British Standard

BRITISH STANDARD

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

The European Standard EN 12071:1999 has the status of a British Standard

ICS 25.160.20

National foreword

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The UK participation in its preparation was entrusted to Technical Committee WEE/39, Welding consumables, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Produits consommables pour le soudage - Fils fourrés pour le soudage à l'arc sous protection gazeuse des aciers résistant au fluage - Classification

Schweißzusätze - Fülldrahtelektroden zum Metall-Schutzgasschweißen von warmfesten Stählen - Einteilung

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Contents **Page**

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 121, Welding, the Secretariat of which is held by DS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2000, and conflicting national standards shall be withdrawn at the latest by April 2000.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

For creep-resisting steel welding consumables it should be noted that the mechanical properties of all-weld metal test specimens used for classification will vary from those obtained in production joints because of differences in welding conditions, material composition and shielding gas.

Although tubular cored electrodes supplied by individual companies can have the same grading, the individual electrodes from different companies are not interchangeable unless verified in accordance with this standard.

1 Scope

This standard specifies requirements for classification of tubular cored electrodes used in gas shielded metal arc welding of creep-resisting and low alloy elevated temperature steels. The classification is based on the chemical composition of the all-weld metal.

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

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 439	Shielding gases for arc welding and cutting
EN 759	Welding consumables - Technical delivery conditions for welding filler metals - Type of product, dimensions, tolerances and marking
EN 1597-1	Welding consumables - Test methods - Part 1: Test piece for all-weld metal test specimens in steel, nickel and nickel alloys
EN 1597-3	Welding consumables - Test methods - Part 3: Testing of positional capability of welding consumables in a fillet weld
EN ISO 13916	Welding - Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature (ISO 13916:1996)

prEN ISO 3690	Welding and allied processes - Determination of hydrogen content in ferritic arc weld metal (ISO/DIS 3690:1998)
ISO 31-0:1992	Quantities and units - Part 0: General principles

3 Classification

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

The classification is divided into six parts:

1) the first part gives a symbol indicating the product/process to be identified;

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

3) the third part gives a symbol indicating the type of electrode core;

4) the fourth part gives a symbol indicating the shielding gas;

5) the fifth part gives a symbol indicating the welding position;

6) the sixth part gives a symbol indicating the hydrogen content of deposited metal.

In order to promote the use of this standard, the classification is split into two sections:

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**, **4.3** and **4.4**;

b) Optional section

This section includes the symbols for the welding positions for which the electrode is suitable, and the symbol for the hydrogen content, i.e. the symbols defined in **4.5** and **4.6**.

The full identification (see clause **8**) 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**. The all-weld metal obtained with the tubular cored electrodes in Table 1 under conditions given in clause **5** shall also fulfil the requirements in Table 2.

Table 1: Symbol for the chemical composition of all-weld metal

Symbol	Chemical composition in % (m/m) [1)2)3)]							
	C	Si	Mn	P	S	Cr	Mo	V
Mo	0,07 to 0,12	0,80	0,60 to 1,30	0,020	0,020	-	0,40 to 0,65	-
MoL	0,07	0,80	0,60 to 1,70	0,020	0,020	-	0,40 to 0,65	-
MoV	0,07 to 0,12	0,80	0,40 to 1,00	0,020	0,020	0,30 to 0,60	0,50 to 0,80	0,25 to 0,45
CrMo1	0,05 to 0,12	0,80	0,40 to 1,30	0,020	0,020	0,90 to 1,40	0,40 to 0,65	-
CrMo1L	0,05	0,80	0,40 to 1,30	0,020	0,020	0,90 to 1,40	0,40 to 0,65	-
CrMo2	0,05 to 0,12	0,80	0,40 to 1,30	0,020	0,020	2,00 to 2,50	0,90 to 1,30	-
CrMo2L	0,05	0,80	0,40 to 1,30	0,020	0,020	2,00 to 2,50	0,90 to 1,30	-
CrMo5	0,03 to 0,12	0,80	0,40 to 1,30	0,020	0,025	4,00 to 6,00	0,40 to 0,70	-
Z	Any other agreed composition							

1) If not specified: Ni < 0,3, Cu < 0,3, V < 0,03, Nb < 0,01, Cr < 0,2.
2) Single values shown in the table are maximum values.
3) The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with annex B, Rule A of ISO 31-0:1992.

Table 2: Mechanical properties of all-weld metal

Symbol	Minimum proof strength $R_{p0,2}$ N/mm^2	Minimum tensile strength R_m N/mm^2	Minimum [1] elongation A %	Impact energy K_V (J) at +20 °C		Heat treatment of all-weld metal		
				Minimum average from three test specimens J	Minimum [2] single value J	Preheat and interpass temperature °C	Post weld heat treatment of test assembly	
							Tempera-ture [3] °C	Time [4] min
Mo/MoL	355	510	22	47	38	< 200	570 to 620	60
MoV	355	510	18	47	38	200 to 300	690 to 730	60
CrMo1	355	510	20	47	38	150 to 250	660 to 700	60
CrMo1L	355	510	20	47	38	150 to 250	660 to 700	60
CrMo2	400	500	18	47	38	200 to 300	690 to 750	60
CrMo2L	400	500	18	47	38	200 to 300	690 to 750	60
CrMo5	400	590	17	47	38	200 to 300	730 to 760	60
Z	Any other agreed mechanical properties							

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

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

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

[4] Tolerance ± 10 min.

