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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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Contents

Page

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 document 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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This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 18276:2017), which has been technically revised.

The main changes are as follows:

— document has been reformatted in single column format. Some clauses and subclauses have been merged or separated and some tables have been merged;

— dated normative references have been updated to the latest editions;

— Tables 3A and 3B have been revised and merged and is now Table 6;

— sub-clause 5.7 has been revised and is now 5.8;

— Clause 11 contains new designation examples.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

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 columns 3 and 7 of Table 3.

Note that the mechanical properties of all-weld metal test specimens used to classify tubular cored electrodes 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. 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 "system 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 "system 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 "system A" or the suffix "system 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, *Welding and allied processes — Welding positions*

ISO 13916, *Welding — 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, *Welding consumables — Test methods — Part 1: Preparation of all-weld metal test pieces and specimens in steel, nickel and nickel alloys*

ISO 80000-1:2022, *Quantities and units — Part 1: General*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

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

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

4 Classification

4.1 General

Classification designations are based 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. Annex A gives figures that explain how the classification systems are structured. Annex B gives information on composition designations for electrodes in the classification system based upon tensile strength and average impact energy of 27 J.

The classification includes all-weld metal properties obtained with a tubular cored electrode and appropriate shielding gas combination as given in 4.2. 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 largest 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.

4.2 Classification systems

Each classification system, A and B, is split into nine parts as given in Table 1.

Table 1 — Parts of the classification systems, A and B

Part of classification designation	Classification system	
	System A **Classification by yield strength and 47 J impact energy**	**System B** **Classification by tensile strength and 27 J impact energy**
1	T indicates a tubular cored electrode.	
2	symbol indicating the strength and elongation of the all-weld metal in the as-welded or post-weld heat-treated condition (see Table 3).	
3	symbol indicating the impact properties of the all-weld metal (see Table 4 and 5).	symbol indicating the impact properties of the all-weld metal (see Table 4 and 5). 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	symbol indicating the chemical composition of the all-weld metal (see Table 6)	symbol indicating the usability characteristics of the electrode (see Table 8)
5	symbol indicating the type of electrode core (see Table 7).	symbol indicating the welding position (see Table 9).
6	symbol indicating the shielding gas (see 5.7)	
7	symbol indicating the welding position (see Table 9).	symbol indicating the classification tests were conducted in the: a) as-welded condition (A) or b) post-weld heat-treated condition (P)
8	symbol indicating the hydrogen content of the deposited metal (see Table 10).	symbol indicating the chemical composition of the all-weld metal (see Table 6)
9	symbol indicating the post-weld heat treatment if this is applied (see 5.10.1).	symbol indicating the hydrogen content of the deposited metal (see Table 10).

Electrodes can 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 can include the optional section, as given in 4.3.

4.3 Compulsory and optional sections in classifications

Table 2 gives the compulsory and optional sections in each classification system, A and B.

Table 2 — Compulsory and optional sections in classifications

Section	Classification system	
	System A **Classification by yield strength and 47 J impact energy**	**System B** **Classification by tensile strength and 27 J impact energy**
Compulsory	symbols for the: a) type of product (see 5.1); b) strength and elongation (see 5.2); c) impact properties (see 5.3); d) chemical composition (see 5.4); e) type of electrode core (see 5.5); f) shielding gas (see 5.7); and g) post-weld heat treatment (see 5.10).	symbols for the: a) type of product (see 5.1); b) strength and elongation in the as-welded condition or post-weld heat-treated condition (see 5.2); c) welding positions for which the electrode is suitable (see 5.8); d) usability characteristics (see 5.6); e) shielding gas (see 5.7); f) impact properties (see 5.3); and g) chemical composition (see 5.4).
Optional	symbols for: a) the welding positions for which the electrode is suitable (see 5.8); and b) hydrogen content (see 5.9).	a) symbol "U" to indicate that the weld metal will have an average of 47 J impact energy at the classification test temperature (see 5.3); and b) the symbol for hydrogen content (see 5.9).

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 or 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 symbols in Table 3 give the, tensile properties of the all-weld metal, determined in accordance with Clause 7.

