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

Produits consommables pour le soudage — Electrodes enrobées pour le soudage manuel à l'arc des aciers à haute résistance — Classification

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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.

ISO 18275 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

Introduction

This International Standard was prepared by Technical Committee ISO/TC 44/SC 3 through the International Institute of Welding, Commission II. It 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 International Standard. The classification in accordance with system A is mainly based on EN 757. The classification in accordance with system B is mainly based upon standards used around the Pacific Rim.

This International Standard proposes a classification system for covered electrodes for high-tensile 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 the weld metal is generally higher than that of the parent metal. Users should 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 8B.

It should be noted that the mechanical properties of all-weld metal test specimens used to classify covered electrodes will 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.

Requests for official interpretations of any aspect of this International Standard 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.

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

1 Scope

This International Standard 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 International Standard is a combined specification providing a 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.

1) Subclauses and tables which carry the suffix letter "A" are applicable only to covered 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 International Standard.

2) Subclauses and tables which carry the suffix letter "B" are applicable only to covered 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 International Standard.

3) 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 International Standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 31-0:1992, *Quantities and units — Part 0: General principles*

ISO 544, *Welding consumables — Technical delivery conditions for welding filler materials — Type of product, dimensions, tolerances and markings*

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

ISO 2560:2002, *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 ferritic steel arc weld metal*

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

ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation*

ISO 14344, *Welding and allied processes — Flux and gas shielded electrical welding processes — Procurement guidelines for consumables*

ISO 15792-1:2000, *Welding consumables — Test methods — Part 1: Test methods for all-weld metal test specimens in steel, nickel and nickel alloys*

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

3 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 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, with the exception of the symbol for welding position which is based on ISO 15792-3.

3.1A 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 4.5A);

6) the sixth part gives a symbol indicating post-weld heat treatment if this is applied (see 4.6A);

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 hydrogen content of the deposited metal (see Table 7).

3.1B 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 4.6B);

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 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 below.

3.2A 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 and the type of covering, i.e. the symbols defined in 4.1, 4.2A, 4.3A, 4.4A and 4.5A.

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 hydrogen content, i.e. the symbols defined in 4.6A, 4.7A, 4.8A and 4.9.

3.2B 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, 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 4.1, 4.2B, 4.4B, 4.5B and 4.6B.

b) Optional section

This section includes the symbol for the optional supplemental designator for 47 J impact energy, i.e. the symbol defined in 4.3B, and the symbol for the hydrogen content, i.e. the symbol defined in 4.9.

The full designation (see Clause 10) shall be used on packages and in the manufacturer's literature and data sheets. See Figure A.1 in Annex A for a schematic representation of the full designation of electrodes classified by yield strength and 47 J impact energy, system A. See Figure A.2 for a schematic representation of the full designation of electrodes classified by tensile strength and 27 J impact energy, system B.

4 Symbols and requirements

4.1 Symbol for the product/process

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

4.2 Symbol for tensile properties of all-weld metal

4.2A 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 4.6, determined in accordance with Clause 5.

4.2B 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 5. The yield strength and elongation requirements depend upon the specific chemical composition, heat treatment condition and coating type, as well as upon the tensile strength requirements, as given for the complete classification in Table 8B.

NOTE Stress relief heat treatment can alter the strength of the weld metal from that 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 (R_{eL}) is used when yielding occurs, otherwise the 0,2 % proof strength ($R_{p0,2}$) is 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

4.3 Symbol for impact properties of all-weld metal

4.3A 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 5. 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.

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
7	– 70
8	– 80

4.3B 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 5. 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 these 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, three specimens shall be tested. The impact value shall be determined as the average of the three test specimens. The average of the three values shall be 47 J or greater.

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

4.4 Symbol for chemical composition of all-weld metal

4.4A 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 6.

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	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.

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

4.4B 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 6. The symbol for chemical composition does not immediately follow the symbol for strength, but follows the symbol for coating type. The complete compulsory classification designation, given in 4.10B, determines the exact chemical composition requirements for a particular electrode classification.

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)
-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

Table 3B — *(continued)*

Alloy symbol	Chemical composition	
	Principal alloy element(s)	Nominal level (% by mass)
-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
-N5CM3	Ni	2,5
	Cr	0,3
	Mo	0,5
-N7CM3	Ni	3,5
	Cr	0,3
	Mo	0,5
-G	Any other agreed composition	

4.5 Symbol for type of electrode covering

4.5A Classification by yield strength and 47 J impact energy

The type of covering of these electrodes is basic and the symbol is B.

For cellulosic and other electrode coverings, see ISO 2560:2002, 4.5A.

NOTE A description of the characteristics of each of the types of covering is given in Annex B.

4.5B 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 component. The type of covering also determines the positions suitable for welding and the type of current, in accordance with Table 4B.

Table 4B — Symbol for type of covering
(Classification by tensile strength and 27 J impact energy)

Symbol	Type of covering	Welding positions [a]	Type of current [b]
10	Cellulosic	All	d.c. (+)
11	Cellulosic	All	a.c. and d.c. (+)
13	Rutile	All[c]	a.c. and d.c. (±)
15	Basic	All[c]	d.c. (+)
16	Basic	All[c]	a.c. and d.c. (+)
18	Basic + iron powder	All[c]	a.c. and d.c. (+)

NOTE A description of the characteristics of each of the types of covering is given in Annex C.

