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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

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 18276 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

Introduction

This International Standard 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. 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 1B.

It should be noted 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 12535:2000, *Welding consumables — Tubular cored electrodes for gas shielded metal arc welding of high strength steels — Classification*. The classification in accordance with system B is mainly based upon standards used around the Pacific Rim.

Requests for official interpretation of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 3 via the user's national standardization body. A complete listing of these bodies can be found at <http://www.iso.org>.

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

1 Scope

This International Standard specifies 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.

1) 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 International Standard.

2) 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 International Standard.

3) 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 International Standard.

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 International Standard, pulsed current is not used for determining the electrode classification.

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 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 6947:1990, *Welds — Working positions — Definitions of angles of slope and rotation*

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

ISO 14175:1997, *Welding consumables — Shielding gases for arc welding and cutting*

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 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, which is based on ISO 15792-3, 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.

3.1A 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);

3.1B 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 type of electrode core (see Table 4A);

6) the sixth part gives a symbol indicating the shielding gas (see 4.6 and 4.6A);

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 4.9A).

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 4.6 and 4.6B);

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.

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, the type of electrode core, the shielding gas and the post-weld heat treatment, i.e. the symbols defined in 4.1, 4.2, 4.3A, 4.4, 4.5A, 4.6 and 4.9A.

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 4.7 and 4.8.

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 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 4.1, 4.2, 4.3B, 4.4, 4.5B, 4.6, 4.7 and 4.9B.

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 4.3B and the symbols defined in 4.8.

The full designation (see Clause 10) shall be used on packages and in the manufacturer’s literature and data sheets.

4 Symbols and requirements

4.1 Symbol for the product/process

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

4.2 Symbol for tensile properties of all-weld metal

The symbol in Table 1A or 1B indicates the yield strength, tensile strength and elongation of the all-weld metal, determined in accordance with Clause 5.

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.

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

4.3B Classification by tensile strength and 27 J impact energy

The symbols in Table 2 indicate 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 the three remaining values shall be at least 27 J. Three test specimens shall be tested when the optional symbol “U” is used to indicate that the weld deposit will meet a minimum impact energy of 47 J at the test temperature. The impact value shall be determined by the average of the three test specimens. The average of the three values shall be 47 J or greater.

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 4.3A).	
[b] Classification by tensile strength and 27 J impact energy (see 4.3B).	

4.4 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 6.

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
Z	Any other agreed composition								
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

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

[b] Cu $\leqslant$ 0,3, Nb $\leqslant$ 0,05

Table 3B — Symbol for chemical composition of all-weld metal (classification by tensile strength and 27 J impact energy)

Symbol	Chemical composition, % (by mass) [a, b, c]								
	C	Mn	Si	P	S	Ni	Cr	Mo	V
3M2	0,15	1,25 to 2,00	0,80	0,030	0,030	0,90	—	0,25 to 0,55	—
4M2	0,15	1,65 to 2,25	0,80	0,030	0,030	0,90	—	0,25 to 0,55	—
3M3	0,15	1,00 to 1,75	0,80	0,030	0,030	0,90	—	0,40 to 0,70	—
N2M1	0,15	2,25	0,80	0,030	0,030	0,40 to 1,50	0,20	0,35	0,05
N2M2	0,15	2,25	0,80	0,030	0,030	0,40 to 1,50	0,20	0,20 to 0,65	0,05
N3M1	0,15	2,25	0,80	0,030	0,030	1,00 to 2,00	0,20	0,35	0,05
N3M2	0,15	2,25	0,80	0,030	0,030	1,25 to 2,25	0,20	0,20 to 0,65	0,05
N4M1	0,12	2,25	0,80	0,030	0,030	1,75 to 2,75	0,20	0,35	0,05
N4M2	0,15	2,25	0,80	0,030	0,030	1,75 to 2,75	0,20	0,20 to 0,65	0,05
N4C1M2	0,15	2,25	0,80	0,030	0,030	1,75 to 2,75	0,20 to 0,60	0,20 to 0,65	0,05
N4C2M2	0,15	2,25	0,80	0,030	0,030	1,75 to 2,75	0,60 to 1,00	0,20 to 0,65	0,05
N6C1M4	0,12	2,25	0,80	0,030	0,030	2,50 to 3,50	1,00	0,40 to 1,00	0,05
N3C1M2	0,10 to 0,25	1,75	0,80	0,030	0,030	0,75 to 2,00	0,20 to 0,70	0,15 to 0,65	0,05
G		1,75 min. [d]	0,80 min. [d]	0,030	0,030	0,50 min. [d]	0,30 min. [d]	0,20 min. [d]	0,10 min. [d]