Table 3 — Symbols for tensile properties of all-weld metal

System A — Classification by yield strength and 47 J impact energy				System B — Classification by tensile strength and 27 J impact energy			
Symbol	**Minimum yield strength**[a] MPa	**Tensile strength** MPa	**Minimum elongation**[b] %	**Symbol**	**Minimum yield strength**[a] MPa	**Tensile strength** MPa	**Minimum elongation**[b] %
55	550	640 to 820	18	59	490	590 to 790	16
62	620	700 to 890	18	62	530	620 to 820	15
69	690	770 to 940	17	69	600	690 to 890	14
79	790	880 to 1 080	16	76	680	760 to 960	13
89	890	940 to 1 180	15	78	680	780 to 980	13
96	960	≥ 1 180	14	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

Table 4 gives the requirements for impact properties of the all-weld metal, determined in accordance with Clause 7.

Table 4 — Requirements for impact properties of all-weld metal

Symbol	System A — Classification by yield strength and 47 J impact energy	System B — Classification by tensile strength and 27 J impact energy
See Table 5	Indicates the temperature at which an impact energy of 47 J is achieved under the conditions given in Clause 7.	Indicates 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 7.
	Three test specimens shall be tested. Only one individual value can be lower than 47 J but not lower than 32 J.	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 can be lower but shall not be less than 20 J. The average of the three remaining values shall be at least 27 J. 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 5.3, System A.

When an all-weld metal has been classified for a certain temperature, it automatically covers any higher temperature in Table 5.

Table 5 — 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 Table 4).

[b] Classification by tensile strength and 27 J impact energy (see Table 4).

5.4 Symbol for chemical composition of all-weld metal

The symbols in Table 6 indicate the chemical composition of the all-weld metal, determined in accordance with Clause 8.

Table 6 — Symbol for chemical composition of all-weld metal

System A - Classification by yield strength and 47 J impact energy									
Symbol	**Chemical composition**, % (by mass) [a, b]								
	C	**Mn**	**Si**	**P**	**S**	**Ni**	**Cr**	**Mo**	**Other**[d]
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	Ti 0,08 B 0,005
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	B 0,005
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	B 0,005
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	B 0,005
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	—
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	—
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	—
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	—
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	—
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	—
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	—
Z[c]	Any other agreed composition								
System B - Classification by tensile strength and 27 J impact energy									
Symbol	**Chemical composition**, % (by mass) [e, f]								
	C	**Mn**	**Si**	**P**	**S**	**Ni**	**Cr**	**Mo**	**Other**[d, g]
1N3M1	0,15	1,00	0,80	0,030	0,030	1,00 to 2,00	0,15	0,35	V 0,05 Al 1,8
3M2	0,12	1,25 to 2,00	0,80	0,030	0,030	—	—	0,25 to 0,55	—
3M3	0,12	1,00 to 1,75	0,80	0,030	0,030	—	—	0,40 to 0,65	—

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

[b] Cu ≤ 0,3, Nb ≤ 0,05, V ≤ 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, therefore it is possible that two electrodes with the same Z classification are not interchangeable.

[d] Analysis for B is required to be reported if intentionally added or if it is known to be present at levels greater than 0,001 0 %.

[e] The weld metal shall be analysed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total (excluding iron) does not exceed 0,50 % (by mass).

[f] Al ≤ 1,8 for self-shielded electrodes.

[g] Consumables for which the chemical composition is not listed in this table shall be symbolized by the letter G. In order to meet the alloy requirements of G, the all-weld metal shall contain at least one of the elements. Additional chemical-composition requirements may be agreed between purchaser and supplier. The chemical composition ranges are not specified and therefore it is possible that two products with the a G classification are not interchangeable.

Table 6 *(continued)*

4M2	0,15	1,65 to 2,25	0,80	0,030	0,030	—	—	0,25 to 0,55	—
4N1M2	0,15	1,00 to 2,50	0,80	0,030	0,030	0,40 to 1,00	0,20	0,50	V 0,05 Al 1,8
4N3M2	0,15	1,50 to 2,75	0,80	0,030	0,030	0,75 to 2,00	0,20	0,50	V 0,05 Al 1,8
4N4M2	0,12	1,25 to 2,25	0,80	0,030	0,030	1,75 to 2,75	0,20	0,50	Cu 0,50
N1M2	0,15	1,00 to 2,00	0,80	0,030	0,030	0,40 to 1,00	0,20	0,50	V 0,05
N2	0,15	1,00 to 2,00	0,40	0,030	0,030	0,50 to 1,50	0,20	0,20	V 0,05 Al 1,8
N2M1	0,15	2,25	0,80	0,030	0,030	0,40 to 1,50	0,20	0,35	V 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	V 0,05
N3C1M2	0,10 to 0,25	0,60 to 1,60	0,80	0,030	0,030	0,75 to 2,00	0,20 to 0,70	0,15 to 0,55	V 0,05
N3M1	0,15	0,50 to 1,75	0,80	0,030	0,030	1,00 to 2,00	0,15	0,35	V 0,05 Al 1,8
N3M2	0,15	0,75 to 2,25	0,80	0,030	0,030	1,25 to 2,60	0,15	0,25 to 0,65	V 0,05
N4M1	0,12	2,25	0,80	0,030	0,030	1,75 to 2,75	0,20	0,35	V 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	V 0,05
N4M21	0,12	1,25 to 2,25	0,80	0,030	0,030	1,75 to 2,75	0,20	0,50	—
N4C1M2	0,15	1,20 to 2,25	0,80	0,030	0,030	1,75 to 2,60	0,20 to 0,60	0,20 to 0,65	V 0,03
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	V 0,05

