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Welding consumables — Covered electrodes for manual metal arc welding of high-strength steels — Classification

Produits consommables pour le soudage — Électrodes enrobées pour le soudage manuel à l'arc des aciers à haute résistance — 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*.

Any feedback, question or request for official interpretation related to any aspect of this document should be directed to the Secretariat of ISO/TC 44/SC 3 via your national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

This third edition cancels and replaces the second edition (ISO 18275:2011), which has been technically revised. The main changes compared to the previous edition are as follows:

— fillet weld testing has been removed from the document;

— requirements for diffusible hydrogen removal treatment have been revised;

— new classifications have been added: NiCrCu, E6218-N4M2 P;

— post-weld heat treatment details have been clarified on the B-side;

— Clauses 7, 8 and 9 have been updated to reflect agreed text for all ISO/TC 44/SC 3 standards.

Introduction

This document recognizes that there are two somewhat different approaches in the global market to classifying a given electrode, and allows for either or both to be used, to suit a particular market need. Application of either type of classification designation (or of both, where suitable) identifies a product as classified in accordance with this document. The classification in accordance with system A was originally based on EN 757:1997. The classification in accordance with system B is mainly based on standards used around the Pacific Rim.

This document provides a classification system for covered electrodes for high-strength steels in terms of the tensile properties, impact properties and chemical composition of the all-weld metal, as well as the type of electrode covering. The ratio of yield strength to tensile strength of weld metal is generally higher than that of parent metal. Users should note that matching weld metal yield strength to parent metal yield strength does not necessarily ensure that the weld metal tensile strength matches that of the parent metal. Therefore, where the application requires matching tensile strength, selection of the consumable should be made by reference to column 3 of Table 1A or column 2 of Table 8B.

It should be noted that the mechanical properties of all-weld metal test specimens used to classify covered electrodes can vary from those obtained in production joints because of differences in welding procedure such as electrode size, width of weave, welding position, and parent metal composition.

Welding consumables — Covered electrodes for manual metal arc welding of high-strength steels — Classification

1 Scope

This document specifies requirements for classification of covered electrodes and deposited metal in the as-welded condition and in the post-weld heat-treated condition for manual metal arc welding of high-strength steels with a minimum yield strength greater than 500 MPa or a minimum tensile strength greater than 570 MPa.

This document is a combined specification providing a classification utilizing a system based on the yield strength and an average impact energy of 47 J of the all-weld metal, or utilizing a system based on the tensile strength and an average impact energy of 27 J of the all-weld metal.

a) Subclauses and tables which carry the suffix letter "A" are applicable only to covered electrodes classified under the system based on the yield strength and an average impact energy of 47 J of the all-weld metal given in this document.

b) Subclauses and tables which carry the suffix letter "B" are applicable only to covered electrodes classified under the system based on the tensile strength and an average impact energy of 27 J of the all-weld metal given in this document.

c) Subclauses and tables which do not have either the suffix letter "A" or the suffix letter "B" are applicable to all covered electrodes classified under this document.

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 2401, *Covered electrodes — Determination of the efficiency, metal recovery and deposition coefficient*

ISO 2560:2009, *Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification*

ISO 3690, *Welding and allied processes — Determination of hydrogen content in arc weld metal*

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

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

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

ISO 15792-1, *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 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological 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

4.1 General

Classification designations are based on two approaches to indicate the tensile properties and the impact properties of the all-weld metal obtained with a given electrode. The two designation approaches include additional designators for some other classification requirements, but not all, as will be clear from the following subclauses. In most cases, a given commercial product can be classified in both systems. Then either or both classification designations can be used for the product.

The classification is based on an electrode diameter of 4,0 mm.

Classification is as follows:

4.1A Classification by yield strength and 47 J impact energy

The classification is divided into nine parts:

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

2) the second part gives a symbol indicating the strength and elongation of the all-weld metal (see Table 1A);

3) the third part gives a symbol indicating the impact properties of the all-weld metal (see Table 2A);

4) the fourth part gives a symbol indicating the chemical composition of the all-weld metal (see Table 3A);

5) the fifth part gives a symbol indicating the type of electrode covering (see 5.5A);

6) the sixth part gives a symbol indicating post-weld heat treatment if this is applied (see 5.6A);

7) the seventh part gives a symbol indicating the nominal electrode efficiency and type of current (see Table 5A);

8) the eighth part gives a symbol indicating the welding position (see Table 6A);

9) the ninth part gives a symbol indicating the diffusible hydrogen content of the deposited metal (see Table 7).