[a] Positions are defined in ISO 6947.

[b] a.c. = alternating current; d.c. = direct current.

[c] The indication “all positions” may or may not include vertical down welding. This shall be specified in the manufacturer's trade literature.

4.6 Symbol for condition of post-weld heat treatment of all-weld metal

4.6A Classification by yield strength and 47 J impact energy

The letter T indicates that strength, elongation and impact properties in the classification of the deposited metal are obtained after a post-weld heat treatment between 560 °C and 600 °C for 1 h. The test piece shall be left in the furnace to cool down to 300 °C.

4.6B Classification by tensile strength and 27 J impact energy

If the electrode has been classified in the as-welded condition, the symbol A shall be added to the classification. If the electrode has been classified in the post-weld heat-treated condition, the temperature of the post-weld heat treatment shall be 620 °C ± 15 °C, or 580 °C ± 15 °C in the case of chemical composition N13L, and the symbol P shall be added to the classification. If the electrode has been classified in both conditions, the symbol AP shall be added to the classification. See Table 9B for the use of A and P in specific classifications.

4.7 Symbol for nominal electrode efficiency and type of current

4.7A Classification by yield strength and 47 J impact energy

The symbols in Table 5A indicate the nominal electrode efficiency, determined in accordance with ISO 2401 with the type of current shown in Table 5A.

4.7B Classification by tensile strength and 27 J impact energy

There is no specific symbol for nominal electrode efficiency and type of current. Type of current is included in the symbol for type of covering (Table 4B). Nominal electrode efficiency is not addressed.

Table 5A — Symbol for nominal electrode efficiency and type of current
(Classification by yield strength and 47 J impact energy)

Symbol	Nominal electrode efficiency %	Type of current [a]
1	⩽ 105	a.c. + d.c.
2	⩽ 105	d.c.
3	> 105 ⩽ 125	a.c. + d.c.
4	> 105 ⩽ 125	d.c.
5	> 125 ⩽ 160	a.c. + d.c.
6	> 125 ⩽ 160	d.c.
7	> 160	a.c. + d.c.
8	> 160	d.c.

[a] In order to demonstrate operability on a.c., tests shall be carried out with a no-load voltage not higher than 65 V.

4.8 Symbol for welding position

4.8A Classification by yield strength and 47 J impact energy

The symbols in Table 6A for welding positions indicate the positions for which the electrode is tested in accordance with ISO 15792-3. Welding positions are defined in ISO 6947.

4.8B Classification by tensile strength and 27 J impact energy

There is no specific symbol for welding position. The welding position requirements are included with the symbol for type of covering (Table 4B).

Table 6A — Symbol for welding position
(Classification by yield strength and 47 J impact energy)

Symbol	Welding positions
1	PA, PB, PC, PD, PE, PF, PG
2	PA, PB, PC, PD, PE, PF
3	PA, PB
4	PA
5	PA, PB, PG

4.9 Symbol for hydrogen content of deposited metal

The symbols in Table 7 indicate the hydrogen content determined in the metal deposited from an electrode of size 4,0 mm in accordance with the method given in ISO 3690. The current used shall be 70 % to 90 % of the maximum value recommended by the manufacturer. Electrodes recommended for use with a.c. shall be tested using a.c. Electrodes recommended for d.c. only shall be tested using d.c. with the electrode positive [d.c.(+)].

The manufacturer shall provide information on the recommended type of current and drying conditions for achieving the hydrogen levels.

Table 7 — Symbol for hydrogen content of deposited metal

Symbol	Hydrogen content max. ml/100 g of deposited weld metal
H5	5
H10	10
H15	15

See Annex D for additional information about diffusible hydrogen.

4.10 Mechanical property and composition requirements

4.10A Classification by yield strength and 47 J impact energy

The mechanical property and chemical composition requirements are determined from the symbols with reference to Tables 1A, 2A and 3A. No additional information is required.

4.10B Classification by tensile strength and 27 J impact energy

The mechanical property and chemical composition requirements are only determined from the complete compulsory section of the electrode designation. Mechanical property requirements are specified in Table 8B. Chemical composition requirements are specified in Table 9B.