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

[b] The weld metal shall be analysed for the specific elements for which values are shown in this table. Other elements listed without specified values shall be reported, if intentionally added. The total of these latter unspecified elements and all other elements not intentionally added shall not exceed 0,50 %.

[c] Al $\leqslant$ 1,8 for self-shielded electrodes.

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

4.5 Symbol for type of electrode core or the usability characteristics of the electrodes

4.5A Classification by yield strength and 47 J impact energy

The symbols in Table 4A indicate the different types of tubular cored electrode relative to their core composition and slag characteristics. Manufacturers shall provide information on recommended polarity.

Table 4A — Symbol for type of electrode core (classification by yield strength and 47 J impact energy)

Symbol	Characteristics
R	Slow-freezing rutile slag
P	Fast-freezing rutile slag
B	Basic
M	Metal powder
Z	Other types
NOTE A description of the characteristics of each of the types of core is given in Annex C.	

4.5B Classification by tensile strength and 27 J impact energy

The symbols in Table 4B indicate the usability characteristics of the electrode.

Table 4B — Usability characteristics (classification by tensile strength and 27 J impact energy)

Usability designator	Shielding gas	Operating polarity	Transfer of droplet	Type of core	Welding position [a]	Characteristics
T1	Required	d.c.(+)	Spray type	Rutile	0 or 1	Low spatter loss, flat to slightly convex bead and high deposition rates
T4	Not required	d.c.(+)	Globular type	Basic	0	Very high deposition rates, excellent resistance to hot cracking and low penetration
T5	Required	d.c.(+)	Globular type	Lime-fluoride	0 or 1	Slightly convex bead, a thin slag without completely covering the weld bead, good impact properties and hot and cold crack resistance compared with “T1”
T7	Not required	d.c.(-)	Small droplet to spray type	Not specified	0 or 1	High deposition rates and excellent resistance to hot cracking
T8	Not required	d.c.(-)	Small droplet or spray type	Not specified	0 or 1	Very good low-temperature impact properties
T11	Not required	d.c.(-)	Spray type	Not specified	0 or 1	Not recommended on thicknesses greater than 19 mm without maintaining preheat and interpass temperature control
T15	Required	d.c.(+)	Very fine droplet spray type	Metal	0 or 1	Core consisting of metal alloys and iron powder, and minimal slag cover
TG [b]	As agreed between purchaser and supplier					
NOTE A description of the usability characteristics of the electrodes is given in Annex D.						
[a] See Table 5B.						
[b] For electrodes that are not covered by any currently defined usability designator.						

4.6 Symbol for shielding gas

The symbols M and C indicate shielding gases as described in ISO 14175:1997.

The symbol C shall be used when the classification has been performed with shielding gas ISO 14175-C1, carbon dioxide.

The symbol N shall be used for tubular cored electrodes without an external gas shield.

4.6A Classification by yield strength and 47 J impact energy

The symbol M, for mixed gases, shall be used when the classification has been performed with shielding gas ISO 14175-M2 but without helium.

4.6B Classification by tensile strength and 27 J impact energy

The symbol M, for mixed gases, shall be used when the classification has been performed with shielding gas ISO 14175-M21, but restricted to Ar + (20 to 25) % CO_2.

The symbol G shall be used to indicate that some other shielding gas was used by agreement between supplier and purchaser.

4.7 Symbol for welding position

The symbols in Table 5A or Table 5B indicate the positions for which the electrode is suitable for classification to ISO 18276-A or ISO 18276-B in accordance with ISO 15792-3. PA, PB, PC, PD, PE, PF and PG are the symbols specified in ISO 6947:1990. See Clause 7 for test requirements.

