Ti	0,015	1,5	3,0	0,2	0,50	min. 56,0	2,0	—	0,70	14,0 to 18,0	—	14,0 to 17,0	—	0,5	—
Ni 6620	NiCr14Mo7Fe	0,10	2,0 to 4,0	10,0	1,0	0,5	min. 55,0	—	—	—	12,0 to 17,0	0,5 to 2,0	5,0 to 9,0	—	1,0 to 2,0	—
Ni 6625	NiCr22Mo9Nb	0,10	2,0	7,0	0,8	0,5	min. 55,0	—	—	—	20,0 to 23,0	3,0 to 4,2	8,0 to 10,0	—	—	—
Ni 6625B	NiCr22Mo9Nb	0,10	1,0	7,0	0,7	0,50	min. 55,0	—	—	—	20,0 to 23,0	3,15 to 4,15	8,0 to 10,0	—	—	—
Ni 6627	NiCr21MoFeNb	0,03	2,2	5,0	0,7	0,5	min. 57,0	—	—	—	20,5 to 22,5	1,0 to 2,8	8,8 to 10,0	—	—	
Ni 6650	NiCr20Fe14Mo-11WN	0,03	0,7	12,0 to 15,0	0,6	0,3	min. 44,0	1,0	0,5	—	19,0 to 22,0	0,3	10,0 to 13,0	0,15	1,0 to 2,0	0,15 N 0,02 S
Ni 6686	NiCr21Mo16W4	0,02	1,0	5,0	0,3	0,5	min. 49,0	—	—	0,3	19,0 to 23,0	—	15,0 to 17,0	—	3,0 to 4,4	—
Ni 6686B	NiCr21Mo16W4	0,02	1,0	5,0	0,25	0,50	min. 49,0	—	—	0,25	19,0 to 23,0	—	15,0 to 17,0	—	3,0 to 4,4	0,02 P 0,02 S
Ni 6985	NiCr22Mo7Fe19	0,02	1,0	18,0 to 21,0	1,0	1,5 to 2,5	min. 45,0	5,0	—	—	21,0 to 23,5	0,5	6,0 to 8,0	—	1,5	—
Nickel-chromium-cobalt-molybdenum																
Ni 6117	NiCr22Co12Mo	0,05 to 0,15	3,0	5,0	1,0	0,5	min. 45,0	9,0 to 15,0	1,5	0,6	20,0 to 26,0	1,0	8,0 to 10,0	—	—	—

[a] Symbols with B generally have more restrictive chemical compositions and are typically used in Pacific Rim countries.

[b] Single values for all elements except nickel are maxima. Two values shown indicate minimum and maximum limits for a range.

[c] Up to 1 % of the nickel content can be cobalt unless otherwise specified. For certain applications, lower cobalt levels can be required and should be agreed between contracting parties.

[d] Up to 20 % of the niobium content can be tantalum.

[e] The total of unspecified elements shall not exceed 0,5 %, excluding cobalt and tantalum.

[f] Phosphorus 0,020 max., sulfur 0,015 max. unless otherwise stated.

[g] Boron 0,005 % max., Zr 0,020 %.

[h] Consumables for which the chemical composition is not listed in the table may be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore two electrodes with the same Z-classification may not be interchangeable.

Table 1 *(continued)*

Alloy symbol [a]		Chemical composition % (by mass)[b]														
Numerical symbol	**Chemical symbol**	C	Mn	Fe	Si	Cu	Ni [c]	Co	Al	Ti	Cr	Nb [d]	Mo	V	W	Notes [e, f]
Ni 6117B	(NiCr22Co12Mo)	0,05 to 0,15	0,3 to 2,5	5,0	0,7	0,50	min. 45,0	9,0 to 15,0	—	—	21,0 to 26,0	1,0	8,0 to 10,0	—	—	0,03 P
	NiZ [h]	Any other agreed composition														

a Symbols with B generally have more restrictive chemical compositions and are typically used in Pacific Rim countries.

b Single values for all elements except nickel are maxima. Two values shown indicate minimum and maximum limits for a range.

c Up to 1 % of the nickel content can be cobalt unless otherwise specified. For certain applications, lower cobalt levels can be required and should be agreed between contracting parties.

d Up to 20 % of the niobium content can be tantalum.

e The total of unspecified elements shall not exceed 0,5 %, excluding cobalt and tantalum.

f Phosphorus 0,020 max., sulfur 0,015 max. unless otherwise stated.

g Boron 0,005 % max., Zr 0,020 %.

h Consumables for which the chemical composition is not listed in the table may be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore two electrodes with the same Z-classification may not be interchangeable.