Table 8B — Mechanical test requirements
(Classification by tensile strength and 27 J impact energy)

Classification, compulsory section	Tensile strength [a] MPa	Yield strength [a, b] MPa	Elongation [a] A_5 %	Temperature of Charpy V-notch determination [a] °C
E5916-3 M2 A and/or P	590	490	16	– 20
E5916-N1M1 A and/or P	590	490	16	– 20
E5916-N5M1 A and/or P	590	490	16	– 60
E5918-N1M1 A and/or P	590	490	16	– 20
E6210-G A and/or P	620	530	15	N.S.
E6211-G A and/or P	620	530	15	N.S.
E6213-G A and/or P	620	530	12	N.S.
E6215-G A and/or P	620	530	15	N.S.
E6216-G A and/or P	620	530	15	N.S.
E6218-G A and/or P	620	530	15	N.S.
E6215-N13L P	620	530	15	– 115
E6215-3 M2 P	620	530	15	– 50
E6216-3 M2 A and/or P	620	530	15	– 20
E6216-N1M1 A and/or P	620	530	15	– 20
E6216-N2M1 A and/or P	620	530	15	– 20
E6216-N4M1 A and/or P	620	530	15	– 40
E6216-N5M1 A and/or P	620	530	15	– 60
E6218-3 M2 P	620	530	15	– 50
E6218-3 M3 P	620	530	15	– 50
E6218-N1M1 A and/or P	620	530	15	– 20
E6218-N2M1 A and/or P	620	530	15	– 20
E6218-N3M1 A	620	540 to 620[c]	21	– 50
E6910-G A and/or P	690	600	14	N.S.
E6911-G A and/or P	690	600	14	N.S.
E6913-G A and/or P	690	600	11	N.S.
E6915-G A and/or P	690	530	14	N.S.
E6916-G A and/or P	690	530	14	N.S.
E6918-G A and/or P	690	530	14	N.S.
E6915-4 M2 P	690	600	14	– 50
E6916-4 M2 P	690	600	14	– 50
E6916-N3CM1 A	690	600	14	– 20
E6916-N4M3 A and/or P	690	600	14	– 20
E6916-N7CM3 A	690	600	14	– 60
E6918-4 M2 P	690	600	14	– 50
E6918-N3M2 A	690	610 to 690[c]	18	– 50

Table 8B (*continued*)

Classification, compulsory section	Tensile strength [a] MPa	Yield strength [a,b] MPa	Elongation [a] in 5D %	Temperature of Charpy V-notch determination [a] °C
E7610-G A and/or P	760	670	13	N.S.
E7611-G A and/or P	760	670	13	N.S.
E7613-G A and/or P	760	670	11	N.S.
E7615-G A and/or P	760	670	13	N.S.
E7616-G A and/or P	760	670	13	N.S.
E7618-G A and/or P	760	670	13	N.S.
E7618-N4M2 A	760	680 to 760[c]	18	– 50
E7816-N4CM2 A	780	690	13	– 20
E7816-N4C2M1 A	780	690	13	– 40
E7816-N5M4 A	780	690	13	– 60
E7816-N5CM3 A and/or P	780	690	13	– 20
E7816-N9M3 A	780	690	13	– 80
E8310-G A and/or P	830	740	12	N.S.
E8311-G A and/or P	830	740	12	N.S.
E8313-G A and/or P	830	740	10	N.S.
E8315-G A and/or P	830	740	12	N.S.
E8316-G A and/or P	830	740	12	N.S.
E8318-G A and/or P	830	740	12	N.S.
E8318-N4C2M2 A	830	745 to 830[c]	16	– 50

[a] Single values are minimum requirements. N.S. = not specified.

[b] For yield strength, the lower yield limit is used when yielding occurs, otherwise the 0,2 % proof strength is used.

[c] For 2,4 mm electrodes, the upper limit may be 35 MPa greater.

Table 9B — Chemical composition requirements
(Classification by tensile strength and 27 J impact energy)

Classification, compulsory section	C [a] %	Si [a] %	Mn [a] %	P [a] %	S [a] %	Ni [a] %	Cr [a] %	Mo [a] %	Other [a] %
E5916-3 M2 A and/or P	0,12	0,60	1,00 to 1,75	0,03	0,03	0,90	N.S.	0,25 to 0,45	N.S.
E5916-N1M1 A and/or P	0,12	0,80	0,70 to 1,50	0,03	0,03	0,30 to 1,00	N.S.	0,10 to 0,40	N.S.
E5916-N5M1 A and/or P	0,12	0,80	0,60 to 1,20	0,03	0,03	2,00 to 2,75	N.S.	0,30	N.S.
E5918-N1M1 A and/or P	0,12	0,80	0,70 to 1,50	0,03	0,03	0,30 to 1,00	N.S.	0,10 to 0,40	N.S.
E6210-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6211-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6213-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6215-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6216-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6218-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6215-N13L P	0,05	0,50	0,40 to 1,00	0,03	0,03	6,00 to 7,25	N.S.	N.S.	N.S.
E6215-3 M2 P	0,12	0,60	1,00 to 1,75	0,03	0,03	0,90	N.S.	0,25 to 0,45	N.S.
E6216-3 M2 A and/or P	0,12	0,60	1,00 to 1,75	0,03	0,03	0,90	N.S.	0,20 to 0,50	N.S.
E6216-N1M1 A and/or P	0,12	0,80	0,70 to 1,50	0,03	0,03	0,30 to 1,00	N.S.	0,10 to 0,40	N.S.
E6216-N2M1 A and/or P	0,12	0,80	0,70 to 1,50	0,03	0,03	0,80 to 1,50	N.S.	0,10 to 0,40	N.S.
E6216-N4M1 A and/or P	0,12	0,80	0,75 to 1,35	0,03	0,03	1,30 to 2,30	N.S.	0,10 to 0,30	N.S.
E6216-N5M1 A and/or P	0,12	0,80	0,60 to 1,20	0,03	0,03	2,00 to 2,75	N.S.	0,30	N.S.
E6218-3 M2 P	0,12	0,80	1,00 to 1,75	0,03	0,03	0,90	N.S.	0,25 to 0,45	N.S.
E6218-3 M3 P	0,12	0,80	1,00 to 1,80	0,03	0,03	0,90	N.S.	0,40 to 0,65	N.S.
E6218-N1M1 A and/or P	0,12	0,80	0,70 to 1,50	0,03	0,03	0,30 to 1,00	N.S.	0,10 to 0,40	N.S.
E6218-N2M1 A and/or P	0,12	0,80	0,70 to 1,50	0,03	0,03	0,80 to 1,50	N.S.	0,10 to 0,40	N.S.
E6218-N3M1 A	0,10	0,80	0,60 to 1,25	0,030	0,030	1,40 to 1,80	0,15	0,35	V: 0,05
E6910-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6911-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6913-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6915-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6916-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]

