International Standard 1071

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Covered electrodes for manual arc welding of cast iron — Symbolization

Électrodes enrobées pour le soudage manuel à l'arc des fontes — Symbolisation

First edition — 1983-12-15

UDC 621.791.753.042 : 003.62 **Ref. No. ISO 1071-1983 (E)**

Descriptors : welding, arc welding, manual metal arc welding, covered electrodes, cast iron, symbols.

Price based on 5 pages

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1071 was developed by Technical Committee ISO/TC 44, *Welding and allied processes*, and was circulated to the member bodies in February 1983.

It has been approved by the member bodies of the following countries :

Australia	Finland	Norway
Austria	France	Poland
Brazil	Germany, F.R.	Romania
Canada	India	Sweden
China	Italy	Switzerland
Czechoslovakia	Japan	United Kingdom
Denmark	New Zealand	USSR

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Belgium
USA

This International Standard cancels and replaces ISO Recommendation R 1071-1969, of which it constitutes a technical revision.

Covered electrodes for manual arc welding of cast iron — Symbolization

1 Scope and field of application

This International Standard defines a symbolization for covered electrodes suitable for the manual welding of cast iron, and fixes the specifications with which they shall comply on the basis of the chemical composition of the electrode core wire or of the weld metal.

NOTES

1 For each chemical composition symbol, additional information and examples of the application of the electrode are given in the annex.

2 If a user requires special properties, consultation with the manufacturer for further information is advised.

2 Reference

ISO 6847, *Manual metal arc deposition of a weld metal pad for chemical analysis.* 1)

3 Coding

The method of symbolization used in this International Standard consists of symbols for the following elements :

a) general symbol (see 3.1) : the letter E;

b) symbol for the chemical composition of the electrode core wire or weld metal (see 3.2) : a group of letters and possibly a number;

c) symbol characterizing the type of coating (see 3.3) : one or two letters;

d) symbol relating to conditions of use :

- welding positions (see 3.4) : a number,
- power supply (see 3.5) : a number.

3.1 General symbol

The letter E at the head of the symbol code is intended to distinguish a covered electrode for arc welding from any other filler product.

3.2 Symbol for chemical composition

Table 1 gives some symbols according to types of alloys.

Table 1 — Symbols for some alloy types

Symbol	Type of alloy
FeC-1	Grey cast iron
FeC-2	Grey cast iron, with steel core
Fe	Steel
NiFe	Nickel-iron
NiCu-1, NiCu-2	Nickel-copper
Ni	Nickel
CuAl	Copper-aluminium
CuSn-1, CuSn-2	Copper-tin
Z	Other

Table 2 gives the chemical composition of the core wire or weld metal, enabling the content of each of the various constituents to be determined.

For each case, the symbols represent the chemical composition of the electrode core wire or weld metal, taking the chemical symbols of the main constituents as the means of symbolization.

Where there is a number separated by a dash from the chemical symbols, this indicates that more than one chemical composition is possible for an electrode with the same main constituents.

3.3 Symbols for types of coating

The type of coating is indicated by the following letters :

- B = basic;
- G = graphite;
- BG = basic with graphite;
- S = organic salt;
- V = other types.

1) At present at the stage of draft.

