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Welding consumables — Tubular cored electrodes for gas shielded metal arc welding of creep-resisting steels — Classification

Produits consommables pour le soudage — Fils-électrodes fourrés pour le soudage à l'arc avec gaz de protection des aciers résistant au fluage — Classification

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17634 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

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Introduction

This International Standard provides a classification system for tubular cored electrodes in terms of chemical composition of the all-weld metal, type of electrode core, type of shielding gas and welding position, or in terms of the tensile properties, chemical composition of the all-weld metal, usability characteristics of the electrodes, shielding gas and welding position. The ratio of proof to tensile strength of weld metal is generally higher than that of parent metal. Users should note that matching weld metal proof strength to parent metal proof strength will not necessarily ensure that the weld metal tensile strength matches that of the parent metal. Where the application requires matching tensile strength, therefore, selection of the consumable should be made by reference to column 4 of Table 2.

It should be noted 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 differences in welding procedure such as electrode size, width of weave, welding position and parent metal composition.

The classification according to system A is mainly based on EN 12071:1999, *Welding consumables — Tubular cored electrodes for gas shielded metal arc welding of creep-resisting steels — Classification*. The classification according to system B is mainly based upon standards used around the Pacific Rim.

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

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Welding consumables — Tubular cored electrodes for gas shielded metal arc welding of creep-resisting steels — Classification

1 Scope

This International Standard specifies requirements for classification of tubular cored electrodes used in the post-weld heat-treated condition for gas shielded metal arc welding of creep-resisting and low alloy elevated temperature steels. One tubular cored electrode can be tested and classified with different shielding gases.

This International Standard is a combined specification providing for classification utilizing a system based upon the chemical composition of all-weld metal or utilizing a system based upon the tensile strength, and the chemical composition 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 chemical composition, with requirements for 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 chemical composition 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 used for determining the electrode classification.

2 Normative references

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

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

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

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

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

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

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

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

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

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

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

3 Classification

Classification designations are based upon two approaches to indicate the chemical composition, 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 sections. In most cases, a given commercial product can be classified in both systems. Then either or both classification designations can be used for the product.

The classification 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 is based on the tubular cored electrode size 1,2 mm, or if this is not manufactured, the next larger diameter manufactured.

3.1A Classification by chemical composition

The classification is divided into six parts:

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

2) the second part gives a symbol indicating the chemical composition of all-weld metal (see Table 1);

3) the third part gives a symbol indicating the type of electrode core (see Table 3A);

4) the fourth part gives a symbol indicating the shielding gas (see 4.5 and 4.5A);

5) the fifth part gives a symbol indicating the welding position (see Table 4A);

6) the sixth part gives a symbol indicating the hydrogen content of deposited metal (see Table 5).

3.1B Classification by tensile strength and chemical composition

The classification is divided into seven parts:

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

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

3) the third part gives a symbol indicating the usability characteristics of the electrode (see Table 3B);

4) the fourth part gives a symbol indicating the welding position (see Table 4B);

5) the fifth part gives a symbol indicating the shielding gas (see 4.5 and 4.5B);

6) the sixth part gives a symbol indicating the chemical composition of all-weld metal (see Table 1);

7) the seventh part gives a symbol indicating the hydrogen content of deposited metal (see Table 5).

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

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3.2A Compulsory and optional section in the classification by chemical composition

a) Compulsory section

This section includes the symbols for the type of product, the chemical composition, the type of electrode core and the shielding gas, i.e. the symbols defined in 4.1, 4.2, 4.4A, 4.5 and 4.5A.

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 4.6 and 4.7.

3.2B Compulsory and optional section in the classification by tensile strength and chemical composition

a) Compulsory section

This section includes the symbols for the type of product, the strength and elongation in the post-weld heat-treated condition, the welding positions for which the electrode is suitable, the usability characteristics, the shielding gas, the impact properties and the chemical composition, i.e. the symbols defined in 4.1, 4.2, 4.3B, 4.4B, 4.5, 4.5B and 4.6.

b) Optional section

This section includes the symbol for hydrogen content, i.e. the symbol defined in 4.7.

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 gas shielded metal arc welding process is the letter T.

4.2 Symbol for the chemical composition of all-weld metal

The symbol in Table 1 indicates the chemical composition of all-weld metal determined in accordance with Clause 6.