Table 9B (*continued*)

Classification, compulsory section	C [a] %	Si [a] %	Mn [a] %	P [a] %	S [a] %	Ni [a] %	Cr [a] %	Mo [a] %	Other [a] %
E6918-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E6915-4 M2 P	0,15	0,60	1,65 to 2,00	0,03	0,03	0,90	N.S.	0,25 to 0,45	N.S.
E6916-4 M2 P	0,15	0,60	1,65 to 2,00	0,03	0,03	0,90	N.S.	0,25 to 0,45	N.S.
E6916-N3CM1 A	0,12	0,80	1,20 to 1,70	0,03	0,03	1,20 to 1,70	0,10 to 0,30	0,10 to 0,30	N.S.
E6916-N4M3 A and/or P	0,12	0,80	0,70 to 1,50	0,03	0,03	1,50 to 2,50	N.S	0,35 to 0,65	N.S.
E6916-N7CM3 A	0,12	0,80	0,80 to 1,40	0,03	0,03	3,00 to 3,80	0,10 to 0,40	0,30 to 0,60	N.S.
E6918-4 M2 P	0,15	0,80	1,65 to 2,00	0,03	0,03	0,90	N.S.	0,25 to 0,45	N.S.
E6918-N3M2 A	0,10	0,60	0,75 to 1,70	0,030	0,030	1,40 to 2,10	0,35	0,25 to 0,50	V: 0,05
E7610-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E7611-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E7613-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E7615-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E7616-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E7618-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E7618-N4M2 A	0,10	0,60	1,30 to 1,80	0,030	0,030	1,25 to 2,50	0,40	0,25 to 0,50	V: 0,05
E7816-N4CM2 A	0,12	0,80	1,20 to 1,80	0,03	0,03	1,50 to 2,10	0,10 to 0,40	0,25 to 0,55	N.S
E7816-N4C2M1 A	0,12	0,80	1,00 to 1,50	0,03	0,03	1,50 to 2,50	0,50 to 0,90	0,10 to 0,40	N.S.
E7816-N5M4 A	0,12	0,80	1,40 to 2,00	0,03	0,03	2,10 to 2,80	N.S	0,50 to 0,80	N.S
E7816-N5CM3 A	0,12	0,80	1,00 to 1,50	0,03	0,03	2,10 to 2,80	0,10 to 0,40	0,35 to 0,65	N.S
E7816-N9M3 A	0,12	0,80	1,00 to 1,80	0,03	0,03	4,20 to 5,00	N.S.	0,35 to 0,65	N.S
E8310-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E8311-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E8313-G and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E8315-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E8316-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E8318-G A and/or P	N.S.	0,80 [b]	1,00 [b]	N.S.	N.S.	0,50 [b]	0,30 [b]	0,20 [b]	V: 0,10 [b] Cu: 0,20 [b]
E8318-N4C2M2 A	0,10	0,60	1,30 to 2,25	0,030	0,030	1,75 to 2,50	0,30 to 1,50	0,30 to 0,55	V: 0,05

[a] Single values are maximum requirements except where otherwise noted. N.S. = not specified.

[b] In order to meet the alloy requirements of the "G" composition, the all-weld metal shall have the minimum level of at least one of the elements listed. Additional chemical requirements may be agreed to between supplier and purchaser.

4.11 Rounding procedure

For the purposes of determining compliance with the requirements of this International Standard, the actual test values obtained shall be rounded using ISO 31-0:1992, Annex B, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this International Standard, the measured values shall be converted to the units of this International Standard before rounding. If an average value is to be compared to the requirements of this International Standard, rounding shall be done only after calculating the average. In the case where the test method standard cited in the normative references of this International Standard contains instructions for rounding that conflict with the instructions of this International Standard, the rounding requirements of the test method standard shall apply. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

5 Mechanical tests

5.1 General

Tensile and impact tests shall be carried out on weld metal in the as-welded condition and/or in the post-weld heat-treated condition, using a type 1.3 all-weld metal test assembly in accordance with ISO 15792-1:2000 using 4,0 mm electrodes and welding conditions as described below in 5.2 and 5.3.