Table 2 — Various symbols for chemical composition

ISO Symbol	FeC-1	FeC-2; Fe	NiFe	NiCu-1	NiCu-2	Ni	CuAl	CuSn-1	CuSn-2
	Composition of core wire, %[1]								
C	3,25 to 3,50	0,15					—	—	—
Si	2,75 to 3,00	0,03					0,10	[4]	[4]
Mn	0,60 to 0,75	0,30 to 0,60					—	[4]	[4]
P	0,50 to 0,75	0,04					—	0,10 to 0,35	0,05 to 0,35
S	0,10	0,04					—	—	—
Fe	remainder	remainder					1,5	[4]	[4]
Mo	trace	—					—	—	—
Ni[2]	trace	—					—	[4]	[4]
Cu[3]	—	—					remainder	remainder	remainder
Zn	—	—					0,02	[4]	[4]
Sn	—	—					—	4,0 to 6,0	7,0 to 9,0
Al	—	—					9,0 to 11,0	0,01[4]	0,01[4]
Pb	—	—					0,02	0,02[4]	0,02[4]
Total of other elements	—	—					0,50	0,50	0,50
	Composition of weld metal, %[1]								
C			2,00	0,35 to 0,55	0,35 to 0,55	2,00			
Si			4,00	0,75	0,75	4,00			
Mn			1,00	2,25	2,25	1,00			
P			—	—	—	—			
S			0,03	0,025	0,025	0,025			
Fe			remainder	3,0 to 6,0	3,0 to 6,0	8,00			
Mo			—	—	—	—			
Ni			45,0 to 60,0	50,0 to 60,0	60,0 to 70,0	85 min.			
Cu[3]			2,50	35,0 to 45,0	25,0 to 35,0	2,50			
Zn			—	—	—	—			
Sn			—	—	—	—			
Al			—	—	—	—			
Pb			—	—	—	—			
Total of other elements			1,00	1,00	1,00	1,00			

1) Unless otherwise stated, single values represent maximum percentages.

2) Nickel plus incidental cobalt.

3) Copper plus incidental silver.

4) Total of other elements including those marked footnote 4, shall not exceed the specified value.

The meanings of these symbols are as follows :

3.3.1 Type B (basic)

Electrodes of the basic type usually have a covering containing considerable quantities of calcium carbonate and other basic carbonates, together with fluorspar and other fluorides, so that they are basic from a metallurgical point of view.

Only an amount of dense slag is produced, which is often of typical aspect. This slag comes away easily and, as it rises quickly to the surface, there is no risk of inclusion with this type of electrode.

These electrodes have a moderately penetrating arc which is suitable for welding in all positions. Direct current and positive polarity are generally preferred, but there are some electrodes of this type which can be used with alternating current if a fairly high no-load voltage is available.

3.3.2 Type G (graphite)

The coating elements and their proportions are indicated below :

- graphite : > 20 %
- iron ore : 10 to 30 %
- CaF2 : < 7 %
- alkaline earth carbonates : < 20 %
- ferro-alloys : < 20 %

With a few exceptions, electrodes of this type can be used for welding in all positions. They have the advantage, especially for iron-based alloys and for welding at high working temperatures, of containing a relatively low amount of slag, which is easily removed at high temperatures.

They can be used with direct current (positive or negative polarity) or with alternating current.

3.3.3 Type BG (basic with graphite)

The coating elements and their proportions are indicated below :

- alkaline earth carbonates : > 40 %
- graphite : 7 to 20 %
- CaF2 : 7 to 30 %
- iron ore : < 10 %
- ferro-alloys : < 15 %

Direct current (positive or negative polarity) or alternating current may be used. The electrodes are suitable for welding in all positions. The welding properties depend, to a certain extent, on the choice of current and polarity. It is therefore important that the recommendations of electrode manufacturers be taken into account.

3.3.4 Type S (organic salt)

The coating elements and their proportions are indicated below:

- sodium components : > 40 %
- cellulose : 10 to 20 %
- other slag-forming components : < 20 %
- ferro-alloys : < 20 %

Direct current (with positive or negative polarity) or alternating current may be used. These electrodes are suitable for welding in all positions.

3.3.5 Type V

The symbol V covers all coatings not specified in 3.3.1 to 3.3.4.

3.4 Symbols for welding positions

The symbols used to denote the basic welding positions for which an electrode is suitable are given in table 3.

Table 3 — Welding positions

Symbol	Basic welding position
1	all
2	all, except vertical downwards
3	flat (butt and fillet welds) and horizontal vertical (fillet weld)
4	flat (butt and fillet)
5	as for 3, and recommended for vertical downwards

3.5 Symbols for welding currents

The symbols used to denote welding current indicate the power supply required to obtain operating conditions free from such occurrences as instability or interruption of the arc.

The no-load voltage necessary for striking the arc varies according to the diameter of the electrode. A reference diameter should therefore be given for symbolization.

