British Standard

BRITISH STANDARD

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1599 : 1997

Welding consumables — Covered electrodes for manual metal arc welding of creep-resisting steels — Classification

The European Standard EN 1599 : 1997 has the status of a British Standard

ICS 25.160.20

National foreword

This British Standard is the English language version of EN 1599 : 1997. Together with BS EN 757 : 1997, it supersedes BS 2493 : 1985, which is withdrawn.

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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Summary of pages

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Welding consumables — Covered electrodes for manual metal arc welding of creep-resisting steels — Classification

Produits consommables pour le soudage — Electrodes enrobées pour le soudage manuel à l'arc des aciers résistant au fluage — Classification

Schweißzusätze — Umhüllte Stabelektroden zum Lichtbogenhandschweißen von warmfesten Stählen — Einteilung

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CEN

European Committee for Standardization
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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of an identical text or by endorsement, at the latest by February 1998, and conflicting national standards shall be withdrawn at the latest by February 1998.

In normative references, reference is made to ISO 3690. It should be noted that a European Standard is under preparation for the same subject in CEN/TC 121/SC 3.

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.

Contents

Introduction

This standard proposes a classification in order to designate covered electrodes in terms of the chemical composition of the all-weld metal.

It should be noted that the mechanical properties of all-weld metal test specimens used to classify the electrodes will vary from those obtained in production joints because of differences in welding procedure such as electrode diameter, width of weave, welding position and material composition.

1 Scope

This standard specifies requirements for classification of covered electrodes based on the all-weld metal in the heat-treated conditions for manual metal arc welding of ferritic and martensitic creep-resisting and low-alloy elevated-temperature steels.

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 759	*Welding consumables — Technical delivery conditions for welding filler metals — Type of product, dimensions, tolerances and marking*
prEN 1597-1	*Welding consumables — Test methods — Part 1: Test assembly for all-weld metal test specimens in steel, nickel and nickel alloys*
prEN 1597-3	*Welding consumables — Test methods — Part 3: Classification testing of positional capability of welding consumables in a fillet weld*
EN ISO 13916	*Welding — Guide for measurement of preheating temperature, interpass temperature and preheat maintenance temperature* (ISO 13916 : 1996)
EN 22401	*Covered electrodes — Determination of the efficiency, metal recovery and deposition coefficient* (ISO 2401 : 1972)
ISO 31-0 : 1992	*Quantities and units — Part 0: General principles*
ISO 3690 : 1977	*Welding — Determination of hydrogen in deposited weld metal arising from the use of covered electrodes for welding mild and low alloy steels*

3 Classification

The classification includes all-weld metal properties obtained with a covered electrode as given below. The classification is based on an electrode diameter of 4 mm, with the exception of the testing for welding position, which is based on a diameter of 3,2 mm.

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 the all-weld metal.

3) The third part gives a symbol indicating the type of electrode covering.

4) The fourth part gives a symbol indicating the weld metal recovery and the type of current.

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 facilitate 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 and the type of covering, i.e. the symbols defined in **4.1, 4.2** and **4.3**.

b) *Optional section*

This section includes the symbols for the weld metal recovery, the type of current and the welding positions for which the electrode is suitable, and the symbol for hydrogen content, i.e. the symbols defined in **4.4, 4.5** and **4.6**.

The full designation (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 covered electrode used in the manual metal arc welding process shall be the letter E.

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 covered electrodes in table 1 in accordance with clause **5** shall also fulfil the mechanical property requirements specified in table 2.