Table 5A — Symbol for welding position (classification by yield strength and 47 J impact energy)

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

[a] PA = Flat position
PB = Horizontal vertical position
PC = Horizontal position
PD = Horizontal overhead position
PE = Overhead position
PF = Vertical up position
PG = Vertical down position

Table 5B — Symbol for welding position (classification by tensile strength and 27 J impact energy)

Symbol	Welding positions [a]
0	PA and PB
1	PA, PB, PC, PD, PE, PF or PG, or both

[a] PA = Flat position
PB = Horizontal vertical position
PC = Horizontal position
PD = Horizontal overhead position
PE = Overhead position
PF = Vertical up position
PG = Vertical down position

4.8 Symbol for hydrogen content of deposited metal

The symbols in Table 6 indicate the hydrogen content determined in accordance with the method given in ISO 3690.

Table 6 — Symbol for hydrogen content of deposited metal

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

When the letter H is included in the classification, the manufacturer shall state in its literature whether the maximum hydrogen level achieved is 15 ml, 10 ml or 5 ml per 100 g of deposited metal, and what restrictions need to be placed on the conditions of storage and on current, arc voltage, electrode extension, polarity and shielding gas to remain within this limit.

Diffusible hydrogen shall be determined in accordance with ISO 3690.

4.9 Symbol for conditions of post-weld heat treatment

4.9A Classification by yield strength and 47 J impact energy

The letter T indicates that strength, elongation and impact properties in the classification of the all-weld metal fulfil the classification criteria after a post-weld heat treatment. The post-weld heat-treated conditions shall be as specified in 5.3A.

4.9B 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 conditions of the post-weld heat treatment shall be as specified in 5.3B, 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.

4.10 Rounding-off procedure

For the purposes of determining compliance with the requirements of this International Standard, the actual test values obtained shall be rounded off 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 off. If an average value is to be compared to the requirements of this International Standard, rounding off shall be done only after calculating the average. In the case where a test method standard cited in the normative references of this International Standard contains instructions for rounding off that conflict with the instructions in this International Standard, the rounding-off requirements of the test method standard shall apply. The rounded-off results shall fulfill the requirements of the appropriate table for the classification under test.

5 Mechanical tests

Tensile and impact tests shall be carried out on the weld metal in the as-welded condition 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 a 1,2 mm electrode in the case of gas-shielded electrodes or, if this size is not manufactured, the next larger diameter manufactured, and 2,4 mm in the case of self-shielded electrodes, or the largest size manufactured if less than 2,4 mm, and welding conditions and PWHT conditions as described below in 5.1A or 5.1B, 5.2, and 5.3A or 5.3B

5.1 Preheating and interpass temperatures

5.1A Classification by yield strength and 47 J impact energy

Welding of the all-weld metal test specimen shall be executed in a temperature range from 120 °C to 180 °C, with the exception of the first layer in the test assembly which may be welded without preheat. The interpass temperature shall be measured using temperature indicator crayons, surface thermometers or thermocouples (see ISO 13916).

The interpass temperature shall not exceed 180 °C. If, after any pass, this interpass temperature is exceeded, the test assembly shall be cooled in air to a temperature within the limits of the interpass temperature.

5.1B Classification by tensile strength and 27 J impact energy

Preheating and interpass temperatures shall be selected for the appropriate weld metal type from Table 7B. The preheating and interpass temperature shall be measured using temperature indicator crayons, surface thermometers or thermocouples (see ISO 13916).

The interpass temperature shall not exceed the maximum temperature indicated in Table 7B. If, after any pass, this interpass temperature is exceeded, the test assembly shall be cooled in air to a temperature within the limits indicated. If below the interpass temperature, reheat to within the limits.

Table 7B — Preheating and interpass temperatures (classification by tensile strength and 27 J impact energy)

Symbol for composition	Preheat temperature °C	Interpass temperature °C
3M2, 4M2, 3M3, N2M1, N2M2, N3M1, N3M2, N4M1, N4M2, N4C1M2, N4C2M2, N6C1M4, N3C1M2	100 min.	150 ± 15
G	Preheat and interpass temperature shall be as agreed between purchaser and supplier.	