4.3 Symbol for the mechanical properties of all-weld metal

4.3A Classification by chemical composition

No symbol shall be used for the mechanical properties of the all-weld metal. The all-weld metal obtained with the tubular cored electrodes in Table 1 under conditions given in Clause 5 shall also fulfil the mechanical property requirements specified in Table 2.

4.3B Classification by tensile strength and chemical composition

The symbol for tensile strength shall be 49 for 490 MPa to 670 MPa tensile strength, 55 for 550 MPa to 740 MPa tensile strength, 62 for 620 MPa to 820 MPa tensile strength, or 69 for 690 MPa to 890 MPa tensile strength. The complete mechanical property requirements that shall be fulfilled by the various compositions are specified in Table 2.

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Table 1 — Symbol for chemical composition of all-weld metal

Chemical composition [a] **symbol for classification according to**		**Chemical composition** (percentage mass fraction) [b,c]								
Chemical composition ISO 17634-A [d]	Tensile Strength and chemical composition ISO 17634-B [e]	**C**	**Mn**	**Si**	**P**	**S**	**Ni**	**Cr**	**Mo**	**V**
Mo	(2M3)	0,07 to 0,12	0,60 to 1,30	0,80	0,020	0,020	0,3	0,2	0,40 to 0,65	0,03
(Mo)	2M3	0,12	1,50	0,80	0,030	0,030	—	—	0,40 to 0,65	—
MoL		0,07	0,60 to 1,70	0,80	0,020	0,020	0,3	0,2	0,40 to 0,65	0,03
MoV		0,07 to 0,12	0,40 to 1,00	0,80	0,020	0,020	0,3	0,30 to 0,60	0,50 to 0,80	0,25 to 0,45
	CM	0,05 to 0,12	1,50	0,80	0,030	0,030	—	0,40 to 0,65	0,40 to 0,65	—
	CML	0,05	1,50	0,80	0,030	0,030	—	0,40 to 0,65	0,40 to 0,65	—
CrMo 1	(1CM)	0,05 to 0,12	0,40 to 1,30	0,80	0,020	0,020	0,3	0,90 to 1,40	0,40 to 0,65	0,03
(CrMo 1)	1CM	0,05 to 0,12	1,50	0,80	0,030	0,030	—	1,00 to 1,50	0,40 to 0,65	—
CrMo 1L	(1CML)	0,05	0,40 to 1,30	0,80	0,020	0,020	0,3	0,90 to 1,40	0,40 to 0,65	0,03
(CrMo 1L)	1CML	0,05	1,50	0,80	0,030	0,030	—	1,00 to 1,50	0,40 to 0,65	—
	1CMH	0,10 to 0,15	1,50	0,80	0,030	0,030	—	1,00 to 1,50	0,40 to 0,65	—
CrMo 2	(2C1M)	0,05 to 0,12	0,40 to 1,30	0,80	0,020	0,020	0,3	2,00 to 2,50	0,90 to 1,30	0,03
(CrMo 2)	2C1M	0,05 to 0,12	1,50	0,80	0,030	0,030	—	2,00 to 2,50	0,90 to 1,20	—
CrMo 2L	(2C1ML)	0,05	0,40 to 1,30	0,80	0,020	0,020	0,3	2,00 to 2,50	0,90 to 1,30	0,03
(CrMo 2L)	2C1ML	0,05	1,50	0,80	0,030	0,030	—	2,00 to 2,50	0,90 to 1,20	—
	2C1MH	0,10 to 0,15	1,50	0,80	0,030	0,030	—	2,00 to 2,50	0,90 to 1,20	—
CrMo 5	(5CM)	0,03 to 0,12	0,40 to 1,30	0,80	0,020	0,025	0,3	4,0 to 6,0	0,40 to 0,70	0,03
(CrMo 5)	5CM	0,05 to 0,12	1,50	1,00	0,030	0,030	0,40	4,0 to 6,0	0,45 to 0,65	—

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Table 1 (*continued*)