5.2 Preheating and interpass temperatures

5.2A Classification by yield strength and 47 J impact energy

Welding of the all-weld metal test assembly shall be executed in the temperature range from 120 °C to 175 °C with the exception of the first layer which may be welded without preheat.

5.2B Classification by tensile strength and 27 J impact energy

Welding of the all-weld metal test assembly for non-low-hydrogen coatings (coating types 10, 11 and 13) shall be executed in the temperature range from 160 °C to 190 °C. Welding of electrodes with basic coatings (coating types 15, 16 and 18) shall be executed in the temperature range from 90 °C to 130 °C.

5.3 Pass sequence

The direction of welding to complete a pass shall not vary. Each pass shall be executed with a welding current of 70 % to 90 % of the maximum current recommended by the manufacturer. Regardless of the type of covering, welding shall be performed with a.c. when both a.c. and d.c. are recommended and with d.c. using the recommended polarity when only d.c. is required.

5.3A Classification by yield strength and 47 J impact energy

The test assembly shall be completed using 6 to 10 layers of weld metal. All layers except the top two shall consist of two passes. The top two layers may be completed with either two or three passes each.

5.3B Classification by tensile strength and 27 J impact energy

The test assembly shall be completed using 7 to 9 layers of weld metal. All layers shall consist of two passes, except the top two layers may be completed with three passes per layer.

6 Chemical analysis

Chemical analysis may be performed on any suitable test piece, but in cases of dispute specimens in accordance with ISO 6847 shall be used. Any analytical technique may be used, but in cases of dispute reference shall be made to established published methods.

6A Classification by yield strength and 47 J impact energy

The results of the chemical analysis shall fulfil the requirements given in Table 3A above.

6B Classification by tensile strength and 27 J impact energy

The results of the chemical analysis shall fulfil the requirements given in Table 9B above for the classification under test.

7 Fillet weld test

The fillet weld test assembly shall be as shown in ISO 15792-3.

7A Classification by yield strength and 47 J impact energy

The plate material shall be selected from the range of materials for which the electrode is recommended by the manufacturer, or shall be unalloyed steel of 0,30 % C maximum. The surface shall be free of scale, rust and other contaminants. The plate thickness (t) shall be 10 mm to 12 mm, the width (w) shall be 75 mm minimum and the length (l) shall be 300 mm minimum. The electrode sizes to be tested for each coating type, the test positions and the required test results are given in Table 10A.

7B Classification by tensile strength and 27 J impact energy

The plate material shall be unalloyed steel of 0,30 % C maximum. The surfaces to be welded shall be clean. The test plate thickness (t), width (w) and length (l), the test positions for each coating type and the required test results are given in Table 10B.

Table 10A — Test requirements for fillet welds
(Classification by yield strength and 47 J impact energy)

Symbol of position for classification	Coating type	Test position	Electrode size [a] mm	Theoretical throat thickness mm	Leg length difference mm	Maximum convexity mm
1 or 2	C RX [b] B	PB	6,0	4,5 min. 5,0 min. 5,0 min.	1,5 max. 2,0 max. 2,0 max.	2,5 3,0 3,0
3	A RR	PB	6,0	5,0 min.	2,0 max.	3,0
5	R B	PB	6,0 5,0	4,5 min.	1,5 max.	2,5
1 or 2	C RX [b] B	PF	4,0	4,5 max. 4,5 max. 5,5 max.	—	2,0
1, 2 or 5	C RX [b] B	PB	4,0	4,5 max. 4,5 max. 5,5 max.	1,5 max. 1,5 max. 2,0 max.	2,5 2,5 3,0
5	B	PG	4,0	5,0 min.	—	1,5 [c]

[a] Where the largest size claimed for positional welding is smaller than that specified, use the largest size and adjust criteria *pro rata*. Otherwise, electrode sizes not shown are not required to be tested.

[b] RX includes R, RC, RA and RB.

[c] Maximum concavity.

Table 10B — Test requirements for fillet welds
(Classification by tensile strength and 27 J impact energy)

Coating type	Current and polarity	Electrode size [a] mm	Test position	Nominal plate thickness t mm	Minimum plate width w mm	Minimum plate length l mm	Fillet weld size mm	Maximum leg length difference mm	Maximum convexity mm
10	d.c. (+)	5,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 6,5 min.	3,5 2,5	1,5 2,0
11	a.c. and d.c. (+)	5,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 6,5 min.	3,5 2,5	1,5 2,0
13	a.c., d.c. (–) and d.c. (+)	5,0 6,0	PF, PD PB	12 12	75	300 400	10,0 max. 8,0 min.	2,0 3,5	1,5 2,0
15	d.c. (+)	4,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 8,0 min.	3,5 3,5	2,0 2,0
16	a.c. and d.c. (+)	4,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 8,0 min.	3,5 3,5	2,0 2,0
18	a.c. and d.c. (+)	4,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 8,0 min.	3,5 3,5	2,0 2,0

[a] Where the largest size claimed for positional welding is smaller than that specified, use the largest size and adjust criteria *pro rata*. Otherwise, electrode sizes not shown are not required to be tested.