5.2 Pass sequence

The procedures used for the welding of multi-run test assemblies shall conform to the requirements given in Table 8A or Table 8B.

Table 8A — Pass and layer sequence (classification by yield strength and 47 J impact energy)

Diameter mm	Passes per layer		No. of layers	Welding current [b, c] A
	First layer	Other [a] layers		
0,9 to 1,2	1 or 2	2 or 3	6 to 9	240 to 280
1,4 to 2,0	1 or 2	2 or 3	5 to 8	290 to 350

[a] The final layer may have four passes.

[b] The welding voltage will depend on the choice of shielding gas.

[c] The contact tube distance shall be 20 mm ± 2 mm.

Table 8B — Pass and layer sequence (classification by tensile strength and 27 J impact energy)

Diameter mm	Required average heat input kJ/mm	Passes per layer		No. of layers
		First layer	Other [a] layers	
0,8 0,9	0,8 to 1,6	1 or 2	2 or 3	6 to 9
1,0 1,2	1,2 to 2,0	1 or 2	2 or 3	6 to 9
1,4 1,6	1,4 to 2,2	1 or 2	2 or 3	5 to 8
2,0	1,8 to 2,4	1 or 2	2 or 3	5 to 8
2,4	2,0 to 2,6	1 or 2	2 or 3	4 to 8
2,8	2,0 to 2,8	1 or 2	2 or 3	4 to 7
3,2	2,2 to 3,0	1 or 2	2	4 to 7

[a] The final layer may have four passes.

5.3 Post-weld heat treatment (PWHT) condition

5.3A Classification by yield strength and 47 J impact energy

Test assemblies made with electrodes classified in the PWHT condition shall be heat treated at 560 °C to 600 °C for 1 h. The test assembly shall be left in the furnace to cool down to 300 °C.

5.3B Classification by tensile strength and 27 J impact energy

Test assemblies made with electrodes classified in the PWHT condition shall be heat treated at (620 ± 15) °C for 1 h $^{+15}_{0}$ min. The furnace shall be at a temperature not higher than 315 °C when the test assembly is placed in it. The heating rate, from that point to the (620 ± 15) °C holding temperature, shall not exceed 280 °C per hour. When the holding time has been completed, the assembly shall be allowed to cool in the furnace to a temperature below 315 °C at a rate not exceeding 195 °C per hour. The assembly may be removed from the furnace at any temperature below 315 °C and allowed to cool in still air to room temperature.

6 Chemical analysis

Chemical analysis can be performed on any suitable all-weld metal test specimen. The referee method for preparation of the specimen is ISO 6847, however. Any analytical technique can be used, but in cases of dispute reference shall be made to established published methods.

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 fillet welds shall be deposited as a single run using the diameter of electrode and welding position shown in Table 9A. Throat thickness, leg length and convexity shall conform to the requirements of Table 9A.

7B Classification by tensile strength and 27 J impact energy

For electrodes classified by symbol 0 in Table 5B, the fillet weld test shall be performed in the PB position. For electrodes classified by symbol 1 in Table 5B, the fillet weld test shall be performed in the PE position, and in the PF or PG position.

The plate material shall be unalloyed steel of 0,30 % C maximum. The welding procedure and the size of the electrode to be tested shall be as selected by the manufacturer. The fillet welds shall be deposited as a single pass.

Table 9A — Test requirements for fillet welds [a]
(classification by yield strength and 47 J impact energy)

Symbol of positional classification	Test position	Electrode size [a] mm	Throat thickness mm	Leg length difference mm	Convexity mm
1 or 2	PB	2,4	5,5 min.	2,0 max.	3,0 max.
3	PB	2,4	5,5 min.	2,0 max.	3,0 max.
5	PB	2,4 [b]	5,5 min.	2,0 max.	3,0 max.
1 or 2	PF	2,4 [c]	7,0 max.	Not specified	2,0 max.
1, 2 or 5	PD	1,2 [d]	4,5 max.	1,5 max.	2,5 max.
5	PG	1,2 [d]	4,5 min.	Not specified	1,5 max. [e]

[a] Where the largest size claimed for positional welding is smaller than that specified, use the largest size and adjust criteria *pro rata*.