4.3 Symbol for type of electrode core

The symbol in Table 3 indicates different types of tubular cored electrodes relative to their core composition and slag characteristics.

Table 3: Symbol for type of electrode core

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 A.

4.4 Symbol for shielding gas

The symbols M and C indicate the shielding gas as described in accordance with EN 439.

The symbol M, for mixed gases, shall be used when the classification has been performed with shielding gas EN 439 - M2, but without helium.

The symbol C shall be used when the classification has been performed with shielding gas EN 439 - C1, carbon dioxide.

4.5 Symbol for welding position

The symbol below for welding positions indicates the positions for which the electrode is tested in accordance with EN 1597-3:

1 all positions;

2 all positions, except vertical down;

3 flat butt weld, flat fillet weld, horizontal-vertical fillet weld;

4 flat butt weld, flat fillet weld;

5 vertical down and positions according to symbol 3.

4.6 Symbol for hydrogen content in deposited metal

The symbol in Table 4 indicates the hydrogen content determined in deposited metal in accordance with the method given in prEN ISO 3690. The electrode diameter used shall be 1,2 mm, or if this diameter is not manufactured the next larger size available.

Table 4: Symbol for hydrogen content in deposited metal

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

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

NOTE 1: Other methods of collection and measurement of the diffusible hydrogen can be used for batch testing provided they possess equal reproducibility with, and are calibrated against, the method given in prEN ISO 3690.

NOTE 2: 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.

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

The water dissociates in the arc and gives rise to atomic hydrogen which is absorbed by the weld metal.

Under given material and stress conditions the risk of cold cracking diminishes with decreasing hydrogen content of the weld metal; also the application of prescribed preheat and interpass temperatures substantially reduces the risk of cold cracking.

5 Mechanical tests

Tensile and impact tests and any required retests shall be carried out in the post weld heat treated condition as specified in Table 2 using an all-weld metal test assembly type 3 in accordance with EN 1597-1 and welding conditions as described below in **5.1** and **5.2**.

5.1 Preheating and interpass temperatures

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

The preheating and interpass temperatures shall be measured using temperature indicator crayons, surface thermometers or thermocouples in accordance with EN ISO 13916.

The interpass temperature shall not exceed the maximum temperature indicated in Table 2.

If, after any pass, the interpass temperature is exceeded, the test assembly shall be cooled in air to a temperature within the limits of the interpass temperature.

5.2 Pass sequence

The pass sequence shall be as indicated in Table 5.

The direction of welding to complete a layer consisting of several passes shall not vary, but the direction of welding of layers shall be alternated.

Table 5: Pass sequence

Tubular cored electrode diameter mm	Total number of passes	Passes per layer		Total number of layers
		First layer	Other layers[1)]	
1,2	12 to 19	1 or 2	2 or 3	6 to 9
1,4 to 2,0	10 to 17	1 or 2	2 or 3	5 to 8
2,4 to 3,2	7 to 14	1 or 2	2 or 3	4 to 7

[1)] The final layer can have four passes.

6 Chemical analysis

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

NOTE: See Bibliography.

7 Technical delivery conditions

Technical delivery conditions shall meet the requirements of EN 759.

8 Designation

The designation of tubular cored electrodes shall follow the principle given in the example below.

EXAMPLE:

A tubular cored electrode (T) for gas shielded arc welding deposits 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) (see **4.4**) and can be used in flat butt and flat fillet welds (4). Hydrogen is determined in accordance with prEN ISO 3690 and does not exceed 5 ml/100 g deposited weld metal (H5).

The designation shall be:

Tubular cored electrode EN 12071 - T CrMo1 B M 4 H5

Compulsory section:

Tubular cored electrode EN 12071 - T CrMo1 B M

where:

EN 12071	= standard number;
T	= tubular cored electrode/gas shielded metal arc welding (see **4.1**);
CrMo1	= chemical composition of all-weld metal (see Table 1);
B	= type of electrode core (see **4.3**);
M	= shielding gas (see **4.4**);
4	= welding position (see **4.5**);
H5	= hydrogen content in deposited metal (see Table 4).

Annex A (informative)

Description of types of electrode core

A.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, the use of argon/carbon dioxide mixtures, when recommended by the manufacturer, can be used to improve arc transfer and reduce spatter.

A.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.

A.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 can 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.

A.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.

A.5 Z type

Other types not covered by these descriptions.

Bibliography

[1] Handbuch für das Eisenhüttenlaboratorium, VdEh, Düsseldorf.

[2] BS 6200-3 Sampling and analysis of iron, steels and other ferrous metals - Part 3: Methods of analysis.

[3] CEN/CR 10261 ECISS Information Circular 11 - Iron and Steel - Review of available methods of chemical analysis.

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