Table 2 — Minimum tensile properties of the all-weld metal

Numerical symbol	Minimum 0,2 % proof strength MPa	Minimum tensile strength MPa	Minimum elongation $5d$[a] %
Nickel			
Ni 2061	200	410	18
Nickel-copper			
Ni 4060; Ni 4061	200	480	27
Nickel-chromium			
Ni 6056	—	620	27
Ni 6082	360	600	22
Ni 6172	550	760	Not available
Ni 6231	350	620	18
Nickel-chromium-iron			
Ni 6025	400	650	18
Ni 6045	240	620	18
Ni 6055	—	550	27
Ni 6062	360	550	27
Ni 6093	360	650	18
Ni 6094; Ni 6095	—	650	22
Ni 6132	360	550	27
Ni 6133; Ni 6152; Ni 6182	360	550	27
Ni 6333	360	550	18
Ni 6701; Ni 6702	450	650	8
Ni 6704	400	690	12
Ni 8025; Ni 8165	240	550	22
Nickel-molybdenum			
Ni 1001; Ni 1004	400	690	22
Ni 1008; Ni 1009	360	650	22
Ni 1062	360	550	18
Ni 1066	400	690	22
Ni 1067	350	690	22
Ni 1069	360	690	22
Ni 1362	—	720	22
Nickel-chromium-molybdenum			
Ni 6002	380	650	18
Ni 6007	—	620	18
Ni 6012	410	650	22
Ni 6022; Ni 6024	350	690	22
Ni 6030	350	590	22
Ni 6035	—	590	22
Ni 6058	450	830	18
Ni 6059	350	690	22
Ni 6200; Ni 6275; Ni 6276	400	690	22
Ni 6205; Ni 6452	350	690	22

[a] Elongation determined from gauge length equal to five times gauge diameter, $5d$.

Table 2 *(continued)*

Numerical symbol	Minimum 0,2 % proof strength MPa	Minimum tensile strength MPa	Minimum elongation $5d^a$ %
Ni 6455	300	690	22
Ni 6620	350	620	32
Ni 6625	420	760	27
Ni 6627	400	650	32
Ni 6650	450	650	27
Ni 6686	350	690	27
Ni 6985	350	620	22
Nickel-chromium-cobalt-molybdenum			
Ni 6117	400	620	22
[a] Elongation determined from gauge length equal to five times gauge diameter, 5*d*.			

9 Retests

If any test fails to meet the requirement(s), that test shall be repeated twice. The results of both retests shall meet the requirements. Specimens for the retest may be taken from the original test assembly or sample or from one or two new test assemblies or samples. For chemical analysis, retests need only be for those specific elements that failed to meet the 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 document 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 sample(s) or test specimen(s), or in conducting the tests, the test shall be considered invalid. This determination is made without regard to whether the test was actually completed or whether the test results met, or failed to meet, the requirements. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

10 Technical delivery conditions

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

11 Designation

The designation of covered electrodes shall follow the principle given in the following examples.

EXAMPLE 1 A covered electrode for manual metal arc welding (E) depositing a nickel-base alloy weld metal (Ni) with a chemical composition of 67 % Ni, 15 % Cr, 7 % Mn and 2 % Nb and all other requirements for the alloy 6182 in Table 1 is designated.

ISO 14172 — E Ni 6182

or alternatively

ISO 14172 — E Ni 6182 (NiCr15Fe6Mn)

where

ISO 14172 designates the number of this document;

E designates covered electrode/manual metal arc welding (see 5.1);

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

NiCr15Fe6Mn designates the optional chemical symbol of the covered electrode (see Table 1).