Chemical composition [a] **symbol for classification according to**		**Chemical composition** (percentage mass fraction) [b,c]								
Chemical composition ISO 17634-A [d]	Tensile Strength and chemical composition ISO 17634-B [e]	**C**	**Mn**	**Si**	**P**	**S**	**Ni**	**Cr**	**Mo**	**V**
	5CML	0,05	1,50	1,00	0,030	0,030	0,40	4,0 to 6,0	0,45 to 0,65	—
	9C1M	0,05 to 0,12	1,50	1,00	0,030	0,030	0,40	8,0 to 10,5	0,85 to 1,20	—
	9C1ML	0,05	1,50	1,00	0,030	0,030	0,40	8,0 to 10,5	0,85 to 1,20	—
	9C1MV [f]	0,08 to 0,13	1,20	0,50	0,020	0,015	1,00	8,0 to 10,5	0,85 to 1,20	0,15 to 0,30
	9C1MV1 [g]	0,05 to 0,12	1,25 to 2,00	0,50	0,020	0,015	1,00	8,0 to 10,5	0,85 to 1,20	0,15 to 0,30
Z	G	Any other agreed composition								

[a] A designation in parentheses [e.g., (CrMo1) or (1CM)] indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one without parentheses. A given product may, by having a more restricted chemical composition which fulfils both sets of designation requirements, be assigned both designations independently, provided that the mechanical property requirements of Table 2 are also satisfied.

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

[c] The results shall be rounded to the same number of significant figures as in the specified value using rule A in accordance with Annex B of ISO 31-0:1992 (see 4.8).

[d] Cu $\leqslant$ 0,3; Nb $\leqslant$ 0,1.

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

[f] Nb: 0,02 to 0,10; N: 0,02 to 0,07; Cu: $\leqslant$ 0,25; Al: $\leqslant$ 0,04.

[g] Nb: 0,01 to 0,08; N: 0,02 to 0,07; Cu $\leqslant$ 0,25; Al: $\leqslant$ 0,04.

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Table 2 — Mechanical properties of all-weld metal

Chemical composition [a] symbol for classification according to		Minimum [b] proof strength	Tensile strength	Minimum [d] elongation	Impact energy J at + 20 °C		Heat treatment of all-weld metal		
Chemical composition ISO 17634-A	Tensile strength and chemical composition ISO 17634-B				Minimum average from three test specimens	Minimum [e] single value	Preheat and interpass temperature	Post weld heat treatment of test assembly	
								Temperature	Time
		MPa	MPa	%			°C	°C	min
Mo	(2M3)	355	510 [c]	22	47	38	< 200	570 to 620 [f]	60 [g]
(Mo)	T49TX-X-2M3	390	490 to 670	18	—	—	135-165	605 to 635 [h]	60 [i]
(Mo)	T55TX-X-2M3	460	550 to 740	17	—	—	135-165	605 to 635 [h]	60 [i]
MoL		355	510 [c]	22	47	38	< 200	570 to 620 [f]	60 [g]
MoV		355	510 [c]	18	47	38	200 to 300	690 to 730 [f]	60 [g]
	T55TX-X-CM	460	550 to 740	17	—	—	160 to 190	675 to 705 [h]	60 [i]
	T55TX-X-CML	460	550 to 740	17	—	—	160 to 190	675 to 705 [h]	60 [i]
CrMo 1	(1CM)	355	510 [c]	20	47	38	150 to 250	660 to 700 [f]	60 [g]
(CrMo 1)	T55TX-X-1CM	460	550 to 740	17	—	—	160 to 190	675 to 705 [h]	60 [i]
CrMo 1L	(1CML)	355	510 [c]	20	47	38	150 to 250	660 to 700 [f]	60 [g]
(CrMo 1L)	T55TX-X-1CML	460	550 to 740	17	—	—	160 to 190	675 to 705 [h]	60 [i]
	T55TX-X-1CMH	460	550 to 740	17	—	—	160 to 190	675 to 705 [h]	60 [i]
CrMo 2	(2C1M)	400	500 [c]	18	47	38	200 to 300	690 to 750 [f]	60 [g]
(CrMo 2)	T62TX-X-2C1M	530	620 to 820	15	—	—	160 to 190	675 to 705 [h]	60 [i]
(CrMo 2)	T69TX-X-2C1M	600	690 to 890	14	—	—	160 to 190	675 to 705 [h]	60 [i]
CrMo 2L	(2C1ML)	400	500 [c]	18	47	38	200 to 300	690 to 750 [f]	60 [g]
(CrMo 2L)	T62TX-X-2C1ML	530	620 to 820	15	—	—	160 to 190	675 to 705 [h]	60 [i]
	T62TX-X-2C1MH	530	620 to 820	15	—	—	160 to 190	675 to 705 [h]	60 [i]
CrMo 5	(5CM)	400	590 [c]	17	47	38	200 to 300	730 to 760 [f]	60 [g]