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

[b] Cu ≤ 0,3, Nb ≤ 0,05, V ≤ 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, therefore it is possible that two electrodes with the same Z classification are not interchangeable.

[d] Analysis for B is required to be reported if intentionally added or if it is known to be present at levels greater than 0,001 0 %.

[e] The weld metal shall be analysed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total (excluding iron) does not exceed 0,50 % (by mass).

[f] Al ≤ 1,8 for self-shielded electrodes.

[g] Consumables for which the chemical composition is not listed in this table shall be symbolized by the letter G. In order to meet the alloy requirements of G, the all-weld metal shall contain at least one of the elements. Additional chemical-composition requirements may be agreed between purchaser and supplier. The chemical composition ranges are not specified and therefore it is possible that two products with the a G classification are not interchangeable.

Table 6 *(continued)*

N5M2	0,07	0,50 to 1,50	0,60	0,015	0,015	1,30 to 3,75	0,20	0,50	V 0,05 Cu 0,06
N6C1M4	0,12	2,25	0,80	0,030	0,030	2,50 to 3,50	1,00	0,40 to 1,00	V 0,05
G [g]		1,75 min.[g]	0,80 min. [g]	0,030	0,030	0,50 min. [g]	0,30 min. [g]	0,20 min. [g]	V 0,10 min. [g]

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

[b] Cu ≤ 0,3, Nb ≤ 0,05, V ≤ 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, therefore it is possible that two electrodes with the same Z classification are not interchangeable.

[d] Analysis for B is required to be reported if intentionally added or if it is known to be present at levels greater than 0,001 0 %.

[e] The weld metal shall be analysed for the specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total (excluding iron) does not exceed 0,50 % (by mass).

[f] Al ≤ 1,8 for self-shielded electrodes.

[g] Consumables for which the chemical composition is not listed in this table shall be symbolized by the letter G. In order to meet the alloy requirements of G, the all-weld metal shall contain at least one of the elements. Additional chemical-composition requirements may be agreed between purchaser and supplier. The chemical composition ranges are not specified and therefore it is possible that two products with the a G classification are not interchangeable.

5.5 Symbol for type of electrode core – Classification by yield strength and 47 J impact energy – System A

The symbols in Table 7 indicate the different types of tubular cored electrode relative to their core composition and slag characteristics. Manufacturers shall provide information on recommended polarity.

Table 7 — Symbol for type of electrode core – Classification by yield strength and 47 J impact energy – System A

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.	

5.6 Symbol for usability characteristics of the electrodes – Classification by tensile strength and 27 J impact energy – System B

The symbols in Table 8 indicate the usability characteristics of the electrode.

Table 8 — Usability characteristics – Classification by tensile strength and 27 J impact energy – System B

Usability designator	Shielding gas	Operating polarity	Transfer of droplet	Type of core	Welding position[a]	Characteristics
T1	Required	DC (+)	Spray type	Rutile	0 or 1	Low spatter loss, flat to slightly convex bead and high deposition rates
T5	Required	DC (+)	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	DC (–)	Small droplet to spray type	Not specified	0 or 1	High deposition rates and excellent resistance to hot cracking
T8	Not required	DC (–)	Small droplet or spray type	Not specified	0 or 1	Very good low-temperature impact properties
T11	Not required	DC (–)	Spray type	Not specified	0 or 1	Not recommended on thicknesses greater than 19 mm without maintaining preheat and interpass temperature control
T15	Required	DC (+)	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					

[a] See Table 5B.