EXAMPLE 2 For a covered electrode producing an all-weld-metal with a nominal composition of the main alloying elements of: 26 % Cr, 12 % Co, 9 % Mo, 4 % Fe, 1 % V and the balance Ni the Z-classification given as:

ISO 14172 – E NiZ (NiCr23Co12Mo9Fe4V1)

where

ISO 14172 designates the number of this document;

E designates covered electrode/manual metal arc welding (see 5.1);

NiZ is the chemical composition, agreed between the manufacturer and customer (Table 1);

NiCr23Co12Mo9Fe4V1 designates the chemical symbol of the covered electrode (see Table 1).

Annex A
(informative)

System for designation of welding consumables

The system provides for one or two initial alpha designators:

— the first letter representing the type of filler metal;

— the second letter representing the alloy system.

A four-digit numeric designator follows the initial letters.

For a number of alloy welding consumables, the four-digit designator is similar to those assigned by the unified numbering system (UNS). In this way, the welding consumables are frequently related to the base metals with which they are often used as described in Annex B.

The system as proposed uses "E" as the initial alpha designator for covered electrodes and "N" for nickel-base alloys. However, because the combination "EN" can cause confusion with the European "EN" standards prepared by CEN, "Ni" has been adopted for the second alpha designator.

Annex B
(informative)

Description and uses of welding consumables

B.1 General

This annex is included to provide an indication of the use for which individual classifications of electrodes are intended. More particular information on techniques to be applied when using electrodes depositing nickel-base alloys should be sought from the manufacturer.

B.2 Nickel

B.2.1 Ni 2061

Electrodes of this classification are used for welding wrought and cast forms of commercially pure nickel (UNS N02200 or UNS N02201), welding the clad side of nickel-clad steel and surfacing of steel, as well as for dissimilar metal welding.

B.3 Nickel-copper

B.3.1 Ni 4060, Ni 4061

Electrodes of these classifications are used for welding nickel-copper alloys (UNS N04400) to each other, welding the clad side of nickel-copper alloy-clad steel, and surfacing of steel. Ni 4060 is preferred for some environments where a significant proportion of niobium is detrimental to corrosion resistance.

B.4 Nickel-chromium

B.4.1 Ni 6056

Filler metal of this classification is used for welding nickel-chromium-iron alloy 690 (UNS N06690) to itself, to steels and to weld overlay steels in nuclear pressure vessel applications. It shows excellent resistance to primary water stress corrosion cracking.

B.4.2 Ni 6082

Electrodes of this classification are used for welding nickel-chromium alloys (e.g. UNS N06075, UNS N07080) and nickel-chromium-iron alloys (e.g. UNS N06600, UNS N06601), and weld metals are distinguished from other alloys for these applications by their relatively high-chromium content. They are also used for cladding and for welding dissimilar metal joints. They can be used for welding nickel steels for cryogenic applications.

B.4.3 Ni 6172

Electrodes of this classification are primarily used to weld cast grade ASTM A560/A560M. It is resistant to carburizing furnace atmospheres and fuel ash corrosion, which occurs when burning low-grade heavy fuels, and is scale resistant up to 1 150 °C.

B.4.4 Ni 6231

Electrodes of this classification are used to weld nickel-chromium-tungsten-molybdenum alloy UNS N06230.

B.5 Nickel-chromium-iron

B.5.1 Ni 6025

Electrodes of this classification are used for welding nickel-base alloys of similar composition, such as UNS N06025 and UNS N06603. Welds exhibit resistance to oxidation, carburization and sulfidization and are used at temperatures up to 1 200 °C.

B.5.2 Ni 6045

Electrodes of this classification are used for welding UNS number N06045, welding nickel-chromium-iron to steel and to other nickel-base alloys.

B.5.3 Ni 6055

Electrodes of this classification are used for welding nickel-chromium-iron alloys (e.g. UNS N06690) to themselves, to steels and to weld clad steels with the nickel-chromium-iron alloy. This classification provides improved resistance to ductility dip cracking under conditions of high restraint when compared with products of the Ni 6152 classification.

B.5.4 Ni 6062

Electrodes of this classification are used for welding nickel-chromium-iron alloys (e.g. UNS N06600, UNS N06601), for the clad side of joints in steel clad with nickel-chromium-iron alloy, and for surfacing steel. They have good dissimilar metal welding capability. They can be used for applications at temperatures up to about 980 °C, but do not exhibit optimum oxidation resistance and strength above 820 °C.