8 Retests

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retest need be only for those specific elements that failed to meet their test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that, during preparation or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test assembly or test specimen(s), or in conducting the test, the test shall be considered invalid, without regard to whether the test was actually completed, or whether the test results met, or failed to meet, the requirement. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9 Technical delivery conditions

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

10 Examples of designation

10A Classification by yield strength and 47 J impact energy

The designation of the covered electrode is indicated by the suffix letter A given after the number of this International Standard and shall follow the principle given in the examples below:

EXAMPLE 1A

A basic covered electrode for manual metal arc welding deposits a weld metal with a minimum yield strength of 620 MPa (62), a minimum average impact energy of 47 J at – 70 °C (7) and a chemical composition of 1,8 % Mn and 0,6 % Ni (Mn1Ni). The electrode with basic covering (B) can be used with a.c. or d.c. with a metal recovery of 120 % (3) in flat butt and flat fillet welds (4). The hydrogen content, determined in accordance with ISO 3690, does not exceed 5 ml/100 g of deposited metal (H5).

The designation will be:

ISO 18275-A - E 62 7 Mn1Ni B 3 4 H5

Compulsory section:

ISO 18275-A - E 62 7 Mn1Ni B

or, if tested after post-weld heat treatment:

ISO 18275-A - E 62 7 Mn1Ni B T

where

ISO 18275-A = International Standard number, with classification by yield strength and 47 J impact energy;

E = covered electrode/manual metal arc welding (see 4.1);

62 = strength and elongation (see Table 1A);

7 = impact properties (see Table 2A);

Mn1Ni = chemical composition of all-weld metal (see Table 3A) (see Annex E for a description of the symbols for chemical composition);

B = type of electrode covering (see 4.5A);

3 = recovery and type of current (see Table 5A);

4 = welding position (see 4.8A);

H5 = hydrogen content (see Table 7).

10B Classification by tensile strength and 27 J impact energy

The designation of the covered electrode is indicated by the suffix letter B given after the number of this International Standard and shall follow the principle given in the examples below:

EXAMPLE 1B

A covered electrode for manual metal arc welding deposits a weld metal with a minimum tensile strength of 690 MPa (69). The electrode with basic covering including iron powder may be used with a.c. and d.c. (+) in all positions except vertical down (18). The all-weld metal chemical composition is 1,5 % Ni and 0,35 % Mo (N3M2) and the impact energy of the deposited weld metal exceeds 27 J at – 50 °C in the as-welded condition (A). The hydrogen content, determined in accordance with ISO 3690, does not exceed 5 ml/100 g of deposited metal (H5).

The designation will be:

ISO 18275-B - E6918-N3M2 A H5

Compulsory section:

ISO 18275-B - E6918-N3M2 A

where

ISO 18275-B = International Standard number, with classification by tensile strength and 27 J impact energy;

E = covered electrode/manual metal arc welding (see 4.1);

69 = tensile strength (see Table 1B);

18 = basic iron powder coating suitable for a.c. and d.c. (+), in all positions (see Table 4B);

N3M2 = nominal composition comprising 1,5 % Ni and 0,35 % Mo (see Table 3B) (see Annex F for a description of the symbols for chemical composition);

A = properties determined in the as-welded condition;

E6918-N3M2 A = complete specification of composition limits and mechanical property requirements (see Tables 8B and 9B);

H5 = hydrogen content (see Table 7).

EXAMPLE 2A

Another basic covered electrode for manual metal arc welding deposits a weld metal with a minimum yield strength of 890 MPa (89), a minimum average impact energy of 47 J at – 50 °C (5) and a chemical composition outside the limits given in Table 3A (Z). The electrode with basic covering (B) may be used with a.c. or d.c. with a metal recovery of 120 % (3) in flat butt and flat fillet welds (4). The hydrogen, determined in accordance with ISO 3690, does not exceed 5 ml/100 g of deposited metal (H5).

The designation will be:

ISO 18275-A - E 89 5 Z B 3 4 H5

Compulsory section:

ISO 18275-A - E 89 5 Z B

or after post-weld heat treatment:

ISO 18275-A - E 89 5 Z B T

EXAMPLE 2B

Another basic covered electrode for manual metal arc welding deposits a weld metal with a minimum tensile strength of 830 MPa (83). The electrode with basic covering including iron powder may be used with a.c. and d.c. (+) in all positions (18). The all-weld metal chemical composition does not match any composition given in Table 3B or any composition range given in Table 9B (G). The hydrogen, determined in accordance with ISO 3690, does not exceed 5 ml/100 g of deposited metal (H5).