[b] For electrodes that are not covered by any current usability designator.

NOTE A description of the usability characteristics of the electrodes is given in Annex D.

5.7 Symbol for shielding gas

The symbols for shielding gases shall be in accordance with ISO 14175, except that the symbol NO shall be used for non-gas shielded tubular cored electrodes.

5.8 Symbol for welding position

The symbols in Table 9 indicate the positions for which the electrode is suitable for classification to ISO 18276-A (System A) or ISO 18276-B (System B).

Table 9 — Symbols for welding position[a]

Symbol	System A – Classification by yield strength and 47 J impact energy	System B – Classification by tensile strength and 27 J impact energy
0	—	PA and PB
1	PA, PB, PC, PD, PE, PF and PG	PA, PB, PC, PD, PE, PF or PG, or both
2	PA, PB, PC, PD, PE and PF	—
3	PA and PB	—
4	PA	—
5	PA, PB and PG	—

[a] Welding positions given in the Key are in accordance with ISO 6947.

Key

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

NOTE A dash indicates not applicable.

5.9 Symbol for hydrogen content of deposited metal

The symbols in Table 10 indicate the hydrogen content determined in accordance with the method given in ISO 3690. Annex E gives additional information on hydrogen content.

Table 10 — 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 hydrogen symbol is included in the designation, the manufacturer shall state in its literature 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.

5.10 Symbol for conditions of post-weld heat treatment

5.10.1 Classification by yield strength and 47 J impact energy – System A

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 7.4.1.

5.10.2 Classification by tensile strength and 27 J impact energy – System B

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 7.4.2 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.

6 Rounding procedure

Actual test values obtained shall be subject to ISO 80000-1:2022, B.3, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this document, the measured values shall be converted to the units of this document before rounding. If an average value is to be compared to the requirements of this document, rounding shall be done only after calculating the average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

7 Mechanical tests

7.1 General

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;

— a 1,2 mm electrode in the case of gas-shielded electrodes or, if this size is not manufactured, the next largest diameter manufactured;

— a 2,4 mm electrode in the case of self-shielded electrodes, or the largest size manufactured if less than 2,4 mm;

— welding conditions and PWHT conditions as described in 7.2, 7.3, and 7.4.1 or 7.4.2

When diffusible hydrogen removal treatment is specified by the manufacturer, it shall be carried out in accordance with ISO 15792-1.

7.2 Preheating and interpass temperatures

The preheating and interpass temperatures required for each classification system, A and B, are given in Table 11.

Table 11 — Preheating and interpass temperatures

Condition	System A – Classification by yield strength and 47 J impact energy	System B – Classification by tensile strength and 27 J impact energy
Preheating	Not required. Welding can start without preheat.	Shall be selected for the appropriate weld metal type from Table 12.
Interpass temperature	Welding of the all-weld metal test piece shall be executed in a temperature range from 120 °C to 180 °C, with the exception of the first layer in the test piece, which may be welded without preheating. 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.	Shall be selected for the appropriate weld metal type from Table 12. Welding shall continue until the maximum interpass temperature given in Table 12 has been reached. 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.
The temperatures shall be measured using temperature indicator crayons, surface thermometers or thermocouples in accordance with ISO 13916.		

Table 12 — Preheating and interpass temperatures – Classification by tensile strength and 27 J impact energy – System B

Symbol for composition	Preheat temperature °C	Interpass temperature °C
All except G	100 min	150 ± 15
G	Preheat and interpass temperature shall be as agreed between purchaser and supplier	

7.3 Pass sequence

The procedures used for the welding of multi-run test assemblies shall conform to the requirements given in Table 13.

Table 13 — Pass and layer sequence

System A – Classification by yield strength and 47 J impact energy					System B – Classification by tensile strength and 27 J impact energy				
Diameter mm	Passes per layer		No. of layers	Welding current[a, b] A	Diameter mm	Required average heat input kJ/mm	Passes per layer		No. of layers
	First layer	Other layers					First layer	Other[c] layers	
0,9 to 1,2	1 or 2	2 to 4	6 to 9	240 to 280	0,8 0,9	0,8 to 1,4	1 or 2	2 or 3	6 to 9
1,4 to 2,0	1 or 2	2 to 4	5 to 8	290 to 350	1,0 1,2	1,0 to 2,0	1 or 2	2 or 3	6 to 9
—	—	—	—	—	1,4 1,6	1,0 to 2,2	1 or 2	2 or 3	5 to 8
—	—	—	—	—	2,0	1,4 to 2,6	1 or 2	2 or 3	5 to 8
—	—	—	—	—	2,4	1,6 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 welding voltage will depend on the choice of shielding gas.

