INTERNATIONAL STANDARD

ISO 17632

Second edition
2015-11-15

Welding consumables — Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels — Classification

Produits consommables pour le soudage — Fils-électrodes fourrés pour soudage à l'arc avec ou sans gaz de protection des aciers non alliés et des aciers à grains fins — Classification

Reference number
ISO 17632:2015(E)

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

This second edition cancels and replaces the first edition (ISO 17632:2004), which has been technically revised.

Requests for official interpretations of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 3, through your national standards body, a complete listing of which can be found at www.iso.org.

Introduction

This International Standard provides a classification system for tubular cored electrodes in terms of tensile properties, impact properties, chemical composition of the all-weld metal, type of electrode core, shielding gas, and welding position. The ratio of yield to tensile strength of weld metal is generally higher than that of the parent metal. 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 strengths, selection of consumables is made by reference to column 3 of Table 1A or Table 1B.

Of note is that the mechanical properties of all-weld metal test specimens used to classify the tubular cored electrodes will vary from those obtained in production joints because of the 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 758:1997. 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 non-alloy and fine grain 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 non-alloy and fine grain steels in the as-welded condition or in the post-weld heat-treated condition with a minimum yield strength of up to 500 MPa or a minimum tensile strength of up to 570 MPa. One tubular cored electrode can be tested and classified with different shielding gases, if any.

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

1) Paragraphs and tables which carry the suffix letter “A” are applicable only to tubular cored electrodes classified to the system based upon the yield strength and the average impact energy of 47 J of all-weld metal in accordance with this International Standard.

2) Paragraphs and tables which carry the suffix letter “B” are applicable only to tubular cored electrodes classified to the system based upon the tensile strength and the average impact energy of 27 J of all-weld metal in accordance with this International Standard.

3) Paragraphs and tables which have neither the suffix letter “A” nor the suffix letter “B” are applicable to all tubular cored electrodes classified in accordance with 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 permitted for determining the electrode classification.

2 Normative references

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

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

ISO 3690, *Welding and allied processes — Determination of hydrogen content in arc weld metal*

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

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

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

ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

ISO 14344, *Welding consumables — Procurement of filler materials and fluxes*

ISO 15792-1:2000, *Welding consumables — Test methods — Part 1: Test methods for all-weld metal test specimens in steel, nickel and nickel alloys*. Amended by ISO 15792-1:2000/Amd 1:2011

ISO 15792-2:2000, *Welding consumables — Test methods — Part 2: Preparation of single-run and two-run technique test specimens in steel*

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

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

3 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. 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 (see Annex A).

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 the 1,2 mm electrode size or if this size is not manufactured, the next larger diameter manufactured. The classification of self-shielded tubular cored electrodes is based on the 2,4 mm diameter or the largest diameter manufactured if less than 2,4 mm.

3.1A Classification by yield strength and 47 J impact energy

The classification is divided into eight parts.

1) The first part (T) indicates a tubular cored electrode.

2) The second part gives a symbol indicating the yield strength and elongation of all-weld metal for multi-run technique or the strength of the parent material used in classification for the single-run technique (see Table 1A or Table 2A).

3) The third part gives a symbol indicating the impact properties of all-weld metal or welded joint (see Table 3).

4) The fourth part gives a symbol indicating the chemical composition of all-weld metal (see Table 4A).

5) The fifth part gives a symbol indicating the type of electrode core (see Table 5A).

6) The sixth part gives a symbol indicating the shielding gas (see 4.6).

3.1B Classification by tensile strength and 27 J impact energy

The classification is divided into nine parts.

1) The first part (T) indicates a tubular cored electrode.

2) The second part gives a symbol indicating the tensile strength and elongation of all-weld metal for multi-run technique or the strength of the parent material used in classification for the single-run technique (see Table 1B or Table 2B).

3) The third part gives a symbol indicating the impact properties of all-weld metal (see Table 3). 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 5B).

5) The fifth part gives a symbol indicating the welding position (see Table 6B).

6) The sixth part gives a symbol indicating the shielding gas (see 4.6). The letter "S" added to this designator indicates that the electrode is classified for single-pass welding.

7) The seventh part gives a symbol indicating the welding position (see Table 6A);

8) The eighth part gives a symbol indicating the hydrogen content of deposited metal (see Table 7).

7) The seventh part gives a symbol indicating whether the classification tests were conducted in the as-welded (A) or post-weld heat-treated condition (P). If the electrode has been classified in both conditions, the symbol AP shall be added to the classification. This designator is omitted in the classification for single-pass welding electrodes as these are tested only in the as-welded condition;

8) The eighth part gives a symbol indicating the chemical composition of all-weld metal (see Table 4B). The symbol is omitted for weld deposits conforming to the "No symbol" in Table 4B.

9) The ninth part gives a symbol indicating the hydrogen content of deposited metal (see Table 7).

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 compulsory sections and can 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 type of product, strength and elongation, impact properties, chemical composition, type of electrode core, and shielding gas, i.e. the symbols defined in 4.1, 4.2.1A, 4.2.2, 4.3A, 4.4, 4.5A, and 4.6.

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 type of product, strength and elongation in the as-welded condition or post-weld heat-treated condition, welding positions for which the electrode is suitable, usability characteristics, shielding gas, impact properties, and chemical composition, i.e. the symbols defined in 4.1, 4.2.1B, 4.2.2, 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 has 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 shall comprise the compulsory symbols and can include optional symbols chosen by the manufacturer. 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 electrode used in the metal arc welding process is the letter T.

4.2 Symbol for tensile properties of all-weld metal or welded joint

4.2.1 Multi-run technique

4.2.1A Classification by yield strength and 47 J impact energy

For products suitable for single- and multi-run welding, the symbol in Table 1A indicates yield strength, tensile strength, and elongation of the all-weld metal in the as-welded condition determined in accordance with 5.1A.

4.2.1B Classification by tensile strength and 27 J impact energy

For electrodes suitable for single- and multi-run welding, the symbol in Table 1B indicates yield strength, tensile strength, and elongation of the all-weld metal in the as-welded condition or in the post-weld heat-treated condition determined in accordance with 5.1B.

Classification of products suitable for both single- and multi-run welding does not require the single-run test of 5.2.