[b] Or largest size made up to 2,4 mm.

[c] Maximum size for which positional classification is sought.

[d] Or as recommended by the manufacturer.

[e] Maximum concavity.

The maximum convexity and leg length difference shall conform to the following requirements:

a) Maximum convexity:

   2,0 mm for measured fillet weld sizes less than 7,0 mm

   2,5 mm for measured fillet weld sizes equal to or more than 7,0 mm

b) Maximum leg length difference (mm):

   $0,5 \times$ [fillet weld size (mm)] $-$ 0,5

Incomplete fusion at the root of the weld shall not exceed 20 % of the total length of the weld.

8 Retest

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 tests, 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 ISO 14344.

10 Examples of designations

The designation of the tubular cored electrode shall follow the principle given in the examples below.

10A Classification by yield strength and 47 J impact energy

EXAMPLE 1A

A tubular cored electrode (T) for gas-shielded metal arc welding deposits a weld metal with a minimum yield strength of 620 MPa (62) and a minimum average impact energy of 47 J at – 50 °C (5) in the as-welded condition and has a chemical composition of 1,7 % Mn, 1,4 % Ni (Mn1,5Ni). The electrode with a basic type of core (B) was tested under mixed gas (M) and can be used in all positions (1). Hydrogen, determined in accordance with ISO 3690, does not exceed 5 ml/100 g of deposited metal (H5).

The designation will be:

ISO 18276-A - T62 5 Mn1,5Ni B M 1 H5

Compulsory section:

ISO 18276-A - T62 5 Mn1,5Ni B M

where

ISO 18276-A = International Standard number, with classification by yield strength and 47 J impact energy;

T = tubular cored electrode/metal arc welding (see 4.1);

62 = strength properties (see Table 1A);

5 = impact properties (see Table 2);

Mn1,5Ni = chemical composition of all-weld metal (see Table 3A);

B = type of electrode core (see Table 4A);

M = shielding gas (see 4.6);

4 = welding position (see Table 5A);

H5 = hydrogen content (see Table 6).

10B Classification by tensile strength and 27 J impact energy

EXAMPLE 1B

A tubular cored electrode (T) for gas-shielded metal arc welding deposits a weld metal with a minimum tensile strength of 690 MPa (69) and a minimum average impact energy of 27 J at – 50 °C (5) in the as-welded condition (A). The symbol “U”, added as an optional supplemental designator, indicates that the deposit also meets a minimum optional requirement of 47 J at the designated Charpy test temperature (– 50 °C). The electrode with a usability designator (T5) was tested using Ar + (20 to 25) % CO_2 (M) and can be used in all positions (1). The weld deposit has a chemical composition of 1,7 % Mn, 1,4 % Ni (N3M1). Hydrogen, determined in accordance with ISO 3690, does not exceed 5 ml/100 g of deposited metal (H5).

The designation will be:

ISO 18276-B - T695T5-1MA-N3M1-UH5

Compulsory section:

ISO 18276-B - T695T5-1MA-N3M1

where

ISO 18276-B = International Standard number, with classification by tensile strength and 27 J impact energy;

T = tubular cored electrode/metal arc welding (see 4.1);

69 = tensile properties (see Table 1B);

5 = impact properties, 27 J minimum (see Table 2);

T5 = usability designator (see Table 4B);

1 = welding position (see Table 5B);

M = shielding gas (see 4.6);

A = tested in the as-welded condition;

N3M1 = chemical composition of all-weld metal (see Table 3B);

U = indicates (optional designator) that weld deposit in the as-welded condition will have impact properties of 47 J minimum at the classification test temperature;

H5 = hydrogen content (see Table 6).