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Table 2 (*continued*)

Chemical composition [a] symbol for classification according to		Minimum [b] proof strength	Tensile strength	Minimum [d] elongation	Impact energy J at + 20 °C		Heat treatment of all-weld metal		
Chemical composition ISO 17634-A	Tensile strength and chemical composition ISO 17634-B				Minimum average from three test specimens	Minimum [e] single value	Preheat and interpass temperature	Post weld heat treatment of test assembly	
								Temperature	Time
		MPa	MPa	%			°C	°C	min
(CrMo 5)	T55TX-X-5CM	460	550 to 740	17	—	—	150 to 250	730 to 760 [h]	60 [i]
	T55TX-X-5CML	460	550 to 740	17	—	—	150 to 250	730 to 760 [h]	60 [i]
	T55TX-X-9C1M	460	550 to 740	17	—	—	150 to 250	730 to 760 [h]	60 [i]
	T55TX-X-9C1ML	460	550 to 740	17	—	—	150 to 250	730 to 760 [h]	60 [i]
	T69TX-X-9C1MV [f]	565	690 to 890	14	—	—	150 to 250	730 to 760 [h]	60 [i]
	T69TX-X-9C1MV1 [f]	565	690 to 890	14	—	—	150 to 250	730 to 760 [h]	60 [i]
Z	TXXTX-X-G	As agreed between purchaser and supplier							

[a] A designation in parentheses [e.g., (CrMo1) or (1CM)] indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one without parentheses. A given product may, by having a more restricted chemical composition which fulfils both sets of designation requirements, be assigned both designations independently, provided that the mechanical property requirements of Table 2 are also satisfied.

[b] The 0,2% proof strength, $R_{p0,2}$, is used.

[c] Minimum tensile strength.

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

[e] Only one single value lower than minimum average is permitted.

[f] The test assembly shall be cooled in the furnace to 300 °C at a rate not exceeding 200 °C/h.

[g] Tolerance shall be $^{+10}_{-10}$ min.

[h] 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 holding temperature, shall not exceed 280 °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 may be removed from the furnace at any temperature below 315 °C and allowed to cool in still air, to room temperature.

[i] Tolerance shall be $^{+15}_{0}$ min.

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

4.4A Classification by chemical composition

The symbol in Table 3A indicates different types of tubular cored electrodes relative to their core composition and slag characteristics. Manufacturers shall provide information on recommended polarity.

Table 3A — Symbol for type of electrode core (Classification by chemical composition)

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

4.4B Classification by tensile strength and chemical composition

The symbol in Table 3B indicates the usability characteristics of the electrodes.

Table 3B — Usability characteristics (Classification by tensile strength and chemical composition)

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

[a] See Table 4B.

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

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4.5 Symbol for shielding gas

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

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

4.5A Classification by chemical composition

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

4.5B Classification by tensile strength and chemical composition

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

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

4.6 Symbol for welding position

The symbol in Table 4A or Table 4B indicates the positions for which the electrode is suitable for classification to ISO 17634-A or ISO 17634-B in accordance with ISO 15792-3. PA, PB, PC, PD, PE, PF and PG are the symbols specified in ISO 6947:1990. See Clause 7 for testing requirements.

Table 4A — Symbol for welding position (Classification by chemical composition)

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

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

Table 4B — Symbol for welding position (Classification by tensile strength and chemical composition)

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

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4.7 Symbol for hydrogen content of deposited metal

The symbol in Table 5 indicates the hydrogen content determined in accordance with the method given in ISO 3690.

Table 5 — Symbol for hydrogen content of deposited metal

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

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

Diffusible hydrogen shall be determined in accordance with ISO 3690.

4.8 Rounding-off procedure

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

5 Mechanical tests

5.1 Tensile and impact tests

Tensile and impact tests shall be carried out on weld metal 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, or if this size is not manufactured the next larger diameter manufactured, and welding conditions as described in 5.2 and 5.3.

5.2 Preheating and interpass temperatures

Preheating and interpass temperatures shall be selected for the appropriate weld metal type from Table 2. 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 2. 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.