Table 1A — Symbol for tensile properties by multi-run technique (classification by yield strength and 47 J impact energy)

Symbol	Minimum yield strength[a]	Tensile strength	Minimum elongation[b]
	MPa	MPa	%
35	355	440 to 570	22
38	380	470 to 600	20
42	420	500 to 640	20
46	460	530 to 680	20
50	500	560 to 720	18

[a] For yield strength, the lower yield, 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 by multi-run technique (classification by tensile strength and 27 J impact energy)

Symbol	Minimum yield strength[a]	Tensile strength	Minimum elongation[b]
	MPa	MPa	%
43	330	430 to 600	20
49	390	490 to 670	18
55	460	550 to 740	17
57	490	570 to 770	17

[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.

4.2.2 Single-run technique

For tubular cored electrodes suitable for single-run welding only, the symbol in Table 2A or Table 2B indicates strength of the welded joint in the as-welded condition in relation to the parent material used in single-run tests satisfactorily completed in accordance with 5.2.

Table 2A — Symbol for tensile properties by single-run technique (classification by yield strength and 47 J impact energy)

Symbol	Minimum parent material yield strength	Minimum tensile strength of the welded joint
	MPa	MPa
3T	355	470
4T	420	520
5T	500	600

Table 2B — Symbol for tensile properties by single-run technique (classification by tensile strength and 27 J impact energy)

Symbol	Minimum tensile strength of the parent metal and of the welded joint
	MPa
43	430
49	490
55	550
57	570

4.3 Symbol for impact properties of all-weld metal or welded joint

4.3A Classification by yield strength and 47 J impact energy

The symbol in Table 3 indicates the temperature at which an impact energy of 47 J is achieved under the conditions given in 5.1A or 5.2. Three test specimens shall be tested. Only one individual value can be lower than 47 J, but not lower than 32 J.

4.3B Classification by tensile strength and 27 J impact energy

The symbol in Table 3 indicates 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 5.1B or 5.2. 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 be no 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 supplemental designator “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 three values shall be 47 J or greater. Only one individual value can be lower than 47 J, but not lower than 32 J.

When an all-weld metal has been classified for a certain temperature, it automatically covers any higher temperature listed in Table 3.

NOTE Impact testing is not required to classify electrodes for the single-run technique.

Table 3 — Symbol for impact properties of all-weld metal or welded joint

Symbol	Temperature for minimum average impact energy of 47 J[a, b] or 27 J[c] °C
Z[a]	No requirements
A[b] or Y[c]	+20
0	0
2	−20
3	−30
4	−40
5	−50
6	−60
7	−70
8	−80
9	−90
10	−100

[a] Only the symbol Z is used for electrodes for the single-run technique.

[b] Classification by yield strength and 47 J impact energy.

[c] Classification by tensile strength and 27 J impact energy.

4.4 Symbol for chemical composition of all-weld metal

The symbol in Table 4A or Table 4B indicates the chemical composition of all-weld metal determined in accordance with Clause 6.

Table 4A — Symbol for chemical composition of all-weld metal (classification by yield strength and 47 J impact energy)

Composition designation	Chemical composition (percentage mass fraction)[a, b]											
	C	Mn	Si	P	S	Cr	Ni	Mo	V	Nb	Al[c]	Cu
No symbol	—	2,0	—	—	—	0,2	0,5	0,2	0,08	0,05	2,0	0,3
Mo	—	1,4	—	—	—	0,2	0,5	0,3 to 0,6	0,08	0,05	2,0	0,3
MnMo	—	1,4 to 2,0	—	—	—	0,2	0,5	0,3 to 0,6	0,08	0,05	2,0	0,3
1Ni	—	1,4	0,80	—	—	0,2	0,6 to 1,2	0,2	0,08	0,05	2,0	0,3
1,5Ni	—	1,6	—	—	—	0,2	1,2 to 1,8	0,2	0,08	0,05	2,0	0,3
2Ni	—	1,4	—	—	—	0,2	1,8 to 2,6	0,2	0,08	0,05	2,0	0,3
3Ni	—	1,4	—	—	—	0,2	2,6 to 3,8	0,2	0,08	0,05	2,0	0,3
Mn1Ni	—	1,4 to 2,0	—	—	—	0,2	0,6 to 1,2	0,2	0,08	0,05	2,0	0,3
1NiMo	—	1,4	—	—	—	0,2	0,6 to 1,2	0,3 to 0,6	0,08	0,05	2,0	0,3
Z[d]	Any other agreed composition											

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

[b] Analysis for boron is required if intentionally added.

[c] Self-shielded electrodes only.

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

Table 4B — Symbol for chemical composition of all-weld metal (classification by tensile strength and 27 J impact energy)

Composition designation	Chemical composition (percentage mass fraction)[a, b]										
	C	Mn	Si	P	S	Cr	Ni	Mo	Cu	V	Al[c]
No symbol	0,18[d]	2,00	0,90	0,030	0,030	0,20[e]	0,50[e]	0,30[f]	—	0,08[e]	2,0
K	0,20	1,60	1,00	0,030	0,030	0,20[e]	0,50[e]	0,30[f]	—	0,08[e]	—
2M3	0,12	1,50	0,80	0,030	0,030	—	—	0,40 to 0,65	—	—	1,8
3M2	0,15	1,25 to 2,00	0,80	0,030	0,030	—	—	0,25 to 0,55	—	—	1,8
N1	0,12	1,75	0,80	0,030	0,030	—	0,30 to 1,00	0,35	—	—	1,8
N2	0,12	1,75	0,80	0,030	0,030	—	0,80 to 1,20	0,35	—	—	1,8
N3	0,12	1,75	0,80	0,030	0,030	—	1,00 to 2,00	0,35	—	—	1,8
N5	0,12	1,75	0,80	0,030	0,030	—	1,75 to 2,75	—	—	—	1,8
N7	0,12	1,75	0,80	0,030	0,030	—	2,75 to 3,75	—	—	—	1,8
CC	0,12	0,60 to 1,40	0,20 to 0,80	0,030	0,030	0,30 to 0,60	—	—	0,20 to 0,50	—	1,8
NCC	0,12	0,60 to 1,40	0,20 to 0,80	0,030	0,030	0,45 to 0,75	0,10 to 0,45	—	0,30 to 0,75	—	1,8
NCC1	0,12	0,50 to 1,30	0,20 to 0,80	0,030	0,030	0,45 to 0,75	0,30 to 0,80	—	0,30 to 0,75	—	1,8
N1M2	0,15	2,00	0,80	0,030	0,030	0,20	0,40 to 1,00	0,20 to 0,65	—	0,05	1,8
N2M2	0,15	2,00	0,80	0,030	0,030	0,20	0,80 to 1,20	0,20 to 0,65	—	0,05	1,8
N3M2	0,15	2,00	0,80	0,030	0,030	0,20	1,00 to 2,00	0,20 to 0,65	—	0,05	1,8
G[f]	Any other agreed composition										

a Single values shown in the table are maximum values.

b Analysis for boron is required if intentionally added.

c Self-shielded electrodes only.

d 0,30 % for self-shielded electrodes.

e The analysis of these elements shall be reported only if added intentionally.