Annex A
(informative)

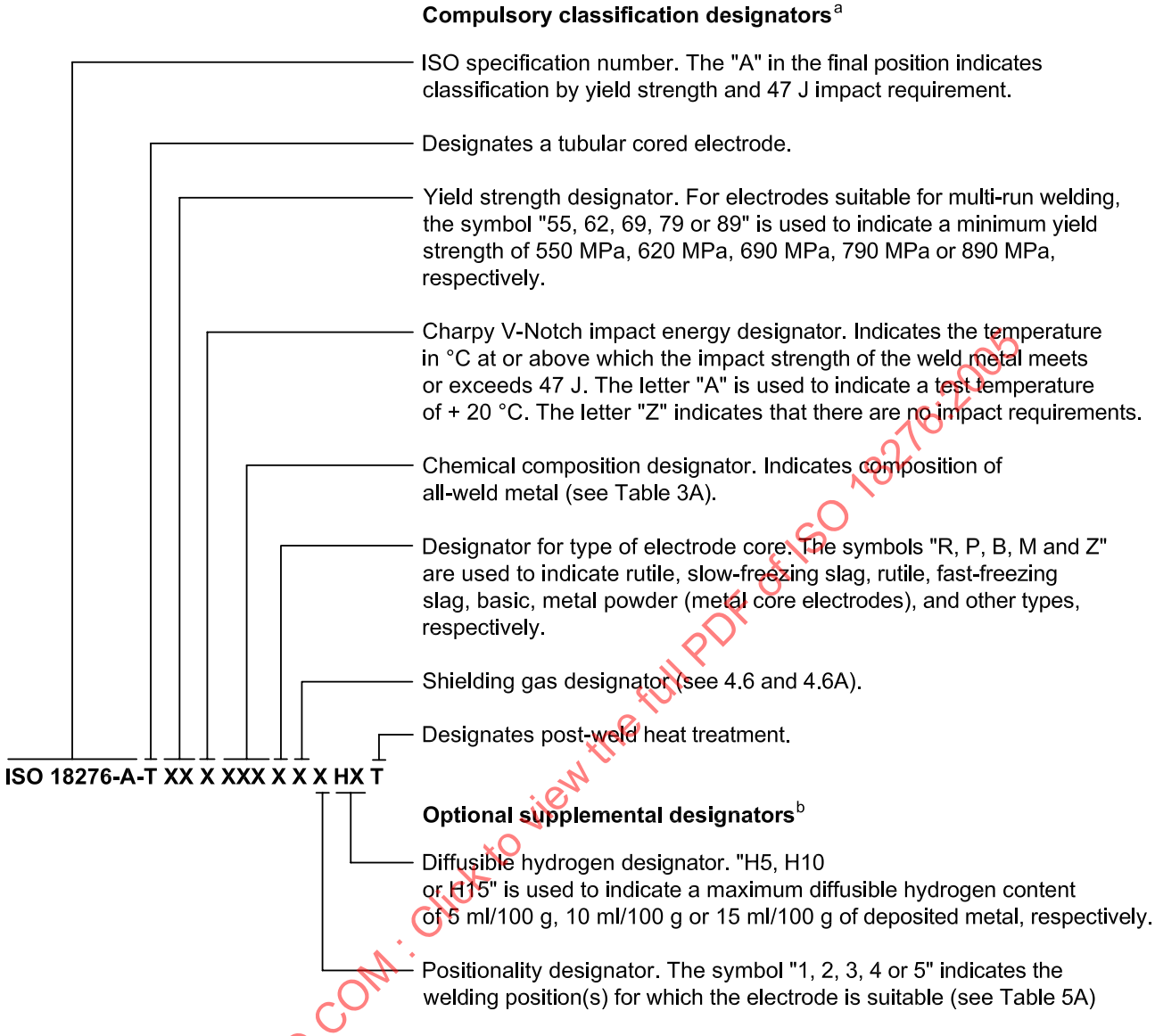
Classification systems

A.1 ISO 18276-A

The ISO 18276 classification system for tubular cored electrodes based upon yield strength and 47 J minimum impact strength is shown in Figure A.1.