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

Symbol	Chemical composition[1) 2) 3)] % *m/m*								
	C	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**V**	**Other elements**
Mo	0,10	0,80	0,40 to 1,50[4)]	0,030	0,025	—	0,40 to 0,70	—	—
MoV	0,03 to 0,12	0,80	0,40 to 1,50	0,030	0,025	0,30 to 0,60	0,80 to 1,20	0,25 to 0,60	—
CrMo0,5	0,05 to 0,12	0,80	0,40 to 1,50	0,030	0,025	0,40 to 0,65	0,40 to 0,65	—	—
CrMo1	0,05 to 0,12	0,80	0,40 to 1,50[4)]	0,030	0,025	0,90 to 1,40	0,45 to 0,70	—	—
CrMo1L	0,05	0,80	0,40 to 1,50[4)]	0,030	0,025	0,90 to 1,40	0,45 to 0,70	—	—
CrMoV1	0,05 to 0,15	0,80	0,70 to 1,50	0,030	0,025	0,90 to 1,30	0,90 to 1,30	0,10 to 0,35	—
CrMo2	0,05 to 0,12	0,80	0,40 to 1,30	0,030	0,025	2,0 to 2,6	0,90 to 1,30	—	—
CrMo2L	0,05	0,80	0,40 to 1,30	0,030	0,025	2,0 to 2,6	0,90 to 1,30	—	—
CrMo5	0,03 to 0,12	0,80	0,40 to 1,50	0,025	0,025	4,0 to 6,0	0,40 to 0,70	—	—
CrMo9	0,03 to 0,12	0,80	0,40 to 1,30	0,025	0,025	8,0 to 10,0	0,90 to 1,20	0,15	Ni 1,0
CrMo91	0,06 to 0,12	0,60	0,40 to 1,50	0,025	0,025	8,0 to 10,5	0,80 to 1,20	0,15 to 0,30	Ni 0,40 to 1,00 Nb 0,03 to 0,10 N 0,02 to 0,07
CrMoWV12	0,15 to 0,22	0,80	0,40 to 1,30	0,025	0,025	10,0 to 12,0	0,80 to 1,20	0,20 to 0,40	Ni 0,8 W 0,40 to 0,60
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 rule A in accordance with annex B of ISO 31-0 : 1992.

[4)] Mn contents of 0,4 % to 0,9 % are usual for electrodes with rutile covering, and Mn contents of 0,7 % to 1,5 % for electrodes with basic covering.

Table 2. Mechanical properties of all-weld metal

Symbol	Minimum yield strength R_{eL} [1]	Minimum tensile strength R_m	Minimum elongation A [2]	Impact energy K_V at +20 °C J		Heat treatment of all-weld metal		
				Minimum average from three test specimens	Minimum single value [3]	Preheat and interpass temperature	Post-weld heat treatment of test assembly	
							Temperature [4]	Time [5]
	N/mm²	N/mm²	%			°C	°C	min
Mo	355	510	22	47	38	< 200	570 to 620	60
MoV	355	510	18	47	38	200 to 300	690 to 730	60
CrMo0,5	355	510	22	47	38	100 to 200	600 to 650	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
CrMoV1	435	590	15	24	19	200 to 300	680 to 730	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
CrMo9	435	590	18	34	27	200 to 300	740 to 780	120
CrMo91	415	585	17	47	38	200 to 300	750 to 770	120 to 180
CrMoWV12	550	690	15	34	27	250 to 350 [6] or 400 to 500 [6]	740 to 780	120

[1] For yield strength the lower yield (R_{eL}) shall be used when yielding occurs, otherwise the 0,2 % proof strength ($R_{po,2}$) shall be used.

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

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

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

[5] Tolerance ± 10 min.

[6] Immediately after welding, the specimen is to be cooled down to 120 °C to 100 °C and kept at this temperature for at least 1 h.

4.3 Symbol for type of electrode covering

The type of covering of the electrodes determines to a large extent the usability characteristics of the electrode and the properties of the weld metal.

Two symbols are used to denote the type of covering:

– R rutile covering;

– B basic covering.

NOTE. A description of the characteristics of each of the types of covering is given in annex A.

4.4 Symbol for weld metal recovery and type of current

The symbol in table 3 indicates weld metal recovery, determined in accordance with EN 22401, with the type of current shown in table 3.

Table 3. Symbol for weld metal recovery and type of current

Symbol	Weld metal recovery %	Type of current[1) 2)]
1	≤ 105	a.c. and d.c.
2	≤ 105	d.c.
3	> 105 ≤ 125	a.c. and d.c.
4	> 105 ≤ 125	d.c.

[1)] In order to demonstrate operability on alternating current, tests shall be carried out with a no-load voltage not higher than 65 V.

[2)] a.c. means alternating current; d.c. means direct current.

4.5 Symbol for welding position

The symbol below for welding positions indicates the positions for which the electrode is tested in accordance with prEN 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 position according to symbol 3.