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

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

4.5A Classification by yield strength and 47 J impact energy

The symbol in Table 5A indicates different types of tubular cored electrodes relative to their core composition and slag characteristics. Manufacturers shall provide information on recommended polarity.

Table 5A — Symbol for type of electrode core (classification by yield strength and 47 J impact energy)

Symbol	Characteristics	Types of weld	Shielding gas
R	Rutile, slow-freezing slag	Single and multiple pass	Required
P	Rutile, fast-freezing slag	Single and multiple pass	Required
B	Basic	Single and multiple pass	Required
M	Metal powder	Single and multiple pass	Required
V	Rutile or basic/fluoride	Single pass	Not required
W	Basic/fluoride, slow-freezing slag	Single and multiple pass	Not required
Y	Basic/fluoride, fast-freezing slag	Single and multiple pass	Not required
Z	Other types		

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

4.5B Classification by tensile strength and 27 J impact energy

The symbol in Table 5B indicates the usability characteristics of the electrode.

4.6 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.

Table 5B — Usability characteristics (classification by tensile strength and 27 J impact energy)

Usability designator	Shielding gas	Operating polarity	Transfer of droplet	Type of core	Welding[a] position	Characteristics	Type of weld
T1	Required	d.c.(+)	Spray type	Rutile	0 or 1	Low spatter loss, flat to slightly convex bead, and high deposition rates	Single and multiple pass
T2	Required	d.c.(+)	Spray type	Rutile	0	Similar to “T1” type, higher manganese and/or silicon for improved performance	Single pass
T3	Not required	d.c.(+)	Globular type	Not specified	0	Very high welding speeds	Single pass
T4	Not required	d.c.(+)	Globular type	Basic	0	Very high deposition rates, excellent resistance to hot cracking and low penetration	Single and multiple pass
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”	Single and multiple pass
T6	Not required	d.c.(+)	Spray type	Not specified	0	Good impact properties, good penetration into the root of the weld and excellent slag removal even in a deep groove	Single and multiple pass
T7	Not required	d.c.(−)	Small droplet to spray type	Not specified	0 or 1	High deposition rates and excellent resistance to hot cracking	Single and multiple pass
T8	Not required	d.c.(−)	A small droplet or spray type	Not specified	0 or 1	Very good low temperature impact properties	Single and multiple pass
T10	Not required	d.c.(−)	Small droplet	Not specified	0	High travel speeds on any thickness	Single pass
T11	Not required	d.c.(−)	Spray type	Not specified	0 or 1	Some electrodes are designed for thin plate only. The manufacturer should be consulted regarding any plate thickness limitations.	Single and multiple pass
T12	Required	d.c.(+)	Spray type	Rutile	0 or 1	Similar to “T1” type, improved impact properties, and lower manganese requirements	Single and multiple pass
T13	Not required	d.c.(−)	Short arc transfer	Not specified	0 or 1	Welding for open gap root passes	Single pass
T14	Not required	d.c.(−)	Spray type	Not specified	0 or 1	High speed welding on coated sheet steels	Single pass
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	Single and multiple pass

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

[a] See Table 6B.

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

Table 5B *(continued)*

Usability designator	Shielding gas	Operating polarity	Transfer of droplet	Type of core	Welding[a] position	Characteristics	Type of weld
TG[b]	As agreed between purchaser and supplier						

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

[a] See Table 6B.

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

4.7 Symbol for welding position

The symbols in Table 6A or Table 6B indicate the positions for which the electrode is suitable for classification to ISO 17632-A or ISO 17632-B in accordance with ISO 15792-3 (see Clause 7 for testing requirements).

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

Symbol	Welding positions[a]
1	PA, PB, PC, PD, PE, PF, PG
2	PA, PB, PC, PD, PE, PF
3	PA, PB
4	PA
5	PA, PB, 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
In accordance with ISO 6947:2011.

Table 6B — Symbol for welding position (classification by tensile strength and 27 J impact energy)

Symbol	Welding positions[a]
0	PA, PB
1	PA, PB, PC, PD, PE (PF or PG) or (PF 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
In accordance with ISO 6947:2011.

4.8 Symbol for hydrogen content of deposited metal

The symbols in Table 7 indicate the hydrogen content determined in accordance with the method given in ISO 3690.

Table 7 — Symbol for hydrogen content of deposited metal

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

When the symbol for hydrogen content in accordance with Table 7 is included in the classification, the manufacturer shall state in their 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 the required limit.

4.9 Symbol for condition of postweld heat treatment of all-weld metal

4.9A Classification by yield strength and 47 J impact energy

Classification is based upon mechanical properties of the all-weld metal in the as-welded condition only. No symbol is used to indicate this.

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 condition of post-weld heat treatment shall be as specified in 5.1.3B 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.

5 Mechanical tests

5.1 Multi-run technique

5.1A Classification by yield strength and 47 J impact energy

Tensile and impact tests and any required retests shall be carried out on weld metal prepared as described in 5.1.1A and 5.1.2, in the as-welded condition using an all-weld metal, test assembly type 1.3 in accordance with ISO 15792-1:2000 using 1,2 mm for gas shielded electrodes or, if this size is not manufactured, the next larger diameter manufactured, and 2,4 mm for self-shielded electrodes, or the largest size manufactured if less than 2,4 mm.