Table 4 applies to electrodes of diameter equal to or greater than 2,5 mm. The frequency of the alternating current is assumed to be 50 or 60 Hz. The no-load voltage required when the electrodes are used with a direct current depends essentially on the dynamic characteristics of the welding plant.

4 Example of symbolization application

As an example, take an electrode for manual arc welding of cast iron with the following characteristics :

- chemical composition of weld metal : Nickel 55 %, iron 42 %;
- coating with high contents of graphite, arc stabilizing elements and flux;
- welding in a flat position only (butt and fillet welds);
- for direct current a positive electrode is preferred; for welding with an alternating current, the no-load voltage will be at least 75 V.

This electrode will be symbolized as follows :

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Table 4 — Welding currents

Symbol	Direct current : recommended polarity[2]	Alternating current : minimum no-load voltage V
0[1]	+	
1	+ or —	50
2	—	50
3	+	50
4	+ or —	70
5	—	70
6	+	70
7	+ or —	90
8	—	90
9	+	90

1) Symbol reserved for electrodes used exclusively with direct current.

2) Positive polarity : +
Negative polarity : —

Annex

Descriptions and examples of use of electrodes

A.1 FeC-1 — Cast iron core wire

This electrode has a cast iron core wire to which a heavy covering is applied in order to make it suitable for metal arc welding. The weld metal is very fluid and flows readily with a light slag over it. The slag can be easily removed. The weld is machinable, with a hardness of about 170 to 220 Brinell. Castings to be welded should first be grooved to an angle of 60 to 90°. The V-groove should have a root face to prevent difficulties with alignment and melting through.

Preheating is recommended within the range 250 to 760 °C, depending on the size of the workpiece and the machinability desired. Subsequent runs should be welded without delay to prevent cooling.

Example of use : Manufacture and repair of pieces of grey cast iron.

A.2 FeC-2 — Steel core wire

This electrode has a steel core wire, but the weld deposit becomes alloyed with carbon and silicon from the covering. In general the carbon content of the deposit is lower and the silicon content higher than for the deposit of an FeC-1 electrode, so that the weld metal has a high tendency to solidify with a structure similar to that of grey cast iron. It is important to follow the manufacturer's instructions as there is an upper limit for the solidification rate which should not be exceeded. The molten metal is less fluid and the strength of the weld metal is higher than with an FeC-1 electrode. The problems of weld stresses and their control are the same as for other cast iron welding methods. The weld deposit is machinable.

Example of use : Manufacture and repair of grey iron castings.

A.3 Fe — Steel core wire

This covered electrode for use in all positions closely resembles electrodes of type ISO 2560 E 5xxB1x. Weld deposits of this electrode are not readily machinable. The formation of a hard fusion zone and the possibility of cracking, due to the difference of shrinkage between steel and cast iron, makes it generally advisable to employ studs which key the weld to the parent metal below the fusion zone.

Preheating is employed where necessary to prevent excessive stresses in other parts of the casting.

This electrode is generally used at low current intensities in order to minimize the dilution effect and cracking of the parent metal. Short runs and slight peening of the runs is recommended.

Example of use : Due to the unfavourable mechanical properties of the weld metal, the use of these electrodes is largely confined to the repair of small pits and cracks with some application in the repair of castings that require no machining.

A.4 Ni; NiFe; NiCu — Nickel base electrodes

Welds made with these electrodes can usually be machined. The hardness of the weld metal depends to a great extent upon the extent of dilution by the parent metal. A high level of dilution may give rise to a hardness of 350 Brinell. Moderately heavy runs, where the dilution is reduced by using a low current and directing the arc on the weld metal, or multiple layer welds, may give a hardness within the range of 175 to 200 Brinell. These electrodes have a soft stable arc with globular metal transfer. Penetration is low. The weld metal wets the cast iron well, resulting in good metal "wash up". The liquid slag is fluid and small in amount.

The solidified slag is generally easy to remove. Deposits from NiFe and NiCu electrodes differ less in colour from the cast iron than do Ni deposits. The choice between these electrodes is to be made on the basis of the colour of the deposit and the mechanical properties.

Examples of use : Joining or repair of ordinary grey iron castings in light and medium sizes, joining of cast irons to other ferrous and non-ferrous metals.