4.1B Classification by tensile strength and 27 J impact energy

The classification is divided into seven parts:

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

2) the second part gives a symbol indicating the strength of the all-weld metal (see Table 1B);

3) the third part gives a symbol indicating the type of electrode covering, the type of current, and the welding position (see Table 4B);

4) the fourth part gives a symbol indicating the chemical composition of the all-weld metal (see Table 3B);

5) the fifth part gives a symbol indicating the condition of the post-weld heat treatment under which the all-weld metal test was conducted (see 5.6B);

6) the sixth part gives a symbol indicating that the electrode has satisfied a requirement for 47 J impact energy at the temperature normally used for the 27 J requirement;

7) the seventh part gives a symbol indicating the diffusible hydrogen content of the deposited metal (see Table 7).

In both systems, the electrode classification shall include all compulsory sections and may include optional sections as outlined in 4.2A and 4.2B.

4.2 Compulsory and optional sections

4.2A Classification by yield strength and 47 J impact energy

a) Compulsory section

This section includes the symbols for the type of product, the strength and elongation, the impact properties, the chemical composition and the type of covering, i.e. the symbols defined in 5.1, 5.2A, 5.3A, 5.4A and 5.5A.

b) Optional section

This section includes the symbols for post-weld heat treatment, the weld metal recovery, the type of current, the welding positions for which the electrode is suitable, and the symbol for diffusible hydrogen content, i.e. the symbols defined in 5.6A, 5.7A, 5.8A and 5.9.

4.2B Classification by tensile strength and 27 J impact energy

a) Compulsory section

This section includes the symbols for the type of product, the strength, the type of covering (which includes the type of current and the welding position), the chemical composition and the condition of heat treatment, i.e. the symbols defined in 5.1, 5.2B, 5.4B, 5.5B and 5.6B.

b) Optional section

This section includes the symbol for the optional supplemental designator for 47 J impact energy, i.e. the symbol defined in 5.3B, and the symbol for the diffusible hydrogen content, i.e. the symbol defined in 5.9.

The designation (see Clause 11) shall be used on packages and in the manufacturer's literature and data sheets. Figure A.1 gives a schematic representation of the designation of electrodes classified by yield strength and 47 J impact energy (system A). Figure A.2 gives a schematic representation of the designation of electrodes classified by tensile strength and 27 J impact energy (system B).

5 Symbols and requirements

5.1 Symbol for the product/process

The symbol for the covered electrode used in the manual metal arc process shall be the letter E.

5.2 Symbol for tensile properties of all-weld metal

5.2A Classification by yield strength and 47 J impact energy

The symbols in Table 1A indicate the yield strength, tensile strength and elongation of the all-weld metal in the as-welded condition or, if a T is added to the designation, after post-weld heat treatment as described in 5.6, determined in accordance with Clause 6.

5.2B Classification by tensile strength and 27 J impact energy

The symbols in Table 1B indicate the tensile strength of the all-weld metal in the as-welded condition, in the post-weld heat-treated condition, or in both conditions, determined in accordance with Clause 6. The yield strength and elongation requirements depend on the specific chemical composition, heat treatment condition and covering type, as well as on the tensile strength requirements, as given for the complete classification in Table 8B.

NOTE Post-weld heat treatment (sometimes referred to as stress relief heat treatment) can alter the mechanical properties of the weld from those obtained in the as-welded condition.

Table 1A — Symbol for tensile properties of all-weld metal
(Classification by yield strength and 47 J impact energy)

Symbol	Minimum yield strength[a] MPa	Tensile strength MPa	Minimum elongation[b] %
55	550	610 to 780	18
62	620	690 to 890	18
69	690	760 to 960	17
79	790	880 to 1 080	16
89	890	980 to 1 180	15

[a] For yield strength, the lower yield strength (R_{eL}) shall be used when yielding occurs, otherwise the 0,2 % proof strength ($R_{p0,2}$) shall be used.

[b] The gauge length is equal to five times the test specimen diameter.

Table 1B — Symbol for tensile strength of all-weld metal
(Classification by tensile strength and 27 J impact energy)

Symbol	Minimum tensile strength MPa
59	590
62	620
69	690
76	760
78	780
83	830

5.3 Symbol for impact properties of all-weld metal

5.3A Classification by yield strength and 47 J impact energy

The symbols in Table 2A indicate the temperature at which an average impact energy of 47 J is achieved under the conditions given in Clause 6. Three test specimens shall be tested. Only one individual value may be lower than 47 J, but it shall not be lower than 32 J. When an all-weld metal has been classified for a certain temperature, this automatically covers any higher temperature in Table 2A.