5.1B Classification by tensile strength and 27 J impact energy

Tensile and impact tests shall be carried out on weld metal prepared as described in 5.1.1B, 5.1.2, and 5.1.3B in the as-welded condition and/or in the post-weld heat-treated condition using an all-weld metal test assembly type 1.3 in accordance with ISO 15792-1:2000 using 1,2 mm for gas shielded electrodes or if this size is not manufactured, the closest diameter manufactured and 2,4 mm for self-shielded electrodes or the closest size manufactured.

When the manufacturer specifies hydrogen removal treatment for tensile test specimen, it should be done in accordance with ISO 15792-1:2000.

5.1.1 Preheating and interpass temperatures

5.1.1A Classification by yield strength and 47 J impact energy

Preheating is not required. Welding can start from room temperature. The interpass temperature shall be measured using temperature indicator crayons, surface thermometers, or thermocouples (see ISO 13916).

The interpass temperature shall not exceed 250 °C. If after any pass this interpass temperature is exceeded, the test assembly shall be cooled in air to a temperature below that limit.

5.1.1B Classification by tensile strength and 27 J impact energy

Preheating and interpass temperatures shall be selected for the appropriate weld metal type from Table 8B. 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 8B. If after any pass this interpass temperature is exceeded, the test assembly shall be cooled in air to a temperature within that range. If below interpass, reheat into interpass range.

Table 8B — Preheating and interpass temperatures (classification by tensile strength and 27 J impact energy)

Composition designation	Preheat temperature °C	Interpass temperature °C
No symbol, K	Room temperature	150 ± 15
2M3, 3M2, N1, N2, N3, N5, N7, CC, NCC, NCC1, N1M2, N2M2, N3M2	100 min.	

5.1.2 Procedure requirements for welding multi-run test assemblies

The procedures used for the welding of multi-run test assemblies shall conform to the requirements given in Table 9A or Table 9B.

Table 9A — Pass and layer sequence for multi-run electrode classifications (classification by yield strength and 47 J impact energy)

Diameter mm	Passes per layer		Number of layers
	First layer	Other layers[a]	
0,8 0,9	1 or 2	2 or 3	6 to 9
1,0 1,2	1 or 2	2 or 3	6 to 9
1,4 1,6	1 or 2	2 or 3	5 to 8
2,0	1 or 2	2 or 3	5 to 8
2,4	1 or 2	2 or 3	4 to 8
2,8	1 or 2	2 or 3	4 to 7
3,2	1 or 2	2	4 to 7
4,0	1	2	4 to 7

[a] The final layer can have four passes.

Table 9B — Pass and layer sequence for multi-run electrode classifications (classification by tensile strength and 27 J impact energy)

Diameter mm	Required average heat input kJ/mm	Passes per layer		Number of layers
		First layer	Other layers[a]	
0,8 0,9	0,8 to 1,6	1 or 2	2 or 3	6 to 9
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
4,0	2,6 to 3,3	1	2	4 to 7

[a] The final layer can have four passes.

5.1.3 Post-weld heat treatment (PWHT) condition

5.1.3A Classification by yield strength and 47 J impact energy

No PWHT condition is used in this specification.

5.1.3B 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 °C ± 15 °C for 1 h ($^{+15}_{0}$ min). The furnace shall be at a temperature no higher than 315 °C when the test assembly is placed in it. The heating rate from that point to the 620 °C ± 15 °C holding temperature shall not exceed 220 °C/h. 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/h. The assembly can be removed from the furnace at any temperature below 315 °C and allowed to cool in still air to room temperature.

5.2 Single-run technique

Tensile tests shall be carried out in the as-welded condition using a test assembly type 2.1 or 2.3 in accordance with ISO 15792-2:2000. Impact testing is not required for single-run technique.

Test assembly and welding conditions shall correspond to the range recommended by the manufacturer and shall be recorded to demonstrate compliance with this International Standard.

6 Chemical analysis

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

7 Rounding procedure

For the purposes of determining compliance with the requirements of this International Standard, the actual test values obtained shall be subject to ISO 80000-1:2009, B.3, 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 arithmetic average value is to be compared to the requirements of this International Standard, rounding shall be done only after calculating the arithmetic average. If the test method cited in Clause 2 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.

8 Fillet weld test

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

8A 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 10A. Throat thickness, leg length, and convexity shall conform to the requirements of Table 10A.

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

Symbol of position for classification	Test position	Electrode size[a] mm	Throat thickness mm	Maximum leg length difference mm	Maximum convexity mm
1 or 2	PB	2,4	5,5 min.	2,0	3,0
3	PB	2,4	5,5 min.	2,0	3,0
5	PB	2,4[b]	5,5 min.	2,0	3,0
1 or 2	PF	2,4[c]	7,0 max.	–	2,0
1, 2 or 5	PD	1,2[d]	4,5 max.	1,5	2,5
1 or 5	PG	1,2[d]	4,5 max.	–	1,5[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.

8B Classification by tensile strength and 27 J impact energy

For the electrodes classified as symbol 0 in Table 6B, the fillet weld test shall be performed in the PB position. For the electrodes classified as symbol 1 in Table 6B, the fillet weld test shall be performed in the PE and PF or PG positions.

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.

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

a) maximum convexity

2,0 mm for < 7,0 mm in measured fillet weld size;

2,5 mm for ≥ 7,0 mm in measured fillet weld size;

b) maximum leg length difference (mm) = 0,5 × [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.

9 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 could 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 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.

10 Technical delivery conditions

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

11 Examples of designation

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

11A Classification by yield strength and 47 J impact energy

EXAMPLE 1:

A tubular cored electrode (T) for gas shielded arc welding deposits a weld metal with a minimum yield strength of 460 MPa (46) and a minimum average impact energy of 47 J at −30 °C (3) in the as-welded condition and has a chemical composition of 1,1 % Mn and 1,0 % Ni (1Ni). The electrode with a basic type core (B) was tested under mixed gas (M21) and can be used in all positions (1). Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100 g deposited metal (H5).