Welding of nodular graphite cast irons.

A.4.1 Ni electrodes

Satisfactory welds can be produced on light and medium-size castings and where the welding stresses set up are not severe or where the phosphorus content of the cast iron is not too high.

A.4.2 NiFe electrodes

Castings containing higher than normal phosphorus (approximately 0,20 %) are more readily welded using these electrodes. Due to the higher tensile strength and ductility of the nickel-iron deposits, satisfactory welds can be made on heavy or highly stressed sections. These same characteristics also enable satisfactory welds to be made on high strength and engineering grades of cast iron.

A.4.3 NiCu electrodes

These electrodes are used in many of the same applications as Ni and NiFe electrodes. Advantages can be found in the colour matching, a slightly lower heat input, and a lower sensitivity to impurities in the cast iron. However, regarding ductility and resistance to cracking, these electrodes are generally somewhat inferior to the other nickel base types. It is difficult to obtain crack-free multi-run welds.

A.5 CuSn — Copper-tin type electrodes

This group contains electrodes depositing tin-bronzes. The weld metal has reasonable mechanical properties with an elongation of about 25 % and hardness of 70 to 140 Brinell. The weld deposit retains its toughness at sub-zero temperatures and is non-magnetic. The material is not creep-resistant. The metal melts at a temperature of 900 to 1050 °C. The lower heat input minimizes fusion zone cracking due to the fact that less hard, brittle, white cast iron is formed in this critical area.

The difference between the CuSn-1 and CuSn-2 types is in tin content only. The higher tin content of the CuSn-2 type results in a weld metal of greater hardness and a higher tensile strength and yield stress.

In welding with these electrodes it is advisable to use wide grooves, to clean the edges for joining of all traces of moisture, grease, oil and dirt, to preheat the castings to between 150 and 200 °C, to use the lowest possible current for good fusion, and to weld at high speed without weaving to minimize dilution from the parent metal.

After welding, the part should be cooled slowly to obtain the best properties in the weld metal. A large part of the contraction strain takes place before the cooling weld metal reaches 300 °C. The copper-base alloy deposit has good plastic yielding properties, thus resulting in low residual stresses and thereby greatly reducing the chances of cracking.

The weld metal has a bronze colour.

Examples of use : Joining and repair of grey cast iron where the danger of stresses and cracking due to heat input is great. Surfacing of heat-resistant and corrosion-resistant surfaces.

A.6 CuAl — Copper aluminium type electrodes

In general the same can be said for the CuAl electrodes as for the CuSn types. The tensile strength and yield stress of the deposits are almost double those of the copper-tin deposits and the ductility is relatively high. The deposit also retains its toughness at sub-zero temperatures but, unlike the previous type, the weld metal is creep-resistant up to a temperature of 250 °C. The deposit is non-magnetic.

The weld metal has a golden-yellow colour.

Examples of use : The same as the CuSn types but these electrodes are more suitable for joining higher strength cast irons, as well as for the surfacing of wear-resistant surfaces.

A.7 Cross-references to certain national standards

Table 5 — ISO Symbols and comparable notation from certain national standards[1)]

Because of differences between national specifications, the correspondence between these symbols has no absolute significance.

ISO Symbol	AWS A5.15-1982[3)]	DIN 8573	JIS Z 3252[3)]
FeC-1	E C-I	Fe CL Fe CG	DFC CI
FeC-2	—	Fe N1	—
Fe	St E	Fe	DFC Fe
NiFe	ENiFe-CI	Ni Fe[2)]	DFC Ni Fe
NiCu-1	ENiCu-A	—	—
NiCu-2	ENiCu-B	Ni Cu[2)]	DFC Ni Cu
Ni	ENi-CI	Ni[2)]	DFC Ni
CuAl		Cu A1	—
CuSn-1		—	—
CuSn-2		Cu Sn	—

1) The French national standard (A81 342) will give symbolization as defined by this International Standard.

2) DIN 8573 in table 1 gives only the composition of the core wire. The electrodes correspond to those with International Standard symbols.

3) For each symbol the electrodes are classified according to the chemical composition of the weld metal.

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