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CODE OF SYMBOLS FOR COVERED ELECTRODES FOR MANUAL METAL-ARC WELDING OF CAST IRON

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BRIEF HISTORY

The ISO Recommendation R 1071, *Code of symbols for covered electrodes for manual metal-arc welding of cast iron*, was drawn up by Technical Committee ISO/TC 44, *Welding*, the Secretariat of which is held by the Association Française de Normalisation (AFNOR).

Work on this question led, in 1966, to the adoption of a Draft ISO Recommendation.

In April 1967, this Draft ISO Recommendation (No. 1163) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Belgium	Ireland	Spain
Canada	Israel	Sweden
Czechoslovakia	Japan	Switzerland
Denmark	Korea, Rep. of	Thailand
Finland	Norway	Turkey
France	Poland	U.A.R.
Germany	Portugal	U.S.A.
Greece	Romania	U.S.S.R.
India	South Africa. Rep. of	Yugoslavia

Two Member Bodies opposed the approval of the Draft :

Austria
United Kingdom

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in May 1969, to accept it as an ISO RECOMMENDATION.

ISO Recommendation R 1071 May 1969

CODE OF SYMBOLS FOR COVERED ELECTRODES FOR MANUAL METAL-ARC WELDING OF CAST IRON

1. SCOPE

This ISO Recommendation gives a code of symbols applicable to covered electrodes used for manual metal-arc welding of cast iron. The coding is based upon the chemical composition of the core wire and upon the normal uses of the electrodes.

Additional descriptions of the various groups of electrodes are also given.

NOTE. – When the purchaser requires special properties, he is advised to consult the manufacturer for further information.

2. CODING

2.1 General plan

The code follows the general scheme of coding for filler metals which is divided into the four following groups of symbols :

Group I : welding process, form of filler metal, flux, gas, etc.

Group II : composition or chemical analysis.

Group III : properties of the deposited metal.

Group IV : particulars of the method of operation.

2.2 Group I

In the special case of welding cast iron by manual metal-arc welding, only covered electrodes are considered.

For simplicity, only the symbol E is used. The ISO Recommendation number which precedes it indicates which type of covered electrode is defined, i.e.

ISO/R . . . E . . .

2.3 Group II

Group II concerns the chemical composition.

Usually the weld deposit is taken as the basis of coding for covered electrodes, but for cast iron the composition of the weld deposit is not generally the same as the composition of the parent metal, and no specification referring to a particular chemical composition of the weld deposit is required. The coding in this case is therefore based on the chemical composition of the core wire. Group II gives the chemical symbols of the main constituents of the core wire. Where a number, separated by a dash from the chemical symbols, is used, this indicates that more than one chemical composition is available for an electrode having the main constituents shown by the symbol.

TABLE 1

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

NOTE. – Detailed descriptions and examples of application are given in the Annex. Table A.1 of the Annex gives *as a guide* fuller details of chemical compositions.

2.4 Group III

Group III normally indicates mechanical properties. In the case of covered electrodes for welding cast iron, each type has its specific mechanical properties as indicated in the Annex. There is not much difference in the mechanical properties of the different brands of any given type and therefore, for simplicity, no symbol is used for this group. A dash indicates this omission.

2.5 Group IV

Group IV comprises three symbols.

2.5.1 *The first symbol* denotes the type of covering, as follows :

B = basic
G = graphite
S = salt
V = other types

The meanings of these symbols are as follows :

B. Electrodes of the basic type usually with a thick covering containing considerable quantities of calcium or other basic carbonates, and fluorspar, so that metallurgically they are basic in character. There is only a small quantity of dense slag, which often has a typical brown-black and glossy appearance. It is easily detached and as it rises to the surface very quickly, inclusions are not likely to occur 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 usually preferred but there are some electrodes of this type which can be used with alternating current at fairly high open circuit voltages.

G. This symbol indicates that graphite forms an important part of the composition of the covering. Certain amounts of carbonates and ferro-alloys are often present. The slag is of small black flakes and is easily removed.

S. This type of covering is used almost exclusively for electrodes of the non-ferrous and of the light-alloy type. The term "salt" refers to the raw materials forming the main part of the composition of the covering such as chlorides and fluorides of metals of the alkali group and of the alkali earth metals, boron compounds, titanates, carbonates, etc.

Certain amounts of ferro-alloys may often be present, especially in the case of non-ferrous electrodes (copper and bronze electrodes). The coverings are usually of the extruded type but dipping is also widely used. The electrodes are generally packed in sealed containers to prevent the absorption of moisture by the covering.