This is designated as follows:

ISO 17632 A – T46 3 1Ni B M21 1 H5

Compulsory section:

ISO 17632-A – T46 3 1Ni B M21

where

ISO 17632-A	is the number of this International Standard with classification by yield strength and 47 J impacts;
T	indicates a tubular cored electrode/metal arc welding (see 4.1);
46	represents the tensile properties (see Table 1A);
3	indicates impact properties of 47 J minimum (see Table 3);

11B Classification by tensile strength and 27 J impact energy

EXAMPLE 1:

A tubular cored electrode (T) for gas shielded arc welding deposits a weld metal with a minimum tensile strength of 550 MPa (55) and a minimum average impact energy of 27 J at −40°C (4) 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 (−40 °C). The electrode with a usability designator (T5) was tested using mixed gas (M21) and can be used in all positions (1). The weld deposit has a chemical composition of 1,1 % Mn and 1,0 % Ni (N_2). Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100 g deposited metal (H5).

This is designated as follows:

ISO 17632-B – T55 4 T5-1 M21 A-N2-U H5

Compulsory section:

ISO 17632-B – T55 4 T5-1 M21 A-N2

where

ISO 17632-B	is the standard number of this International Standard with classification by tensile strength and 27 J impacts;
T	indicates a tubular cored electrode;
55	represents the tensile properties (see Table 1B);
4	indicates impact properties of 27 J minimum (see Table 3);

1Ni	is the chemical composition of all-weld metal (see Table 4A);	T5	is the usability designator (see Table 5B);
B	is the type of electrode core (see Table 5A);	1	is the welding position (see Table 6B);
M21	is the shielding gas (see 4.6);	M21	is the shielding gas (see 4.6);
1	is the welding position (see Table 6A);	A	indicates tested in the as-welded condition;
H5	is the hydrogen content (see Table 7).	N2	is the chemical composition of all-weld metal (see Table 4B);
		U	indicates (optional designator) that the weld deposit in the as-welded condition will have impact properties of 47 J minimum at the classification test temperature;
		H5	is the hydrogen content (see Table 7).

EXAMPLE 2:

A tubular cored electrode (T) for gas shielded arc welding deposits a weld metal using a single-run technique with a minimum yield strength of 355 MPa (3T) and no impact requirement in the as-welded condition. The electrode with a rutile, slow freezing slag (R) was tested under CO_2 gas (C1) and can be used in flat and horizontal vertical position (3). Hydrogen is determined in accordance with ISO 3690 and does not exceed 10 ml/100 g deposited metal (H10).

This is designated as follows:

ISO 17632-A – T3T Z R C1 3 H10

Compulsory section:

ISO 17632-A – T3T Z R C1

where

ISO 17632-A	is the number of this International Standard with classification by yield strength and 47 J impacts;
T	indicates a tubular cored electrode/metal arc welding (see 4.1);

EXAMPLE 2:

A tubular cored electrode (T) for gas shielded arc welding deposits a weld metal using a single-run technique (S) with a minimum tensile strength of 490 MPa (49). The electrode with a usability designator (T2) was tested using CO_2 gas (C1) and can be used in flat and horizontal vertical position (0). The absence of a chemical composition designator indicates that the all-weld metal composition conforms to the “No symbol” (Table 4B). Hydrogen is determined in accordance with ISO 3690 and does not exceed 10 ml/100 g deposited metal (H10).

This is designated as follows:

ISO 17632-B – T49T2–0 C1 S H10

Compulsory section:

ISO 17632-B – T49T2–0 C1 S

where

ISO 17632-B	is the number of this International Standard with classification by tensile strength and 27 J impacts;
T	indicates a tubular cored electrode;

3T represents the tensile properties (see Table 2A);

Z indicates no impact requirement (see Table 3);

R is the type of electrode core (see Table 5A);

C1 is the shielding gas (see 4.6);

3 is the welding position (see Table 6A);

49 represents the tensile properties (see Table 2B);

T2 is the usability designator (see Table 5B);

0 is the welding position (see Table 6B);

C1 is the shielding gas (see 4.6);

S indicates classification is for single-run technique;

H10 is the hydrogen content (see Table 7).

EXAMPLE 3

Example for a tubular cored electrode with a chemical composition of all-weld metal (classification by yield strength and 47 J impact energy) not listed in Table 4A:

A tubular cored electrode (T) for gas shielded arc welding deposits a weathering steel weld metal with a minimum yield strength of 460 MPa (46) and a minimum average impact energy of 47 J at 0 °C (0) in the as-welded condition and has a chemical composition of 1,2 % Mn, 0,5 % Si, 0,5 % Ni, and 0,4 % Cu (Z).

The electrode with a metal core (M) was tested under mixed gas (M21) and can be used in all positions (1).

Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100 g deposited metal (H5).

This is designated as follows:

ISO 17632-A – T46 0 Z M M21 1 H5

Compulsory section:

ISO 17632-A – T46 0 Z M M21

where

ISO 17632-A is the number of this International Standard with classification by yield strength and 47 J impacts;

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

46	represents the tensile properties (see Table 1A);
A	indicates impact properties of 47 J, minimum (see Table 3);
Z	is the chemical composition of all-weld metal (see Table 4A);
M	is the type of electrode core (see Table 5A);
M21	is the shielding gas (see 4.6);
1	is the welding position (see Table 6A);
H5	is the hydrogen content (see Table 7).

Annex A
(informative)

