British Standard

BRITISH STANDARD

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Welding consumables — Tubular cored electrodes for gas shielded metal arc welding of high strength steels — Classification

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ICS 25.160.20

National foreword

This British Standard is the official English language version of EN 12535:2000.

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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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of an identical text or by endorsement, at the latest by August 2000, and conflicting national standards shall be withdrawn at the latest by August 2000.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

This standard proposes a classification in order to designate tubular cored electrodes in terms of the yield strength, tensile strength and elongation of the all-weld metal. The ratio of yield to tensile strength of weld metal is generally higher than that of parent metal. Users should note that matching weld metal yield strength to parent metal yield strength will not necessarily ensure that the weld metal tensile strength matches that of the parent material. Where the application requires matching tensile strength, selection of the consumable should be based on column 3 of Table 1. When selecting the consumables, it should be noted that with increasing thickness of the parent metal, the requirements of tensile strength and proof strength may decrease.

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 diameter, width of weave, gas shield used, welding position and material composition.

1 Scope

This standard specifies requirements for classification of tubular cored electrodes in the as-welded or stress relieved condition for gas shielded metal arc welding of high strength steels with a minimum specified yield strength higher than 500 N/mm². One tubular cored electrode may be tested and classified with different gases.

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	Welding consumables - 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 26847	Covered electrodes for manual metal arc welding - Deposition of a weld metal pad for chemical analysis (ISO 6847:1985)
EN ISO 13916	Welding - Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature (ISO 13916)

ISO 31-0:1992	Quantities and units - Part 0: General principles
ISO 3690	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 tubular cored electrode and appropriate shielding gas combination as given below. The classification is based on the tubular cored electrode diameter 1,2 mm, or if this is not manufactured the next larger diameter manufactured, with the exception of the symbol for welding position which is based on EN 1597-3.

The classification is divided into nine parts:

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

2) the second part gives a symbol indicating the strength and the elongation of the all-weld metal;

3) the third part gives a symbol indicating the impact properties of the all-weld metal;

4) the fourth part gives a symbol indicating the chemical composition of the all-weld metal;

5) the fifth part gives a symbol indicating the type of electrode core;

6) the sixth part gives a symbol indicating the shielding gas;

7) the seventh part gives a symbol indicating the welding position;

8) the eighth part gives a symbol indicating the hydrogen content of deposited metal;

9) the ninth part gives a symbol indicating the stress relief treatment in case this is applied.

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 strength and elongation, the impact properties, the chemical composition, the type of core, the shielding gas and the stress relief treatment, i.e. the symbols defined in 4.1, 4.2, 4.3, 4.4, 4.5, 4.6 and 4.9.

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.

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 tubular cored electrode used in the metal arc welding process shall be the letter T.

4.2 Symbol for strength and elongation of all-weld metal

The symbol in Table 1 indicates yield strength, tensile strength and elongation of the all-weld metal determined in accordance with clause 5.

NOTE: Stress relief treatment may alter the strength of the weld metal from that obtained in the as-welded condition.

Table 1 - Symbol for strength and elongation of all-weld metal

Symbol	Minimum[1)] yield strength N/mm^2	Tensile strength N/mm^2	Minimum elongation[2)] %
55	550	640 - 820	18
62	620	700 - 890	18
69	690	770 - 940	17
79	790	880 - 1080	16
89	890	940 - 1180	15

[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.

4.3 Symbol for impact properties of all-weld metal

The symbol in Table 2 indicates the temperature at which an average impact energy of 47 J is achieved under conditions given in clause 5. Three specimens shall be tested. Only one individual value may 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 in Table 2.

Table 2 - Symbol for impact properties of all-weld metal

Symbol	Temperature for minimum average impact energy 47 J °C
Z	No requirements
A	+ 20
0	0
2	- 20
3	- 30
4	- 40
5	- 50
6	- 60

NOTE: Stress relief treatment can alter the impact properties of the weld metal from that obtained in the as-welded condition.

4.4 Symbol for chemical composition of all-weld metal

The symbol in Table 3 indicates the chemical composition of all-weld metal determined in accordance with clause 6.

Table 3 - Symbol for chemical composition of all-weld metal

Symbol	Chemical composition % [1)2)3)]			
	Mn	Ni	Cr	Mo
Z	Any other agreed composition			
MnMo	1,4 to 2,0	-	-	0,3 to 0,6
Mn1Ni	1,4 to 2,0	0,6 to 1,2	-	-
Mn1,5Ni	1,1 to 1,8	1,3 to 1,8	-	-
Mn2,5Ni	1,1 to 2,0	2,1 to 3,0	-	-
1NiMo	1,4	0,6 to 1,2	-	0.3 to 0,6
1,5NiMo	1,4	1,2 to 1,8	-	0,3 to 0,7
2NiMo	1,4	1,8 to 2,6	-	0,3 to 0,7
Mn1NiMo	1,4 to 2,0	0,6 to 1,2	-	0,3 to 0,7
Mn2NiMo	1,4 to 2,0	1,8 to 2,6	-	0,3 to 0,7
Mn2NiCrMo	1,4 to 2,0	1,8 to 2,6	0,3 to 0,6	0,3 to 0,6
Mn2Ni1CrMo	1,4 to 2,0	1,8 to 2,6	0,6 to 1,0	0,3 to 0,6

[1)] If not specified: C 0,03 to 0,10 %, Si ≤ 0,90 %, Ni < 0,3 %, Cr < 0,2 %, Mo < 0,2 %, V < 0,05 % Nb < 0,05 %, Cu < 0,3 %, P < 0,020 % and S < 0,020 %.
[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.