Redrying before welding is recommended.

V. The symbol V is used to denote a covering other than one of those specified under B, G or S.

2.5.2 *The second symbol* denotes the welding position in which welding is possible.

TABLE 2

Symbol	Fundamental welding positions
1	– all positions
2	– all positions, except the vertical downwards position
3	– flat (butt and fillet welds) and horizontal-vertical (fillet weld)
4	– flat (butt and fillet welds)

NOTE. – When an electrode can be used in fundamental welding positions other than those corresponding to a symbol but does not permit welding in all the fundamental positions corresponding to the symbol with the index immediately preceding it, no account is taken thereof in the coding of this electrode.

2.5.3 *The third symbol* denotes the electrical characteristics required in order to ensure operating conditions free of such difficulties as instability or interruptions of the arc.

The open circuit voltage necessary for striking the arc varies according to the diameter of electrode. A reference diameter is therefore required for coding.

Table 3, below, applies to electrode diameters greater than or equal to 2.5 mm. The frequency of the alternating current is assumed to be 50 or 60 Hz. The open circuit voltage necessary when electrodes are used on direct current is closely related to the dynamic characteristics of the welding plant.

TABLE 3

Symbol	Direct current Recommended polarity**	Alternating current Nominal open circuit voltage
0*	+	
1	+ or -	50
2	-	50
3	+	50
4	+ or -	70
5	-	70
6	+	70
7	+ or -	90
8	-	90
9	+	90

* Symbol reserved for electrodes used exclusively with direct current.

** Positive polarity +
Negative polarity -

2.6 Non-symbolized characteristics

In cases where a symbol does not exist for a particular characteristic of a given electrode, the letter X is used in place of a symbol.

3. EXAMPLE OF CODING

An electrode for welding cast iron has the following characteristics :

Core wire : nickel-iron (relative proportions of constituents approximately 55 % and 45 %).

Covering : considerable amounts of graphite, arc stabilizing elements and fluxing ingredients.

Welding in the flat position only.

For d.c., electrode positive is preferred; in case of a.c. welding, the no-load voltage should be at least 75 V.

The coding for this electrode will be as follows :

ISO/R 1071 E/NiFe/ – /G49

ANNEX

DESCRIPTIONS AND EXAMPLES OF USE OF ELECTRODES

FeC-1 – Cast iron core wire

Description : 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.

FeC-2 – Steel core wire

Description : 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 the deposit of an FeC-1 electrode, so that the weld metal has a high tendency to solidify to a grey structure. It is important to follow the instructions of the manufacturer as there exists 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 that of 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 pieces of grey cast iron.

Fe – Steel core wire

Description : This covered all-position electrode closely resembles electrodes of type ISO/R 635 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 when necessary in order 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 aspects, use is largely confined to repair of small pits and cracks with some application in the repair of castings that require no machining.

Ni, NiFe, NiCu – Nickel-base electrodes

Description : Welds made with these electrodes usually can be machined. The hardness of the deposit depends to a great extent upon the amount of dilution by the parent metal. High 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 deposited 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. The colour of the deposit matches that of the cast iron fairly well. Deposits from NiFe and NiCu electrodes, however, differ less in colour from the cast iron than Ni deposits. The choice between these electrodes depends, apart from the colour-matching, on the mechanical properties, but differences are small.

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

NiFe : Castings containing phosphorus levels higher than normal (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.

NiCu : 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 combinations of impurities in the cast iron, but 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.

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 materials.

Welding of nodular graphite cast irons.

CuSn – Copper-tin type electrodes

Description : This group contains the 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 it is non-magnetic. The material is not creep-resistant. The material 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 use of electrodes of this type for the welding of grey cast iron is recommended only to a limited degree. Although the hardness of the pure weld metal is below 140 Brinell, machining of the welds on cast iron might be difficult due to separation of individual iron particles in the weld metal.

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 joints thoroughly of moisture, grease, oil and dirt, to preheat between 150 and 200 °C, to use the lowest possible current intensity 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, 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 danger of stresses and cracking due to heat input is great. Surfacing of heat-resistant and corrosion-resistant surfaces.

CuAl – Copper-aluminium type electrodes

Description : In general the same can be said for the CuAl electrodes as has been stated for the CuSn types. The tensile strength and yield stress of the deposits are almost double those of the copper-tin deposits but 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.

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