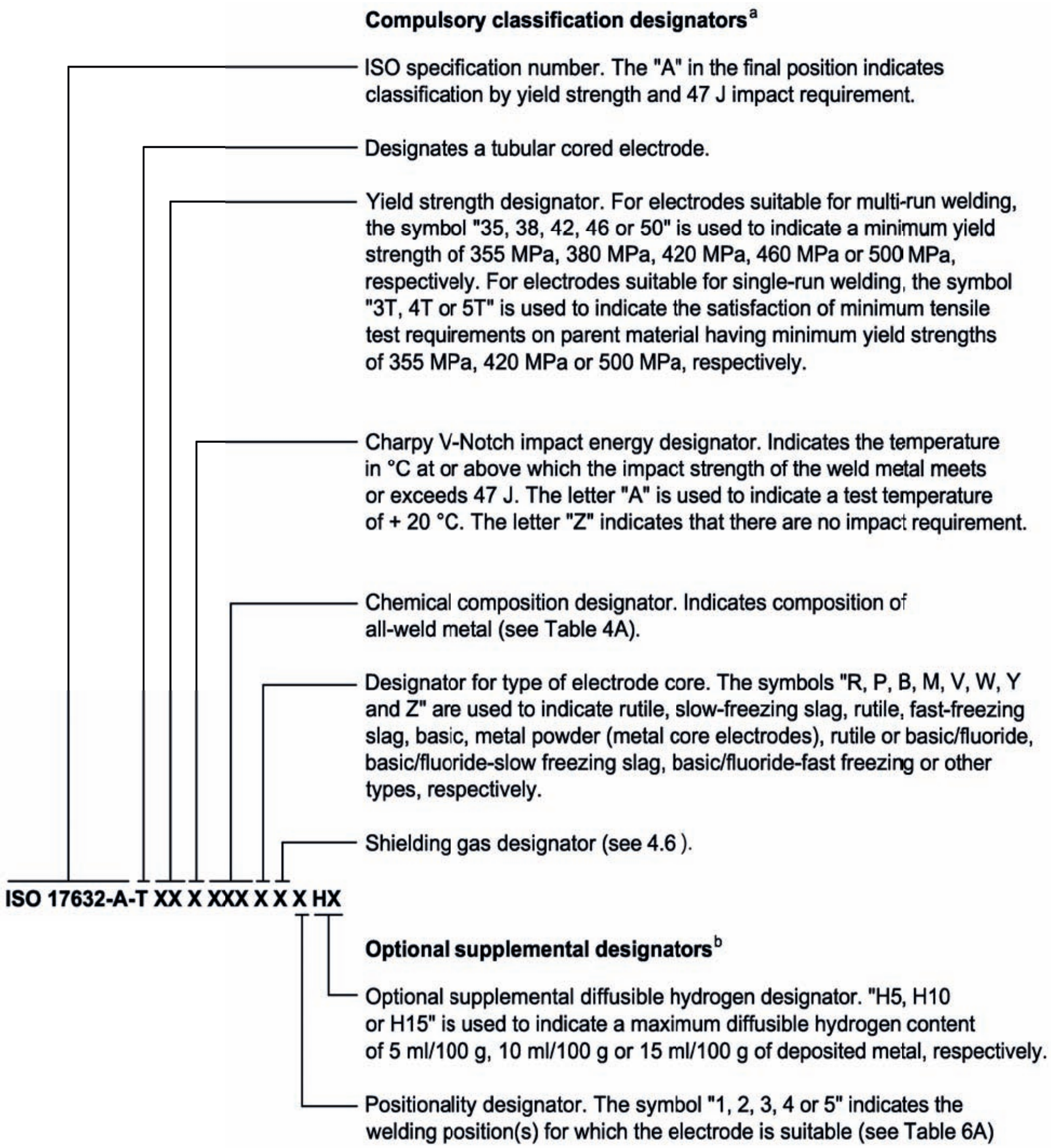
Classification systems

A.1 ISO 17632-A

The ISO 17632 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 17632-B

The ISO 17632 classification system for tubular cored electrodes based upon tensile strength and 27 J minimum impact strength is shown in Figure A.2.

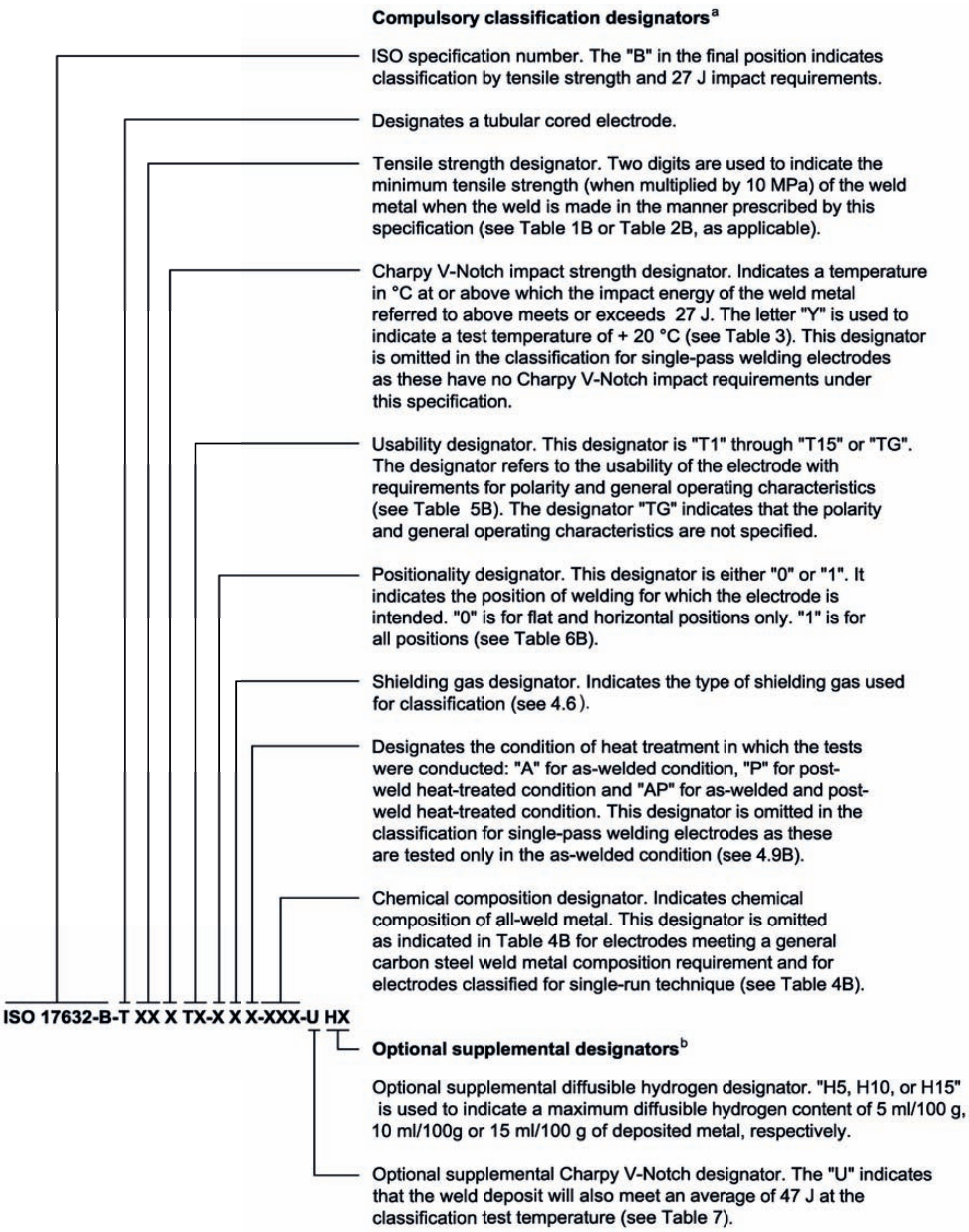


Key

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 — ISO 17632-A classification system for tubular cored electrodes based upon yield strength and 47 J minimum impact energy