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

[c] The final layer can have up to four passes.

NOTE A dash indicates not applicable.

7.4 Post-weld heat treatment (PWHT) condition

7.4.1 Classification by yield strength and 47 J impact energy – System A

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. The heating rate shall not exceed 280 °C per hour and the cooling rate shall not exceed 195 °C per hour.

7.4.2 Classification by tensile strength and 27 J impact energy – System B

Test assemblies made with electrodes classified in the PWHT condition shall be heat treated at (620 ± 15) °C for 1 h 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 can be removed from the furnace at any temperature below 315 °C and allowed to cool in still air to room temperature.

8 Chemical analysis

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

9 Retesting

If any test fails to meet the requirement, it 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, retesting 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 document 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.

10 Technical delivery conditions

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

11 Examples of designations

11.1 General

The designation of the tubular cored electrode shall follow the principles given in 11.2, 11.3, 11.4, and 11.5.

11.2 Example 1 - Classification by yield strength and 47 J impact energy – System A

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 (M21) 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 M21 1 H5

Compulsory section:

ISO 18276-A - T62 5 Mn1,5Ni B M21

where

ISO 18276-A	is the number of this document, with classification by yield strength and 47 J impact energy;
T	designates a tubular cored electrode/metal arc welding (see 5.1);
62	are the strength properties (see Table 3);
5	are the impact properties (see Table 5);
Mn1,5Ni	is thechemical composition of all-weld metal (see Table 6);
B	is the type of electrode core (see Table 7);
M21	is the shielding gas (see 5.7);
1	is the welding position (see Table 9);
H5	is the hydrogen content (see Table 10).

11.3 Example 2 - Classification by tensile strength and 27 J impact energy – System B

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 % CO_2 (M21) 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 - T695T5-1M21A-N3M1-UH5

Compulsory section:

ISO 18276-B - T695T5-1M21A-N3M1

where

ISO 18276-B	is the number of this document with classification by tensile strength and 27 J impact energy;
T	designates a tubular cored electrode/metal arc welding (see 5.1);
69	are the tensile properties (see Table 3);
5	are the impact properties, 27 J minimum (see Table 5);
T5	is the usability designator (see Table 8);
1	is the welding position (see Table 9);
M21	is the shielding gas (see 5.7);
A	designates tested in the as-welded condition;
N3M1	is the chemical composition of all-weld metal (see Table 6);
U	(optional designator) indicates that weld deposit in the as-welded condition will have impact properties of 47 J minimum at the classification test temperature (see Table 4);
H5	is the hydrogen content (see Table 10).

11.4 Example 3 – Classification by yield strength and 47 J impact energy - System A

A tubular cored electrode (T) for gas-shielded metal arc welding deposits a weld metal with a minimum yield strength of 890 MPa (89) and a minimum average impact energy of 47 J at –20 °C (2) in the as-welded condition and has a chemical composition of 2 % Mn, 2 % Ni, 0,5 % Cr and 0,5 % Mo. The electrode with a metal powder type of core (M) was tested under mixed gas (M21) and can be used in all positions except vertical down (2). 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 - T89 2 ZMn2NiCrMo M M21 2 H5

Compulsory section:

ISO 18276-A - T89 2 ZMn2NiCrMo M M21

where

ISO 18276-A	is the number of this document with classification by yield strength and 47 J impact energy;
T	designates a tubular cored electrode/metal arc welding (see 5.1);
89	are the strength properties (see Table 3);
2	are the impact properties (see Table 5);
Z	is the chemical composition of all-weld metal not specified (see Table 6);
Mn2NiCrMo	is the nominal chemical composition of all-weld metal (Table 6);
M	is the type of electrode core (see Table 7);
M21	is the shielding gas (see 5.7);
2	is the welding position (see Table 9);
H5	is the hydrogen content (see Table 10).