A.2 ISO 18276-B

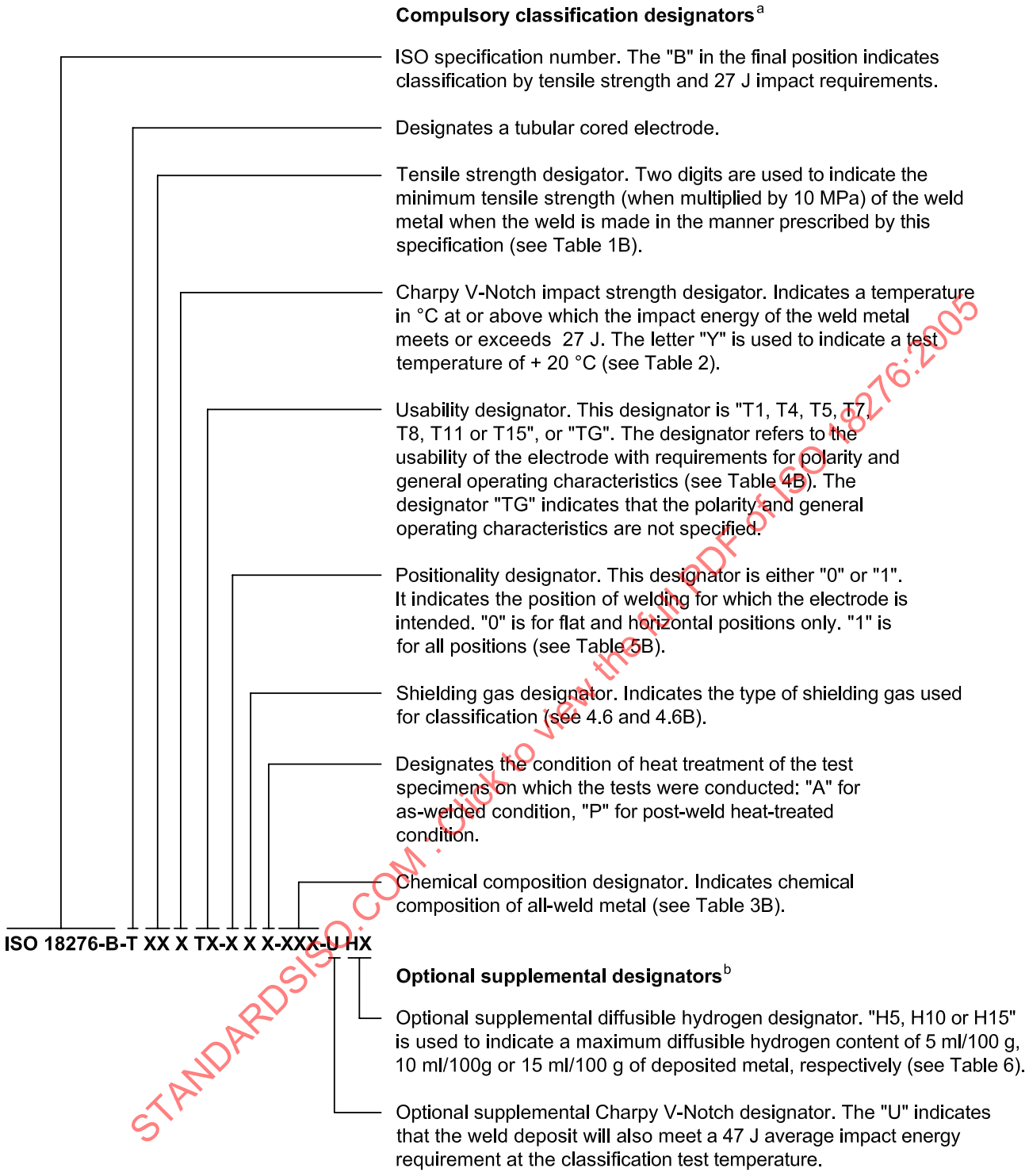
The ISO 18276 classification system for tubular cored electrodes based upon tensile strength and 27 J minimum impact strength is shown in Figure A.2.



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

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

Figure A.1 — Classification system for tubular cored electrodes based upon yield strength and 47 J minimum impact energy



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

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

Figure A.2 — Classification system for tubular cored electrodes based upon tensile strength and 27 J minimum impact energy