Key

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

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

Figure A.2 — ISO 17632-B classification system for tubular cored electrodes based upon tensile strength and 27 J minimum impact energy

Annex B
(informative)

Description of types of electrode core in the classification system based upon yield strength and average impact energy of 47 J

B.1 R type

Tubular cored electrodes of the R type are characterized by a spray metal transfer, low spatter loss, and a rutile-based slag that fully covers the weld bead. These tubular cored electrodes are designed for single and multiple pass welding in the flat and horizontal-vertical position. Tubular cored electrodes of the R type are generally designed for use with carbon dioxide as shielding gas. However, argon/carbon dioxide mixtures can be used to improve arc transfer and reduce spatter when recommended by the manufacturer.

B.2 P type

Tubular cored electrodes of the P type are similar to the R type, but the rutile-based slag is designed for fast-freezing characteristics that enable welding in all positions. These tubular cored electrodes are generally produced in smaller diameters and exhibit spray metal transfer when using carbon dioxide shielding gas. The running characteristics can be improved with the use of argon/carbon dioxide mixtures when recommended by the manufacturer.

B.3 B type

Tubular cored electrodes of the B type are characterized by a globular metal transfer, slightly convex bead shape, and a slag that can or cannot cover the weld bead surface. These tubular cored electrodes are primarily used in the flat and horizontal-vertical welding positions with carbon dioxide or argon-based shielding gas mixtures. The slag composition consists of fluorides and alkaline earth metal oxides. Weld deposits produced with these tubular cored electrodes have superior impact properties and crack resistance.

B.4 M type

Tubular cored electrodes of the M type are characterized by a very fine droplet spray metal transfer and minimal slag cover. The core composition of these tubular cored electrodes consists of metal alloys and iron powder along with other arc enhancers which enable these tubular cored electrodes to produce high deposition rates with an insensitivity to lack of fusion. These tubular cored electrodes are primarily used with argon/carbon dioxide shielding gas mixtures in the flat and horizontal-vertical positions. However, welds in other positions are also possible using the short-circuiting or pulsed arc modes of transfer.

B.5 V type

Tubular cored electrodes of the V type are used without a gas shield and exhibit a slightly globular to spray metal transfer. The rutile or basic/fluoride slag system of these tubular cored electrodes includes a range from slow to fast freezing slag. Tubular cored electrodes with a slow slag freezing system are used for single-pass welding of galvanized, aluminized, or other coated steels in all positions. Tubular cored electrodes with a fast-freezing slag are designed for automatic welding at high speeds. These tubular cored electrodes are used for single-pass welds in the flat, horizontal-vertical, and limited inclined positions.

Some of the electrodes in the V type are recommended for material no thicker than 5 mm. Some tubular cored electrodes are primarily designed for root runs in circumferential pipe girth welds in all pipe thickness.

B.6 W type

Tubular cored electrodes of the W type are used without a gas shield and exhibit a globular to quasi-spray metal transfer. This basic/fluoride slag system is designed to make very high deposition rates possible. Some tubular cored electrodes have a metal powder addition in the core and provide good operability. The weld deposits are very low in sulfur and very resistant to cracking. Tubular cored electrodes of this type are used for single and multiple pass welding in the flat and horizontal-vertical welding positions. With some tubular cored electrodes, vertical down welding is possible.

B.7 Y type

Tubular cored electrodes of the Y type are used without a gas shield and exhibit a quasi-spray transfer. These basic/fluoride slag tubular cored electrodes are designed for single and multiple pass in all welding positions. They exhibit good crack resistance and low temperature impact properties.

B.8 Z type

Other types not covered by these descriptions.

Annex C
(informative)

Description of types of usability characteristics in the classification system based upon tensile strength and average impact energy of 27 J

C.1 Electrodes having a usability designator of “T1”

These electrodes have rutile type slags and are designed for single and multiple pass welding using d.c.(+) polarity. The larger diameters (usually 2,0 mm and larger) are used for welding in the flat position and for welding fillet welds in the horizontal position. The smaller diameters (usually 1,6 mm and smaller) are used for welding in all positions. These electrodes are characterized by a spray transfer, low spatter loss, flat to slightly convex bead contour, and a moderate volume of slag which completely covers the weld bead. Electrodes of this classification have a rutile base slag and produce high deposition rates.

C.2 Electrodes having a usability designator of “T2”

Electrodes of this type are similar to the “T1” types, but with higher manganese or silicon or both and are designed primarily for single pass welding in the flat position and for welding fillet welds in the horizontal position. The higher levels of deoxidizers in these classifications allow single pass welding of heavily oxidized or rimmed steel. Weld metal composition requirements are not specified for single pass electrodes since checking the composition of the undiluted weld metal will not provide an indication of the composition of a single pass weld. These electrodes give good mechanical properties in single pass welds.

C.3 Electrodes having a usability designator of “T3”

Electrodes of this type are self-shielded, used on d.c.(+), and have a spray-type transfer. The slag system is designed to make very high welding speeds possible. The electrodes are used for single pass welds in the flat, horizontal, and vertical (up to 20° incline) positions (downward progression) on sheet metal. Since these electrodes are sensitive to the effects of base metal quenching, they are not generally recommended for the following:

a) T- or lap joints in materials thicker than 5 mm.

b) Butt, edge, or corner joints in materials thicker than 6 mm.

The electrode manufacturer should be consulted for specific recommendations.

C.4 Electrodes having a usability designator of “T4”

Electrodes of this type are self-shielded, operate on d.c.(+), and have a globular type transfer. The basic slag system is designed to make very high deposition rates possible and to produce a weld that is very low in sulfur for improved resistance to hot cracking. These electrodes produce welds with low penetration enabling them to be used on joints with varying gaps and for single and multiple pass welding.