11.5 Example 4 – Classification by tensile strength and 27 J impact energy – System B

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 (T15) was tested using Ar + 5 < CO_2 to </=15 CO_2 (M20) and can be used in all positions (1). The weld deposit has a chemical composition with a minimum of 1,75 % Mn, 0,8 % Si, 0,5 % Ni, 0,30 %Cr, 0,20 % Mo, 0,10 % V (G). 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 - T695T15-1M20A-G-UH5

Compulsory section:

ISO 18276-B - T695T15-1M20A-G

where

ISO 18276-B	is the number of this document with classification by tensile strength and 27 J impact energy;
T	designates a tubular cored electrode/metal arc welding (see 5.1);
69	are the tensile properties (see Table 3);
5	are the impact properties, 27 J minimum (see Table 5);
T15	is the usability designator (see Table 8);
1	is the welding position (see Table 9);
M20	is the shielding gas (see 5.7);
A	designates tested in the as-welded condition;

G	is the chemical composition of all-weld metal (see Table 6);
U	(optional designator) indicates that weld deposit in the as-welded condition will have impact properties of 47 J minimum at the classification test temperature(see Table 4);
H5	is the hydrogen content (see Table 10).

Annex A
(informative)

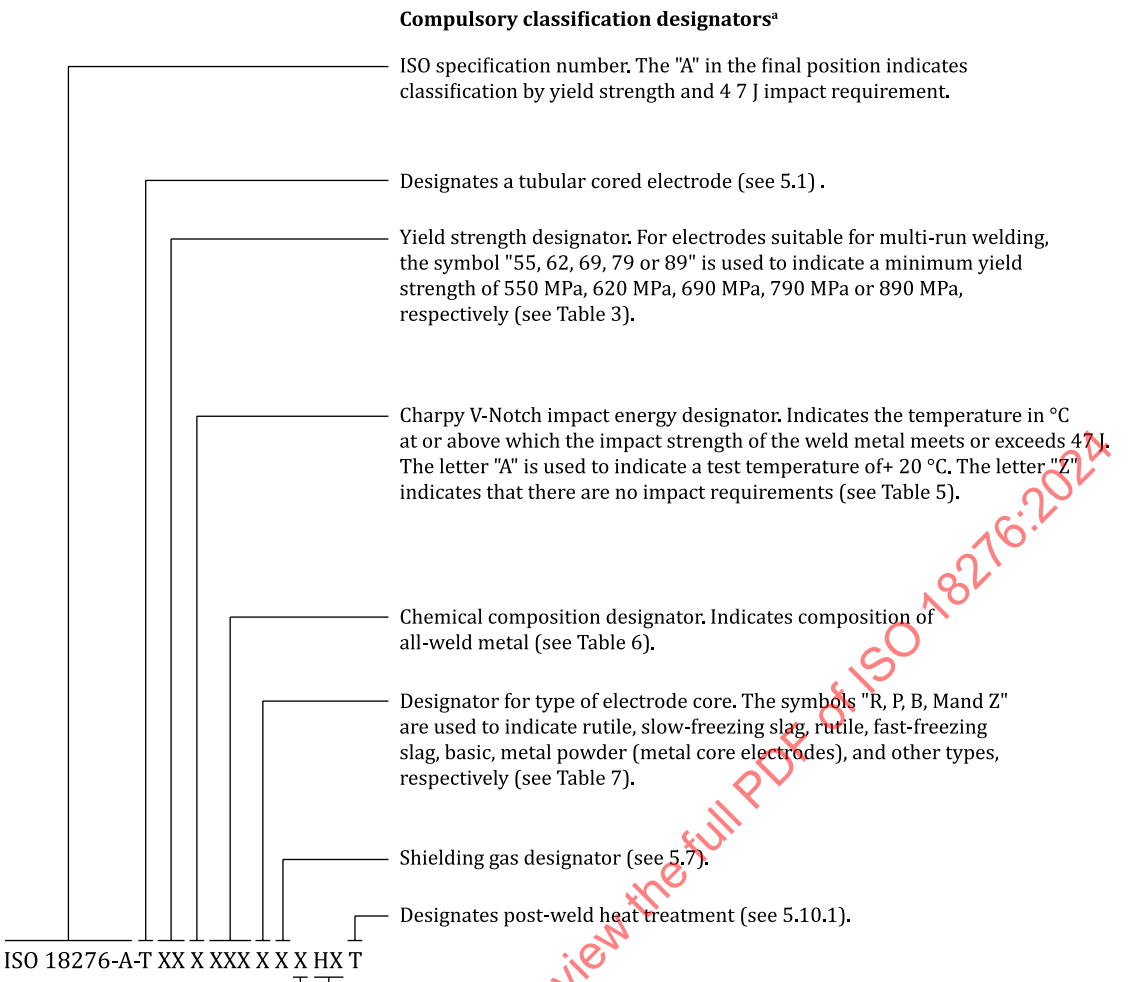
Classification systems

A.1 ISO 18276-A

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

A.2 ISO 18276-B

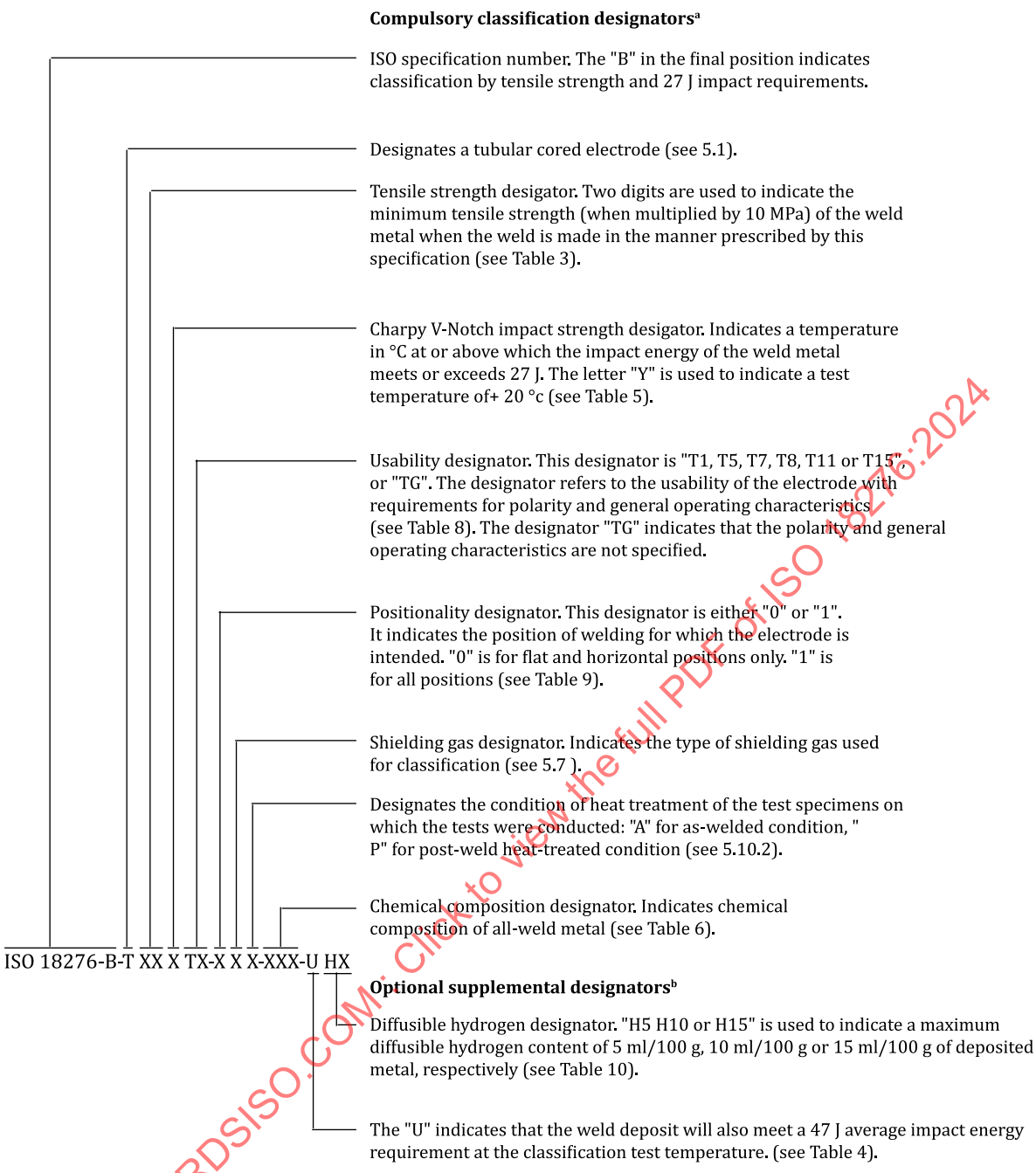
The ISO 18276 classification system for tubular cored electrodes based upon tensile strength and 27 J minimum impact strength (System B) is shown in Figure A.2.



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 – System A



[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 – System B