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Welding consumables — Tubular cored electrodes for gas-shielded and non-gas-shielded metal arc welding of high strength steels — Classification

Produits consommables pour le soudage — Fils-électrodes fourrés pour le soudage à l'arc avec ou sans gaz de protection 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 on 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 the following URL: 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*.

This second edition cancels and replaces the first edition (ISO 18276:2005), which has been technically revised with the following changes:

— content has been aligned with ISO 17632:2015 and ISO 17634:2015;

— shielding gas designations have been updated;

— Table 3B has been extensively revised to align with existing Pacific Rim designations;

— new designations have been added to Table 3B;

— the T4 designator has been deleted from Table 4B;

— heat input ranges given in Table 8B have been modified to match current Pacific Rim values;

— fillet weld tests have been removed;

— an example using the Z designation has been added to Clause 11A.

Requests for official interpretations of 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.

Introduction

This document proposes a classification system for tubular cored electrodes in terms of the tensile properties, impact properties, chemical composition of the all-weld metal, type of electrode core, shielding gas and welding position. The ratio of yield strength to tensile strength of the weld metal is generally higher than that of the parent metal. Note that matching weld metal yield strength to parent metal yield strength will not necessarily ensure that the weld metal tensile strength matches that of the parent metal. Where the application requires matching tensile strength, therefore, selection of the consumable should be made by reference to column 3 of Table 1A or Table 1B.

Note that the mechanical properties of all-weld metal test specimens used to classify tubular cored electrodes will differ from those obtained with production joints because of differences in welding procedure such as electrode size, width of weave, welding position and parent metal composition.

The classification in accordance with system A is mainly based on EN 12535[1]. The classification in accordance with system B is mainly based upon standards used around the Pacific Rim.

Welding consumables — Tubular cored electrodes for gas-shielded and non-gas-shielded metal arc welding of high strength steels — Classification

1 Scope

This document specifies the requirements for classification of tubular cored electrodes with or without a gas shield for metal arc welding of high-strength steels in the as-welded condition or in the post-weld heat-treated condition with a minimum yield strength higher than 550 MPa or a minimum tensile strength higher than 590 MPa. One tubular cored electrode can be tested and classified with different shielding gases, if used with more than one.

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

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

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

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

It is recognized that the operating characteristics of tubular cored electrodes can be modified by the use of pulsed current but, for the purposes of this document, pulsed current is not used for determining the electrode classification.

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 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 6947:2011, *Welding and allied processes — Welding positions*

ISO 13916, *Welding — Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature*

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.* Amended by ISO 15792-1:2000/Amd 1:2011

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:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Classification

Classification designations are based upon 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 under both systems. Then, either or both classification designations can be used for the product.

The classification includes all-weld metal properties obtained with a tubular cored electrode and appropriate shielding gas combination as given below. With the exception of the symbol for welding position, the classification of gas-shielded tubular cored electrodes is based on an electrode size of 1,2 mm or, if this size is not manufactured, the next larger diameter manufactured and the classification of self-shielded tubular cored electrodes is based on a diameter of 2,4 mm or the largest diameter manufactured if less than 2,4 mm.

4.1A Classification by yield strength and 47 J impact energy

The classification designation is divided into nine parts:

1) the first part (T) indicates a tubular cored electrode;

2) the second part gives a symbol indicating the strength and elongation of the all-weld metal in the as-welded or post-weld heat-treated condition (see Table 1A);

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

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 core (see Table 4A);

4.1B Classification by tensile strength and 27 J impact energy

The classification designation is divided into nine parts:

1) the first part (T) indicates a tubular cored electrode;

2) the second part gives a symbol indicating the strength and elongation of the all-weld metal in either the as-welded or the post-weld heat-treated condition (see Table 1B);

3) the third part gives a symbol indicating the impact properties of the all-weld metal (see Table 2). The symbol "U", added as an optional supplemental designator at or near the end of the complete tubular cored electrode designation, indicates that the deposit meets an average optional requirement of 47 J at the designated Charpy test temperature;

4) the fourth part gives a symbol indicating the usability characteristics of the electrode (see Table 4B);

5) the fifth part gives a symbol indicating the welding position (see Table 5B);

6) the sixth part gives a symbol indicating the shielding gas (see 5.6);

7) the seventh part gives a symbol indicating the welding position (see Table 5A);

8) the eighth part gives a symbol indicating the hydrogen content of the deposited metal (see Table 6);

9) the ninth part gives a symbol indicating the post-weld heat treatment if this is applied (see 5.9A).

6) the sixth part gives a symbol indicating the shielding gas (see 5.6);

7) the seventh part gives a symbol indicating whether the classification tests were conducted in the as-welded condition (A) or the post-weld heat-treated condition (P);

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

9) the ninth part gives a symbol indicating the hydrogen content of the deposited metal (see Table 6).

Electrodes may be classified under any number of classifications for either or both the as-welded and post-weld heat-treated condition.

In both systems, the electrode classification shall include all the compulsory section and may include the optional section, as outlined below.