C.5 Electrodes having a usability designator of “T5”

Electrodes of this type are used primarily for single and multiple pass welds in the flat position and for welding fillet welds in the horizontal position using d.c.(+) or d.c.(−) depending on the manufacturer’s recommendation. These electrodes are characterized by a globular transfer, slightly convex bead contour, and a thin slag that might not completely cover the weld bead. These electrodes have a lime-fluoride base slag. Weld deposits produced by these electrodes typically have impact properties and hot and cold crack resistance that are superior to those obtained with rutile base slags. These electrodes using d.c.(−) can be used for welding in all positions. However, the operator appeal of these electrodes is not as good as that of those with rutile base slags.

C.6 Electrodes having a usability designator of “T6”

Electrodes of this type are self-shielded, operated on d.c.(+), and have a spray-type transfer. The slag system is designed to give good low temperature impact properties, good penetration into the root of the weld, and excellent slag removal even in a deep groove. These electrodes are used for single and multiple pass welding in flat and horizontal positions.

C.7 Electrodes having a usability designator of “T7”

Electrodes of this type are self-shielded, operate on d.c.(−) and have a small droplet to spray transfer. The slag system is designed to allow the larger sizes to be used for high deposition rates in the horizontal and flat positions and to allow the smaller sizes to be used for all welding positions. The electrodes are used for single and multiple pass welding and produce very low sulfur weld metal which is very resistant to hot cracking.

C.8 Electrodes having a usability designator of “T8”

Electrodes of this type are self-shielded, operate on d.c.(−), and have a small droplet or spray type transfer. These electrodes are suitable for all welding positions and the weld metal has very good low temperature notch toughness and crack resistance. These electrodes are used for single and multiple pass welds.

C.9 Electrodes having a usability designator of “T10”

Electrodes of this type are self-shielded, operate on d.c.(−), and have a small droplet transfer. The electrodes are used for single pass welds at high travel speeds on material of any thickness in the flat, horizontal, and vertical (up to 20° incline) positions.

C.10 Electrodes having a usability designator of “T11”

Electrodes of this type are self-shielded, operate on d.c.(−), and have a smooth spray-type transfer. They are general purpose electrodes for single and multiple pass welding in all positions. Some electrodes are designed for thin plate only. The manufacturer should be consulted regarding any plate thickness limitations.

C.11 Electrodes having a usability designator of “T12”

These electrodes are similar in arc transfer, welding characteristics, and deposition rates to the “T1” types. However, they have been modified to improve impact toughness and to meet the lower manganese requirements (1,60 % maximum). They therefore have an accompanying decrease in tensile strength and hardness. Since welding procedures influence all weld metal properties, users are urged to check hardness on any application where a maximum hardness level is a requirement.

C.12 Electrodes having a usability designator of “T13”

Electrodes of this type are self-shielded and operate on d.c.(−) and are usually welded with a short-arc transfer. The slag system is designed so that these electrodes can be used in all positions for the root pass on circumferential pipe welds. The electrodes can be used on all pipe wall thicknesses, but are only recommended for the first pass. They generally are not recommended for multiple pass welding.

C.13 Electrodes having a usability designator of “T14”

Electrodes of this type are self-shielded, operate on d.c.(−), and have a smooth spray-type transfer. They are intended for single pass welding. The slag system is designed with characteristics so that these electrodes can be used to weld in all positions and also to make welds at high speed. They are used to make welds on sheet metal up to 4,8 mm thick and often are specifically designed for galvanized, aluminized, or other coated steels. Since these welding electrodes are sensitive to the effects of base metal quenching, they are not generally recommended for the following:

a) T- or lap joints in materials thicker than 5 mm.

b) Butt, edge, or corner joints in materials thicker than 6 mm.

The electrode manufacturer should be consulted for specific recommendations.

C.14 Electrodes having a usability designator of “T15”

The core composition of these tubular electrodes consists of metal alloys and iron powder along with other arc enhancers which enable these tubular cored electrodes to produce high deposition rates with good resistance to lack of fusion. They are characterized by a very fine droplet spray metal transfer and minimal slag cover. They are primarily used with argon/CO_2 shielding gas mixtures in the flat and horizontal-vertical positions. However, welds in other positions are also possible using the short-circuiting or pulsed arc modes of transfer. d.c. (−) can also be used with advantages on certain applications.

C.15 Electrodes having a usability designator of “TG”

This designation is for electrodes that have usability characteristics not covered by any currently defined classification. The requirements for this classification are not specified. They are those that are agreed to by the purchaser and the supplier.

Annex D
(informative)

Notes on hydrogen content

D.1 Hydrogen-induced cracks

Cracks in welded joints can be caused or significantly influenced by hydrogen. The risk of hydrogen-induced cracks increases with rising alloy content and stress level. Such cracks generally develop after the joint has become cold and are therefore termed cold cracks.

Under given material and stress conditions, the risk of cold cracking diminishes with decreasing hydrogen content of the weld metal.

D.2 Hydrogen source in tubular cored electrode

Assuming that the external conditions are satisfactory (weld areas clean and dry), the hydrogen in the weld metal stems from hydrogen-containing compounds in the consumables. In the case of basic tubular cored electrodes, the water taken up by the core is the main source.

The water and hydrogen-containing compounds dissociate in the arc and give rise to atomic hydrogen which is absorbed by the weld metal.

D.3 Effect of operating condition on hydrogen level

The manufacturer can specify boundary conditions of tubular cored electrode diameter and operating conditions applicable to each hydrogen level achieved and does not exclude claims for more than one level where these arise under different operating conditions, e.g. shielding gases with high CO_2 contents generally give lower weld hydrogen levels than those with high argon contents and this can lead to a tubular cored electrode being differently categorized when used with different gases. Categorization of tubular cored electrodes is intended to provide the best basis for the calculation of preheat levels which characterizes a welding consumable by a single hydrogen level. Hydrogen levels generally decrease with increasing electrode extension and/or increasing the arc voltage and/or with decreasing tubular cored electrode feed speed (current). Care should be taken, however, that electrode extension and/or arc voltage and/or tubular cored electrode feed speed (current) are not adjusted to levels outside the manufacturer's recommendations.

ICS 25.160.20
Price based on 29 pages