5.3B Classification by tensile strength and 27 J impact energy

There is no specific symbol for impact properties. The complete classification in Table 8B determines the temperature at which an impact energy of 27 J is achieved in the as-welded condition or in the post-weld heat-treated condition under the conditions given in Clause 6. Five test specimens shall be tested. The lowest and highest values obtained shall be disregarded. Two of the three remaining values shall be greater than the specified 27 J level, one of the three may be lower but shall not be less than 20 J. The average of the three remaining values shall be at least 27 J.

The addition of the optional symbol U, immediately after the symbol for condition of heat treatment, indicates that the supplemental requirement of 47 J impact energy at the normal 27 J impact test temperature has also been satisfied. For the 47 J impact requirement, the number of specimens tested and values obtained shall meet the requirements of 5.3A.

Table 2A — Symbol for impact properties of all-weld metal
(Classification by yield strength and 47 J impact energy)

Symbol	Temperature for minimum average impact energy 47 J °C
Z	No requirements
A	+20
0	0
2	−20
3	−30
4	−40
5	−50
6	−60
7	−70
8	−80

NOTE Post-weld heat treatment (sometimes referred to as stress relief heat treatment) can alter the mechanical properties of the weld from those obtained in the as-welded condition.

5.4 Symbol for chemical composition of all-weld metal

5.4A Classification by yield strength and 47 J impact energy

The symbols in Table 3A indicate the chemical composition of the all-weld metal, determined in accordance with Clause 7.

5.4B Classification by tensile strength and 27 J impact energy

The symbols in Table 3B indicate the principal alloying elements, and sometimes the nominal alloy level of the most significant alloy element, of the all-weld metal, determined in accordance with Clause 7. The symbol for chemical composition does not immediately follow the symbol for strength, but follows the symbol for covering type. The complete compulsory classification designation, given in 5.10B, determines the exact chemical composition requirements for a particular electrode classification.

Table 3A — Symbol for chemical composition of all-weld metal
(Classification by yield strength and 47 J impact energy)

Alloy symbol	Chemical composition[a,b] % (by mass)			
	Mn	Ni	Cr	Mo
MnMo	1,4 to 2,0	—	—	0,3 to 0,6
Mn1Ni	1,4 to 2,0	0,6 to 1,2	—	—
1NiMo	1,4	0,6 to 1,2	—	0,3 to 0,6
1,5NiMo	1,4	1,2 to 1,8	—	0,3 to 0,6
2NiMo	1,4	1,8 to 2,6	—	0,3 to 0,6
Mn1NiMo	1,4 to 2,0	0,6 to 1,2	—	0,3 to 0,6
Mn2NiMo	1,4 to 2,0	1,8 to 2,6	—	0,3 to 0,6
Mn2NiCrMo	1,4 to 2,0	1,8 to 2,6	0,3 to 0,6	0,3 to 0,6
Mn2Ni1CrMo	1,4 to 2,0	1,8 to 2,6	0,6 to 1,0	0,3 to 0,6
Z[c]	Any other agreed composition			

[a] If not specified, Mo < 0,2; Ni < 0,3; Cr < 0,2; V < 0,05; Nb < 0,05; Cu < 0,3; 0,03 ≤ C ≤ 0,10; P < 0,025; S < 0,020; Si < 0,80.

[b] Single values are maxima.

[c] 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 3B — Symbol for chemical composition of all-weld metal
(Classification by tensile strength and 27 J impact energy)

Alloy symbol	Chemical composition % (by mass)	
	Principal alloy element(s)	Nominal level
3 M2	Mn	1,5
	Mo	0,4
4 M2	Mn	2,0
	Mo	0,4
3 M3	Mn	1,5
	Mo	0,5
N1M1	Ni	0,5
	Mo	0,2
N2M1	Ni	1,0
	Mo	0,2
N3M1	Ni	1,5
	Mo	0,2
N3M2	Ni	1,5
	Mo	0,4
N4M1	Ni	2,0
	Mo	0,2
N4M2	Ni	2,0
	Mo	0,4
N4M3	Ni	2,0
	Mo	0,5
N5M1	Ni	2,5
	Mo	0,2
N5M4	Ni	2,5
	Mo	0,6
N9M3	Ni	4,5
	Mo	0,5
N13L	Ni	6,5
N3CM1	Ni	1,5
	Cr	0,2
	Mo	0,2
N4CM2	Ni	1,8
	Cr	0,3
	Mo	0,4
N4C2M1	Ni	2,0
	Cr	0,7
	Mo	0,3
N4C2M2	Ni	2,0
	Cr	1,0
	Mo	0,4