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5.3 Pass sequence

The procedures used for the welding of multi-run test assemblies shall conform to the requirements given in Table 6A or Table 6B.

Table 6A — Pass and layer sequence (Classification by chemical composition)

Diameter mm	Passes per layer		Number of layers	Total number of passes
	First layer	Other layers [a]		
1,2	1 or 2	2 or 3	6 to 9	12 to 19
1,4 to 2,0	1 or 2	2 or 3	5 to 8	10 to 17
2,4 to 3,2	1 or 2	2 or 3	4 to 7	7 to 14

[a] The final layer may have four passes.

Table 6B — Pass and layer sequence (Classification by tensile strength and chemical composition)

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	1,2 to 2,0	1 or 2	2 or 3	6 to 9
1,4 1,6	1,4 to 2,2	1 or 2	2 or 3	5 to 8
2,0	1,8 to 2,4	1 or 2	2 or 3	5 to 8
2,4	2,0 to 2,6	1 or 2	2 or 3	4 to 8
2,8	2,0 to 2,8	1 or 2	2 or 3	4 to 7
3,2	2,2 to 3,0	1 or 2	2	4 to 7

[a] The final layer may have four passes.

6 Chemical analysis

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

7 Fillet weld test

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

7A Classification by chemical composition

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 7A. Throat thickness, leg length and convexity shall conform to the requirements of Table 7A.

7B Classification by tensile strength and chemical composition

For the electrodes classified as symbol 0 in Table 4B, the fillet weld test shall be performed in the PB position. For the electrodes classified as symbol 1 in Table 4B, the fillet weld test shall be performed in positions PE and PF or PG.

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.

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Table 7A — Test requirements for fillet welds (Classification by chemical composition)

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.	Not specified	2,0
1, 2 or 5	PD	1,2 [d]	4,5 max.	1,5	2,5
5	PG	1,2 [d]	4,5 min.	Not specified	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.

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

a) Maximum convexity
2,0 mm for $<$ 7,0 mm in measured fillet weld size
2,5 mm for $\geqslant$ 7,0 mm in measured fillet weld size

b) Maximum leg length difference (mm) = 0,5 $\times$ [fillet weld size (mm)] – 0,5

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

8 Retests

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

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

9 Technical delivery conditions

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

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10 Example of designation

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

10A Classification by chemical composition

A tubular cored electrode (T) for gas shielded metal arc welding deposits a weld metal with a chemical composition within the limits of the alloy symbol CrMo1 of Table 1. The electrode with a basic type core (B) was tested under mixed gas (M) and may be used in flat butt and flat fillet welds (4). Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100g deposited metal (H5).

This is designated as follows:

ISO 17634-A - T CrMo1 B M 4 H5

Compulsory section:

ISO 17634-A - T CrMo1 B M

where

ISO 17634-A is the number of this International Standard, with classification by chemical composition;

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

CrMo1 is the chemical composition of all-weld metal (see Table 1);

B is the type of electrode core (see Table 3A);

M is the shielding gas (see 4.5);

4 is the welding position (see Table 4A);

H5 is the hydrogen content (see Table 5).

10B Classification by tensile strength and chemical composition

A tubular cored electrode (T) for gas shielded metal arc welding deposits a weld metal with a minimum tensile strength in the post-weld heat-treated condition of 550 MPa (55) and has a chemical composition within the limits of the alloy symbol 1CM of Table 1. The electrode with a lime-fluoride slag (T5) was tested under Ar + 20 % to 25 % CO_2 (M) and may be used in flat and horizontal vertical position (0). Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100g deposited metal (H5).

This is designated as follows:

ISO 17634-B - T55T5-0M-1CM-H5

Compulsory section:

ISO 17634-B - T55T5-0M-1CM

where

ISO 17634-B is the number of this International Standard, with classification by tensile strength and chemical composition;

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

55 represents the tensile properties (see Table 2);

T5 is the usability designator (see Table 3B);

0 is the welding position (see Table 4B);

M is the shielding gas (see 4.5);

1CM is the chemical composition of all-weld metal (see Table 1);

H5 is the hydrogen content (see Table 5).

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Annex A
(informative)

Classification systems

A.1 ISO 17634-A

The ISO 17634 classification system for tubular cored electrodes based upon chemical composition is shown in Figure A1.

A.2 ISO 17634-B

The ISO 17634 classification system for tubular cored electrodes based upon tensile strength and chemical composition is shown in Figure A2.