If tested in the as-welded condition, the designation will be:

ISO 18275-B - E8318-G A H5

Compulsory section:

ISO 18275-B - E8318-G A

or, if tested after post-weld heat treatment:

ISO 18275-B - E8318-G P

Annex A
(informative)

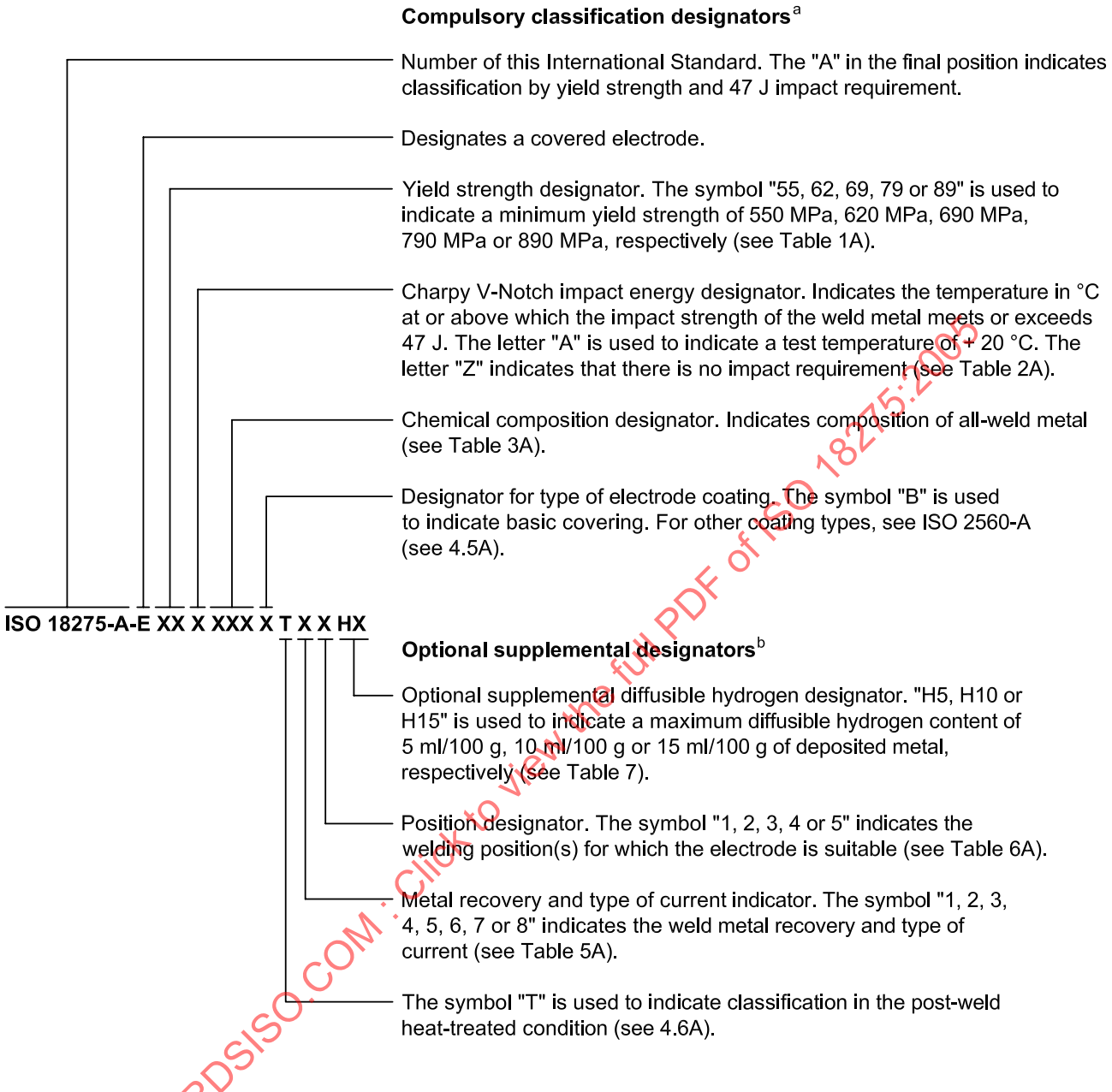
Classification systems

A.1 ISO 18275-A

The ISO 18275-A classification system for covered electrodes for high-tensile steels, based upon yield strength and 47 J minimum impact energy, is shown in Figure A.1.