B.5.5 Ni 6093, Ni 6094, Ni 6095

Electrodes of these classifications are used for welding 9 % nickel steel (UNS K81340) and weld deposits have higher strength than those from Ni 6133 electrodes.

B.5.6 Ni 6132

Electrodes of this classification are used for welding nickel-chromium-iron alloys, for the clad side of joints in steel clad with nickel-chromium-iron alloy and for surfacing steel with nickel-chromium-iron weld metal. The electrodes can be used for applications at temperatures ranging from cryogenic to around 980 °C. However, for temperatures above 820 °C, weld metal produced by these electrodes does not exhibit optimum oxidation resistance and strength. These electrodes are also suitable for joining steel to nickel-base alloys.

B.5.7 Ni 6133

Electrodes of this classification are used for welding nickel-iron-chromium alloys (e.g. UNS N08800) and nickel-chromium-iron alloys (e.g. UNS N06600) and have particular application to dissimilar material welds. They can be used for applications at temperatures up to about 980 °C, but do not exhibit optimum oxidation resistance and strength above 820 °C.

B.5.8 Ni 6152

Electrodes of this classification deposit weld metals of higher chromium content than other nickel-chromium-iron electrodes specified in this document. They are used for welding high-chromium nickel-base alloys, such as UNS N06690. They can also be used for producing corrosion-resistant overlays on low-alloy and stainless steels and for dissimilar metal joints.

B.5.9 Ni 6182

Electrodes of this classification are used for welding nickel-chromium-iron alloys (e.g. UNS N06600), for welding the clad side of joints in steel clad with nickel-chromium-iron alloy and for surfacing steel. They can also be used for welding steel to other nickel-base alloys. The temperature of application is up to about 480 °C in the latter application. Resistance to hot cracking is superior to other weld metals in this group.

B.5.10 Ni 6333

Electrodes of this classification are used for welding nickel-base alloys of similar composition (particularly UNS N06333). Welds exhibit resistance to oxidation, carburization and sulfidization and are used at temperatures up to and exceeding 1 000 °C.

B.5.11 Ni 6701, Ni 6702

Electrodes of these classifications are used for welding cast nickel-base alloys of similar composition. Welds exhibit resistance to oxidation and are used at temperatures up to 1 200 °C.

B.5.12 Ni 6704

Electrodes of this classification are used for welding nickel-base alloys of similar composition, such as UNS N06025 and UNS N06603. Welds exhibit resistance to oxidation, carburization and sulfidization and are used at temperatures up to 1 200 °C.

B.5.13 Ni 8025, Ni 8165

Electrodes of these classifications are used for welding copper-alloyed austenitic stainless chromium-nickel-molybdenum alloys (e.g. UNS N08904) and nickel-chromium molybdenum alloys (e.g. UNS N08825). They can also be used for surfacing steel, provided that a barrier layer of nickel-chromium-iron alloy is deposited first.

B.6 Nickel-molybdenum

B.6.1 Ni 1001

Electrodes of this classification are used for welding nickel-molybdenum alloys of similar composition, particularly UNS N10001, for welding the clad side of joints in steel clad with nickel-molybdenum alloys and for welding nickel-molybdenum alloys to steel and other nickel-base alloys.

B.6.2 Ni 1004

Electrodes of this classification are used for welding dissimilar metal combinations of nickel-base, cobalt-base and iron-base alloys.

B.6.3 Ni 1008, Ni 1009

Electrodes of these classifications are used for welding 9 % nickel steel (UNS K81340) and weld deposits have higher strength than those from Ni 6133 electrodes.

B.6.4 Ni 1062

Electrodes of this classification are used for welding nickel-molybdenum alloys, especially UNS N10629, for welding the clad side in steel clad with a nickel-molybdenum alloy and for welding nickel-molybdenum alloys to steel and other nickel-base alloys.

B.6.5 Ni 1066

Electrodes of this classification are used for welding nickel-molybdenum alloys, especially UNS N10665, for welding the clad side in steel clad with a nickel-molybdenum alloy and for welding nickel-molybdenum alloys to steel and other nickel-base alloys.