4.5 Symbol for type of electrode core

The symbol in Table 4 indicates different types of tubular cored electrodes relative to their core composition and slag characteristics.

Table 4 - 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.

4.6 Symbol for shielding gas

The symbols M and C indicate shielding gas as described in 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.

4.7 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.

4.8 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

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 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.

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

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 consumables.

These compounds dissociate 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: This clause requires the manufacturer to specify boundary conditions of tubular cored electrode size 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. For example, shielding gases with high CO_2 contents generally give lower weld hydrogen levels than those with high argon contents and this may lead to a tubular cored electrode being differently classified when used with different gases. Classification 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. Since hydrogen levels in welds made with tubular cored electrodes generally decrease as the arc voltage and electrode extension increase, care should be taken that the values of these parameters do not fall below the manufacturer's recommendations.

4.9 Symbol for stress relief treatment

The letter T indicates that strength, elongation and impact properties in the classification of all-weld metal fulfil the classification criteria after a stress relief treatment at 560 ^{o}C to 600 ^{o}C for 1 hour. The test piece shall be left in the furnace for cooling down to 300 ^{o}C.

5 Mechanical tests

Tensile and impact tests and any required retests shall be carried out on weld metal in the as-welded or stress relief condition using an all-weld metal test assembly type 3 in accordance with EN 1597-1 using 1,2 mm, or if this is not manufactured the next larger diameter manufactured, tubular cored electrode and welding conditions as described below in 5.1 and 5.2.

5.1 Preheating and interpass temperatures

Welding of the all-weld metal test piece shall be executed in a temperature range from 120 ^{o}C to 180 ^{o}C with the exception of the first layer in the test assembly, which may be welded without preheat.

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

5.2 Welding conditions and pass sequence

The total number of runs, the number of runs per layer and the total number of layers shall be as given in Table 6. 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.

Table 6 - Welding conditions and pass sequence

Electrode diameter	Passes per layer		Total number	Welding current [2)3)]
mm	First layer	Other layers[1)]	of layers	A
0,9 to 1,2	1 or 2	2 or 3	6 to 9	240 to 280
1,4 to 2,0	1 or 2	2 or 3	5 to 8	290 to 350

[1)] The final layer may have four passes.
[2)] The welding voltage will depend on the choice of shielding gas.
[3)] The contact tube distance shall be 20 ± 2 mm.

6 Chemical analysis

Chemical analysis is performed on any suitable all-weld metal test specimen. In case of dispute specimens in accordance with EN 26847 shall be used. 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 tubular cored electrodes has to conform to principles according to following examples.

EXAMPLE 1:

A tubular cored electrode (T) for gas shielded metal arc welding deposits a weld metal with a minimum yield strength in the as-welded condition of 620 N/mm² (62) and a minimum average impact energy of 47 J at - 50 °C (5) and has a chemical composition of 1,7 % Mn, 1,4 % Ni (Mn1,5Ni). The electrode with a basic type core (B) was tested under mixed gas (M) and can be used 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:

Tubular cored electrode EN 12535 - T 62 5 Mn1,5Ni B M 4 H5

Compulsory section:

Tubular cored electrode EN 12535 - T 62 5 Mn1,5Ni B M

where:

EN 12535	= standard number;
T	= tubular cored electrode/gas shielded metal arc welding (see 4.1);
62	= strength properties (see Table 1);
5	= impact properties (see Table 2);
Mn1,5Ni	= chemical composition of all-weld metal (see Table 3);
B	= type of electrode core (see 4.5);
M	= shielding gas (see 4.6);
4	= welding position (see 4.7);
H5	= hydrogen content (see Table 6).

EXAMPLE 2:

A tubular cored electrode (T) for gas shielded metal arc welding deposits a weld metal with a minimum yield strength in stress-relieved condition of 550 N/mm² (55) and a minimum average impact energy of 47 J at - 50 °C (5) and has a chemical composition of 1.7 % Mn, 1,4 % Ni (Mn1,5Ni). The electrode with a basic type core (B) was tested under mixed gas (M) and can be used 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). Mechanical tests were performed after stress relief treatment (T).

The designation will be:

Tubular cored electrode EN 12535 - T 55 5 Mn1,5Ni B M 4 H5 T

Compulsory section:

Tubular cored electrode EN 12535 - T 55 5 Mn1,5Ni B M T

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 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.

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.

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