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Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification

Produits consommables pour le soudage — Électrodes enrobées pour le soudage manuel à l'arc des aciers non alliés et des aciers à grains fins — 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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).

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.

This fourth edition cancels and replaces the third edition (ISO 2560:2009), which has been technically revised.

The main changes compared to the previous edition are as follows:

— all the references have been updated;

— throughout the document, "nominal electrode efficiency" now reads "electrode efficiency";

— in 4B, "strength" has been clarified by changing to "tensile strength;

— in Table 3B, the "Nominal level" for Mn shown in the 1st row of the table for "No symbol, -1, -P1, or –P2" was changed to 1,3;

— in Table 3B, a new footnote has been added regarding G classifications (similar to Table 3A);

— in Table 4B, a new footnote d to symbol "45" was added "Not including PF (vertical up)";

— in Table 8B, the heading of the last column has been revised to read " Impact test temperature";

— in Table 8B, NS (not specified) has been changed to NR (not required) and a new footnote c regarding testing at lower temperatures has been added;

— in Table 10B, E4918, E4918-1, E5516-3M3, E5516-N3 and E5516-N7 have been updated to match values in AWS standards;

— in Clause 8, *b* has been changed to *w* for width in accordance with ISO 15792-1;

— in Clause 9, Rounding procedure has been updated to match current agreed wording;

— in Clause 12B, Example 1B, the %Mn was changed to 0,90 to better match the designation given in the example;

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 is mainly based on EN 499:1994. The classification in accordance with system B is mainly based on standards used around the Pacific Rim.

This document provides a classification in order to designate covered electrodes in terms of the yield strength, tensile strength and elongation of the all-weld metal. 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 to Table 1B and Table 8B.

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

Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification

1 Scope

This document specifies requirements for the 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 non-alloy and fine grain steels with a minimum yield strength of up to 500 MPa or a minimum tensile strength of up to 570 MPa.

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

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

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

c) Clauses, subclauses and tables which do not have either the suffix letter "A" or the suffix letter "B" are applicable to all covered electrodes classified in 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 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 6947:2019, *Welding and allied processes — Welding positions*

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 15792-3:2011, *Welding consumables — Test methods — Part 3: Classification testing of positional capacity and root penetration of welding consumables in a fillet weld*

ISO 80000-1:2009, *Quantities and units — Part 1: General*. Corrected by ISO 80000-1:2009/Cor 1:2011

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 http://www.electropedia.org/

4 Classification

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. 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 includes all-weld metal properties obtained with a covered electrode as given below. The classification is based on an electrode size of 4,0 mm, with the exception of the symbol for welding position, which is based on ISO 15792-3. Where the defined diameter has not been manufactured, the closest diameter to 4,0 mm shall be used for all-weld metal tests.

4A Classification by yield strength and 47 J impact energy

The classification is divided into eight 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 all-weld metal (see Table 1A);
3) the third part gives a symbol indicating the impact properties of all-weld metal (see Table 2A);
4) the fourth part gives a symbol indicating the chemical composition of 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 the electrode efficiency and type of current (see Table 5A);
7) the seventh part gives a symbol indicating the welding position (see Table 6A);
8) the eighth part gives a symbol indicating the diffusible hydrogen content of the deposited metal (see Table 7).

4B 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 tensile strength of 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 all-weld metal (see Table 3B);
5) the fifth part gives a symbol indicating the condition of 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 order to promote the use of this document, the classification is split into two sections:

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 the electrode efficiency, 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 5.7A, 5.8A and 5.9.

In order to promote the use of this document, the classification is split into two sections:

a) Compulsory section

This section includes the symbols for the type of product, the strength, the type of covering, the type of current, 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 diffusible hydrogen content, i.e., the symbol defined in 5.9.

The designation (see Clause 12), compulsory section and any chosen elements of the optional section, shall be used on packages and in the manufacturer's literature and data sheets. Figure A.1 gives a schematic representation of the full designation of electrodes classified by yield strength and 47 J impact energy (system A). Figure A.2 gives a schematic representation of the full 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 welding process shall be the letter E placed at the beginning of the designation.

5.2 Symbols for strength and elongation 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, 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 or in the post-weld heat-treated condition, determined in accordance with Clause 6. The yield strength and elongation requirements depend on the specific chemical composition, heat treatment condition and coating type, as well as on the tensile strength requirements, as given for the complete classification in Table 8B.

Table 1A — Symbol for strength and elongation 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] %
35	355	440 to 570	22
38	380	470 to 600	20
42	420	500 to 640	20
46	460	530 to 680	20
50	500	560 to 720	18

[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 specimen diameter.

Table 1B — Symbol for strength of all-weld metal

(Classification by tensile strength and 27 J impact energy)

Symbol	Minimum tensile strength MPa
43	430
49	490
55	550
57	570

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 specimens shall be tested. Only one individual value may be lower than 47 J but not lower than 32 J. When an all-weld metal has been classified for a certain temperature, it automatically covers any higher temperature in Table 2A.

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 of 47 J °C
Z	No requirement
A	+20
0	0
2	−20
3	−30
4	−40
5	−50
6	−60

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 requirement of 5.3A.

5.4 Symbol for the 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 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 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 coating type. The complete classification, given in Table 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 % (by mass)[a,b,c]		
	Mn	Mo	Ni
No symbol	2,0	—	—
Mo	1,4	0,3 to 0,6	—
MnMo	1,4 to 2,0	0,3 to 0,6	—
1Ni	1,4	—	0,6 to 1,2
Mn1Ni	1,4 to 2,0	—	0,6 to 1,2
2Ni	1,4	—	1,8 to 2,6
Mn2Ni	1,4 to 2,0	—	1,2 to 2,6
3Ni	1,4	—	2,6 to 3,8
1NiMo	1,4	0,3 to 0,6	0,6 to 1,2
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.

[b] Single values shown in the table mean maximum values.

[c] Consumables for which the chemical composition is not listed in the table shall 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 3B — Symbol for chemical composition of all-weld metal
(Classification by tensile strength and 27 J impact energy)

Alloy symbol	Chemical composition	
	Principal alloy element(s)	Nominal level % (by mass)
No symbol, –1, –P1 or –P2	Mn	1,3
–1M3	Mo	0,5
–3M2	Mn Mo	1,5 0,4
–3M3	Mn Mo	1,5 0,5
–N1	Ni	0,5
–N2	Ni	1,0
–N3	Ni	1,5
–3N3	Mn Ni	1,5 1,5
–N5	Ni	2,5
–N7	Ni	3,5
–N13	Ni	6,5
–N2M3	Ni Mo	1,0 0,5
–NC	Ni Cu	0,5 0,4
–CC	Cr Cu	0,5 0,4
–NCC	Ni Cr Cu	0,2 0,6 0,5
–NCC1	Ni Cr Cu	0,6 0,6 0,5
–NCC2	Ni Cr Cu	0,3 0,2 0,5
–G[a]	Any other agreed composition	

[a] The chemical composition ranges are not specified and therefore two electrodes with the same G-classification may not be interchangeable.

5.5 Symbol for type of electrode covering

5.5A Classification by yield strength and 47 J impact energy

The type of covering of a covered electrode depends substantially on the types of slag-forming components. The symbols indicating the covering type shall be in accordance with Table 4A.

5.5B Classification by tensile strength and 27 J impact energy

The type of covering of a covered electrode depends substantially on the types of slag-forming components. The type of covering also determines the positions suitable for welding and the type of current, in accordance with Table 4B.