B.6.6 Ni 1067

Electrodes of this classification are used for welding nickel-molybdenum alloys, particularly UNS N10665 and N10675, and for welding nickel-molybdenum alloys to steel and other nickel-base alloys.

B.6.7 Ni 1069

Electrodes of this classification are used for welding dissimilar metal combinations of nickel-base, cobalt-base and iron-base alloys.

B.6.8 Ni 1362

Filler metal of this classification is used for welding nickel-molybdenum-chromium alloy, UNS number N10362, to itself and for cladding steel with nickel-molybdenum-chromium weld metal.

B.7 Nickel-chromium-molybdenum

B.7.1 Ni 6002

Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, especially UNS N06002, for welding the clad side in steel clad with nickel-chromium-molybdenum alloy and for welding nickel-chromium-molybdenum alloys to steel and other nickel-base alloys.

B.7.2 Ni 6007

Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy and for welding nickel-chromium-molybdenum alloy to steel and to other nickel-base alloys. Typical specifications for the nickel-chromium-molybdenum base metals have UNS number N06007. These electrodes normally are used only in the flat position.

B.7.3 Ni 6012

Electrodes of this classification are used for welding high-austenitic stainless steels of 6 Mo type. The weldments exhibit very good resistance to pitting and crevice corrosion in chloride-containing environments. The low Nb content improves weldability.

B.7.4 Ni 6022

Electrodes of this classification are used for welding low-carbon nickel-chromium-molybdenum alloys, especially UNS N06022, for welding the clad side in steel clad with low-carbon nickel-chromium-molybdenum alloy and for welding low-carbon nickel-chromium-molybdenum alloys to steel and other nickel-base alloys.

B.7.5 Ni 6024

Electrodes of this classification are used to weld stainless steels with a duplex ferritic-austenitic structure; weld metals have a strength and corrosion resistance that make them particularly suitable for joining the “super-duplex” stainless steels, such as UNS S32750.

B.7.6 Ni 6030

Electrodes of this classification are used for welding low-carbon nickel-chromium-molybdenum alloys, especially UNS N06030, for welding the clad side in steel clad with low-carbon nickel-chromium-molybdenum alloy and for welding low-carbon nickel-chromium-molybdenum alloys to steel and other nickel-base alloys.

B.7.7 Ni 6035

Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys (e.g. UNS N06035), for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy and for welding nickel-chromium-molybdenum alloys to steel and to other nickel base alloys.

B.7.8 Ni 6058

Electrodes of this classification are used for welding low-carbon nickel-chromium-molybdenum alloys, especially UNS N06058, and for welding the clad side of joints in steel clad with nickel-chromium-molybdenum alloy to steel and to other nickel base alloys.

B.7.9 Ni 6059

Electrodes of this classification are used for welding low-carbon nickel-chromium-molybdenum alloys, especially UNS N06059 and chromium-nickel-molybdenum austenitic stainless steels, for welding the clad side in steel clad with low-carbon nickel-chromium-molybdenum alloy, and for welding low-carbon nickel-chromium-molybdenum alloys to steel and other nickel-base alloys.

B.7.10 Ni 6200, Ni 6205

Electrodes of these classifications are used to weld nickel-chromium-molybdenum-copper alloy UNS N06200.

B.7.11 Ni 6275

Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, especially UNS N10002, to each other and to steel, and for surfacing steel with nickel-chromium-molybdenum alloys.

B.7.12 Ni 6276

Electrodes of this classification are used for welding nickel-chromium-molybdenum alloys, especially UNS N10276, for welding the clad side in steel clad with low-carbon nickel-chromium-molybdenum alloy and for welding low-carbon nickel-chromium-molybdenum alloys to steel and other nickel-base alloys.

B.7.13 Ni 6452, Ni 6455

Electrodes of these classifications are used for welding low-carbon nickel-chromium-molybdenum alloys, especially UNS N06455, for welding the clad side in steel clad with low-carbon nickel-chromium-molybdenum alloy and for welding low-carbon nickel-chromium-molybdenum alloys to steel and other nickel-base alloys.