Compulsory classification designators[a]

ISO specification number. The "A" in the final position indicates classification by chemical composition.

Designates a tubular cored electrode.

Chemical composition designator. Indicates composition of all-weld metal (see Table 1).

Designator for type of electrode core. The symbols "R, P, B, M and Z" are used to indicate rutile, slow-freezing slag, rutile, fast-freezing slag, basic, metal powder (metal core electrodes), or other types, respectively.

Shielding gas designator (see 4.5 and 4.5A).

ISO 17634-A-T XXX X X X HX

Optional supplemental designators[b]

Optional supplemental diffusible hydrogen designator. "H5, H10 or H15" is used to indicate a maximum diffusible hydrogen content of 5 ml/100 g, 10 ml/100 g or 15 ml/100 g of deposited metal, respectively.

Positionality designator. The symbol "1, 2, 3, 4 or 5" indicates the welding position(s) for which the electrode is suitable (see Table 4A).

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 17634-A classification system for tubular cored electrodes based upon chemical composition

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Compulsory classification designators[a]

ISO specification number. The "B" in the final position indicates classification by tensile strength and chemical composition.

Designates a tubular cored electrode.

Tensile strength designator. Two digits are used to indicate the minimum tensile strength (when multiplied by 10 MPa) of the weld metal when the weld is made in the manner prescribed by this specification (see 4.3B).

Usability designator. This designator is from the symbol "T1", "T5" or "T15", or the symbol "TG". The designator refers to the usability of the electrode with requirements for polarity and general operating characteristics (see Table 3B). The symbol "TG" indicates that the polarity and general operating characteristics are not specified.

Positionality designator. This designator is either "0" or "1". It indicates the position of welding for which the electrode is intended. "0" is for flat and horizontal positions only. "1" is for all positions.

Shielding gas designator. Indicates the type of shielding gas used for classification (see 4.5 and 4.5B).

Chemical composition designator. Indicates chemical composition of all-weld metal (see Table 1B).

ISO 17634-B-T XX TX-X X-XXX-HX

Optional supplemental designators[b]

Optional supplemental diffusible hydrogen designator. "H5, H10 or H15" is used to indicate a maximum diffusible hydrogen content of 5 ml/100 g, 10 ml/100 g or 15 ml/100 g of deposited metal, respectively.

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

b This designator is optional and does not constitute a part of the tubular cored electrode classification.

Figure A.2 — ISO 17634-B classification system for tubular cored electrodes based upon tensile strength and chemical composition.

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Annex B
(informative)

Description of composition designations of electrode in the classification system based upon tensile strength and chemical composition

B.1 XMX type

For an electrode containing molybdenum as the only alloying element which differentiates it from a non-alloy steel electrode, the designation consists of an integer approximately equal to twice the nominal manganese content, followed by the letter “M” to indicate molybdenum, and a digit to indicate the nominal molybdenum level, as follows:

1 = about 0,25 % Mo = low Mo

2 = about 0,4 % Mo = medium Mo

3 = about 0,5 % Mo = high Mo

4 = about 0,7 % Mo = extra high Mo

B.2 XCXMX type

For chromium-molybdenum steels, the designation consists of “C” preceded by an integer to indicate the nominal chromium level, and “M” preceded by an integer to indicate the nominal molybdenum level. For either chromium or molybdenum, if the nominal level is appreciably less than 1 %, there is no preceding integer. If vanadium is added, the corresponding letter “V” is added after the chromium and molybdenum symbols. Deliberately high carbon is indicated by “H” at the end of the designation, while deliberately low carbon is indicated by “L” at the end of the designation. Variations of a basic composition are indicated by an arbitrary integer following the last letter.

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Annex C
(informative)

Description of types of electrode core in the classification system based upon chemical composition

C.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 positions. 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.

C.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.

C.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 may or may not 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.

C.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.

C.5 Z type

Other types not covered by these descriptions.

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Annex D
(informative)

Description of types of usability characteristics in the classification system based upon tensile strength and chemical composition

D.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.

D.2 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 may 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.

D.3 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 some applications.

D.4 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 upon by the purchaser and the supplier.

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Annex E
(informative)

Notes on hydrogen content

E.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.

E.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.

E.3 Effect of operating condition on hydrogen level

The manufacturer may 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 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.

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