4.6 Symbol for hydrogen content of deposited metal

The symbol in table 4 indicates the hydrogen content determined in deposited metal from electrode diameter 4 mm in accordance with the method given in ISO 3690 : 1977. The current used shall be 90 % of the maximum value recommended by the manufacturer. Electrodes recommended for use with alternating current shall be tested using alternating current. Electrodes recommended for direct current only shall be tested using direct current with electrode positive.

The manufacturer shall provide information on the recommended type of current and drying conditions for achieving the hydrogen levels.

Table 4. Symbol for hydrogen content of deposited metal

Symbol	Maximum hydrogen content ml/100 g deposited metal
H5	5
H10	10

NOTE 1. Other methods of collection and measurement of diffusible hydrogen may be used for batch testing provided that they possess equal reproducibility with, and are calibrated against, the method given in ISO 3690. The hydrogen content will be influenced by the type of current.

NOTE 2. Cracks in welded joints may 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-containing compounds in the filler metals. In the case of basic covered electrodes, the water taken up by the covering is the main source.

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.

NOTE 3. In practice, the appropriate hydrogen content will depend on the particular application and, to ensure that this is achieved, the relevant handling, storage and drying conditions recommended by the electrode manufacturer should be followed.

5 Mechanical tests

5.1 General

Tensile and impact tests and any required retests shall be carried out in the post-weld heat-treated condition specified in table 2, using an all-weld metal test assembly type 3 in accordance with prEN 1597-1, with 4 mm electrodes 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 type of weld metal in table 2.

The interpass temperature shall be measured using temperature indicator crayons, surface thermometers or thermocouples; see 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 within the limits of the interpass temperature.

5.3 Pass sequence

The pass sequence shall be as indicated in table 5.

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

Each pass shall be welded with a welding current of 90 % of the maximum current recommended by the manufacturer.

Regardless of the type of covering, welding shall be performed with alternating current when both alternating current and direct current are recommended, and with direct current using the recommended polarity when only direct current is recommended.

Table 5. Pass sequence

Electrode	Split weave		
mm	Layer number	Passes per layer	Number of layers
4,0	1 to top	2	7 to 9

6 Chemical analysis

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

NOTE. See annex B.

7 Technical delivery conditions

Technical delivery conditions shall meet the requirements in EN 759.

8 Designation

The designation of the covered electrode shall follow the principle given in the example below.

EXAMPLE:

A covered electrode for manual metal arc welding deposits weld metal with a chemical composition 1,1 % Cr and 0,6 % Mo (CrMo1) of table 1. The electrode has a basic covering (B) and can be used with direct current and with a metal recovery of 120 % (4) in flat butt and flat fillet welds (4). Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100 g deposited metal (H5).

The designation will be:

Covered electrode EN 1599 − E CrMo1 B 4 4 H5

Compulsory section:

Covered electrode EN 1599 − E CrMo1 B

where

EN 1599 = standard number;

E = covered electrode/manual metal arc welding (see **4.1**);

CrMo1 = chemical composition of all-weld metal (see table 1);

B = type of electrode covering (see **4.3**);

4 = recovery and type of current (see table 3);

4 = welding position (see **4.5**);

H5 = hydrogen content (see table 4).

Annex A (informative)
Description of types of electrode covering

A.1 Rutile covered electrodes

The covering of this type contains as an essential component titanium dioxide, usually as rutile, together with silicates and carbonates.

Electrodes of this type will give a smooth droplet transfer, which ensures that these electrodes are suitable for welding in all positions except for the vertical down position.

A.2 Basic covered electrodes

The covering of this type contains large quantities of alkaline-earth carbonates and fluorspar. These electrodes are capable of giving low hydrogen when used in accordance with the manufacturer's instructions.

Electrodes with basic covering are usually suitable only for direct current, electrode positive.

Basic electrodes are preferred for the welding of thick sections and for joints with gaps. The arc should be kept as short as possible.

Annex B (informative)
Bibliography

B.1 *Handbuch für das Eisenhüttenlaboratorium*, VdEh, Düsseldorf.

B.2 BS 6200-3 *Sampling and analysis of iron, steel and other ferrous metals — Part 3: Methods of analysis.*

B.3 CR 10261 *ECISS Information Circular 11 — Iron and steel — Review of available methods of chemical analysis.*

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