A.2 ISO 18275-B

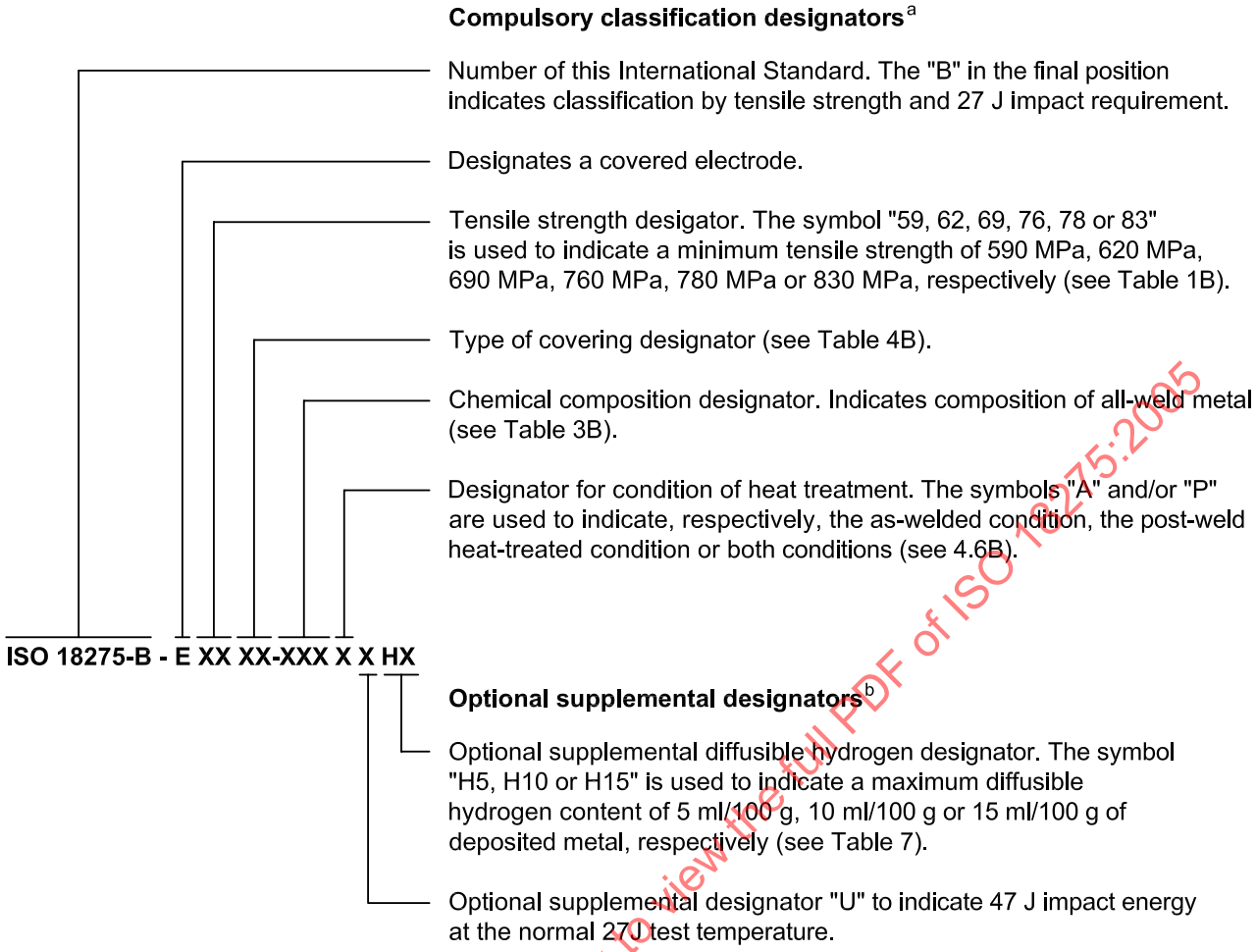
The ISO 18275-B classification system for covered electrodes for high-tensile steels, based upon tensile strength and 27 J minimum impact energy, is shown in Figure A.2.



[a] The combination of these designators constitutes the covered electrode classification.

[b] These designators are optional and do not constitute part of the covered electrode classification.

Figure A.1 — Designation of electrodes in accordance with ISO 18275-A
(classification by yield strength and 47 J impact energy)



[a] The combination of these designators constitutes the covered electrode classification.

[b] These designators are optional and do not constitute part of the covered electrode classification.

Figure A.2 — Designation of electrodes in accordance with ISO 18275-B
(classification by tensile strength and 27 J impact energy)

Annex B
(informative)

Description of electrode covering types — Classification by yield strength and 47 J impact energy

B.1 General

The properties of a covered electrode, i.e. both its welding characteristics and the mechanical properties of the weld metal, are decisively influenced by the covering. This homogeneous mixture of substances generally contains the following six main components:

— slag-forming materials;

— deoxidants;

— shielding-gas-forming materials;

— ionizing agents;

— binders and, if necessary;

— alloying elements.

In addition, iron powder may be added to increase the weld metal recovery, which may affect the positional welding properties.

B.2 Basic covered electrodes

A characteristic feature of the thick covering of these electrodes is the large quantity of carbonates of alkaline-earth metals, e.g. calcium carbonate (lime) and fluorspar. To improve the welding properties, particularly with a.c. welding, higher concentrations of non-basic components (e.g. rutile and/or quartz) may be required.

Basic covered electrodes have two outstanding properties: the impact energy of the weld metal is higher, particularly at low temperatures, and they are more resistant to cracking than all other types. Their resistance to solidification cracking results from the high metallurgical purity of the weld metal, whilst the low risk of cold cracking, provided dry electrodes are used, is attributable to the low hydrogen content. It is lower than with all other types: it should not exceed an upper permissible limit of H = 15 ml/100 g of deposited metal.

Generally, electrodes of the basic type are suitable for all welding positions, except the vertical downward position. Basic-type electrodes especially suited for the vertical downward position have a particular slag composition.

B.3 Other electrode covering types

Most covered electrodes for welding of high-tensile steels have basic coverings. However, other covering types are possible (see Annex B of ISO 2560:2002 for information about other covering types).