4.2A Compulsory and optional sections in the 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, the type of electrode core, the shielding gas and the post-weld heat treatment, i.e. the symbols defined in 5.1, 5.2, 5.3A, 5.4, 5.5A, 5.6 and 5.9A.

b) Optional section

This section includes the symbols for the welding positions for which the electrode is suitable and the symbol for hydrogen content, i.e. the symbols defined in 5.7 and 5.8.

4.2B Compulsory and optional sections in the classification by tensile strength and 27 J impact energy

a) Compulsory section

This section includes the symbols for the type of product, the strength and elongation in the as-welded condition or post-weld heat-treated condition, the welding positions for which the electrode is suitable, the usability characteristics, the shielding gas, the impact properties and the chemical composition, i.e. the symbols defined in 5.1, 5.2, 5.3B, 5.4, 5.5B, 5.6, 5.7 and 5.9B.

b) Optional section

This section includes the symbol "U" to indicate that the weld metal will have an average of 47 J impact energy at the classification test temperature and the symbol for hydrogen content, i.e. the symbol "U" defined in 5.3B and the symbols defined in 5.8.

The designation, compulsory section and any chosen elements of the optional section, shall be used on packages and in the manufacturer's literature and data sheets.

5 Symbols and requirements

5.1 Symbol for the product/process

The symbol for the tubular cored electrodes used in the metal arc welding process is the letter T.

5.2 Symbol for tensile properties of all-weld metal

The symbol in Table 1A or Table 1B indicates the yield strength, tensile strength and elongation of the all-weld metal, determined in accordance with Clause 6.

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	640 to 820	18
62	620	700 to 890	18
69	690	770 to 940	17
79	790	880 to 1 080	16
89	890	940 to 1 180	15

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

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

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

Symbol	Minimum yield strength[a] MPa	Tensile strength MPa	Minimum elongation[b] %
59	490	590 to 790	16
62	530	620 to 820	15
69	600	690 to 890	14
76	680	760 to 960	13
78	680	780 to 980	13
83	745	830 to 1 030	12

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

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

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 2 indicate the temperature at which an 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 not lower than 32 J.

5.3B Classification by tensile strength and 27 J impact energy

The symbols in Table 2 indicate the temperature at which 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.

When an all-weld metal has been classified for a certain temperature, it automatically covers any higher temperature in Table 2.

Table 2 — Symbol for impact properties of all-weld metal

Symbol	Temperature for minimum average impact energy of 47 J [a] or 27 J [b] °C
Z	No requirements
A [a] or Y [b]	+ 20
0	0
2	− 20
3	− 30
4	− 40
5	− 50
6	− 60
7	− 70
8	− 80
[a] Classification by yield strength and 47 J impact energy (see 5.3A).	
[b] Classification by tensile strength and 27 J impact energy (see 5.3B).	

5.4 Symbol for chemical composition of all-weld metal

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

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

Symbol	Chemical composition, % (by mass) [a, b]								
	C	Mn	Si	P	S	Ni	Cr	Mo	V
MnMo	0,03 to 0,10	1,4 to 2,0	0,90	0,020	0,020	0,3	0,2	0,3 to 0,6	0,05
Mn1Ni	0,03 to 0,10	1,4 to 2,0	0,90	0,020	0,020	0,6 to1,2	0,2	0,2	0,05
Mn1,5Ni	0,03 to 0,10	1,1 to 1,8	0,90	0,020	0,020	1,3 to 1,8	0,2	0,2	0,05
Mn2,5Ni	0,03 to 0,10	1,1 to 2,0	0,90	0,020	0,020	2,1 to 3,0	0,2	0,2	0,05
1NiMo	0,03 to 0,10	1,4	0,90	0,020	0,020	0,6 to 1,2	0,2	0,3 to 0,6	0,05
1,5NiMo	0,03 to 0,10	1,4	0,90	0,020	0,020	1,2 to 1,8	0,2	0,3 to 0,7	0,05
2NiMo	0,03 to 0,10	1,4	0,90	0,020	0,020	1,8 to 2,6	0,2	0,3 to 0,7	0,05
Mn1NiMo	0,03 to 0,10	1,4 to 2,0	0,90	0,020	0,020	0,6 to 1,2	0,2	0,3 to 0,7	0,05
Mn2NiMo	0,03 to 0,10	1,4 to 2,0	0,90	0,020	0,020	1,8 to 2,6	0,2	0,3 to 0,7	0,05
Mn2NiCrMo	0,03 to 0,10	1,4 to 2,0	0,90	0,020	0,020	1,8 to 2,6	0,3 to 0,6	0,3 to 0,6	0,05
Mn2Ni1CrMo	0,03 to 0,10	1,4 to 2,0	0,90	0,020	0,020	1,8 to 2,6	0,6 to 1,0	0,3 to 0,6	0,05
Z[c]	Any other agreed composition								

[a] Single values shown in this table are maximum values.

[b] Cu ≤ 0,3, Nb ≤ 0,05.

[c] Consumables for which the chemical composition is not listed in this table shall be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and therefore, it is possible that two electrodes with the same Z classification are not interchangeable.