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Welding consumables — Covered electrodes, wires, rods and tubular cored electrodes for fusion welding of cast iron — Classification

Produits consommables pour le soudage — Electrodes enrobées, fils d'apport, baguettes et fils fourrés pour le soudage par fusion de la fonte — Classification

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Foreword

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The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

This third edition cancels and replaces the second edition (ISO 1071:2003), which has been technically revised.

Introduction

This International Standard classifies welding consumables for fusion welding of various types of unalloyed cast irons.

Applications for welding consumables classified to this International Standard:

— production welding, that means welding of cast materials during the process of production. In that way, the quality of the casting shall be ensured in accordance with the guaranteed properties and to the requirements of the application;

— repair welding of castings which are damaged during service;

— welding for construction purposes where cast irons are joined to themselves or to other ferrous or non-ferrous metals.

The following methods are used for the welding of cast irons:

— using a welding consumable which produces a weld metal similar to the parent metal. High preheating is required (typical temperature range 550 °C to 650 °C);

— using a welding consumable which produces a weld metal dissimilar to the parent metal. No or only low preheating is required.

This International Standard contains different types of welding consumables because the chemical composition of welding rods and wire electrodes, as well as the all-weld metal of the corresponding covered electrodes and tubular cored electrodes, is similar.

Additionally, to the welding consumables specified in this International Standard, consumables classified to other standards can be used (see Annex A).

Welding consumables — Covered electrodes, wires, rods and tubular cored electrodes for fusion welding of cast iron — Classification

1 Scope

This International Standard specifies requirements for classification of covered electrodes for manual metal arc welding, wire electrodes for metal arc welding, tubular cored electrodes for metal arc welding with and without a gas shield, rods for TIG-welding, and rods for oxy-fuel gas welding of unalloyed cast irons. Classification is based on the chemical composition of wires and rods and on the all-weld metal deposit for tubular cored and covered electrodes.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 544, *Welding consumables — Technical delivery conditions for filler materials and fluxes — Type of product, dimensions, tolerances and markings*

ISO 2401, *Covered electrodes — Determination of the efficiency, metal recovery and deposition coefficient*

ISO 6847, *Welding consumables — Deposition of a weld metal pad for chemical analysis*

ISO 14175, *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

ISO 80000-1:2009, *Quantities and units — Part 1: General.* Corrected by ISO 80000-1:2009/Cor 1:2011

3 Classification

3.1 Wire electrodes and rods

For wire electrodes and rods classified in accordance with their chemical composition (see Table 2 and Table 3), the classification is divided into three parts.

a) The first part gives a symbol indicating the product to be identified.

b) The second part indicates the type of alloy (C for cast iron).

c) The third part gives a symbol indicating the chemical composition of the wire electrode or of the rod.

3.2 Tubular cored electrodes

For tubular cored electrodes classified in accordance with the all-weld metal chemical composition produced with an appropriate shielding gas, the classification is divided into four parts.

a) The first part gives a symbol indicating the product to be identified.

b) The second part indicates the type of alloy (C for cast iron).

c) The third part gives a symbol indicating the chemical composition of the all-weld metal.

d) The fourth part gives a symbol indicating the shielding gas.

3.3 Covered electrodes

For covered electrodes classified in accordance with the all-weld metal chemical composition, the classification is based on an electrode diameter of 4 mm. The classification is divided into four parts.

a) The first part gives a symbol indicating the product to be identified.

b) The second part indicates the type of alloy (C for cast iron).

c) The third part gives a symbol indicating the chemical composition of the all-weld metal.

d) The fourth part gives a symbol indicating the effective electrode efficiency and the type of current.

3.4 Tubular cored and covered electrodes

The following classification of tubular cored and covered electrodes is split into two sections.

a) Compulsory section

This section includes the symbol for the type of product, type of alloy, the chemical composition, and the shielding gas as defined in 4.1, 4.2, 4.3, and 4.4.

b) Optional section

This section includes the symbol for the effective electrode efficiency and/or type of current for which the consumable is suitable as defined in 4.5.

The full designation (see examples in Clause 10) shall be used on packages and in the manufacturer's literature and data sheets.

4 Symbols and requirements

4.1 Symbols for the product form

The symbol for the covered electrode shall be the letter E.

The symbol for the solid wire and rod shall be the letter S and the symbol for the tubular cored wire shall be T.

The symbol for the cast rod shall be R.

4.2 Symbol for the type of alloy

The symbol C as the second symbol shall be used to indicate the welding of cast iron as the main application.

4.3 Symbol for the chemical composition

4.3.1 General

The symbols in Table 2 and Table 3 indicate the chemical composition of rods and wire electrodes, as well as the chemical composition of the all-weld metal of covered electrodes and tubular cored electrodes in accordance with Clause 6.

A distinction has to be made between consumables producing similar and dissimilar weld metal.

4.3.2 Consumables producing similar weld metal

The consumables in this group are classified in accordance with the alloy type in Table 1. The symbols in Table 2 indicate the chemical composition of similar rods and similar all-weld metal of covered electrodes and tubular cored electrodes. The description of each consumable and examples for their application are given in Annex A.

Table 1 — Welding consumables producing weld metal similar to parent metal

Symbol	Microstructure	Product form[a]
FeC-1[b]	lamellar graphite	E, R
FeC-2[c]	lamellar graphite	E, T
FeC-3	lamellar graphite	E, T
FeC-4	lamellar graphite	R
FeC-5	lamellar graphite	R
FeC-GF	ferritic microstructure, spheroidal graphite	E, T
FeC-GP1	pearlitic microstructure, spheroidal graphite	R
FeC-GP2	pearlitic microstructure, spheroidal graphite	E, T

[a] See 4.1.

[b] Covered electrode with core rod of cast iron.

[c] Covered electrode with core rod of unalloyed steel.

4.3.3 Consumables producing dissimilar weld metal

The consumables in this group are classified in accordance with the chemical composition of the wire electrode or of the all-weld metal of the covered electrode and of the tubular cored electrode (see Table 3). The description of each consumable and examples for their application are given in Annex A.

4.4 Symbol for shielding gas (tubular cored electrode)

The symbols for shielding gases shall be in accordance with ISO 14175 except that the symbol NO shall be used for non-gas shielded tubular cored electrodes.

Table 2 — Chemical composition of similar rods and of similar all-weld metal of covered electrodes and tubular cored electrodes

Symbol	Product form	Chemical composition %[a, b]									
		C	Si	Mn	P	S	Fe	Ni[c]	Cu[d]	Remark	Sum of other elements
FeC-1	E, R	3,0 to 3,6	2,0 to 3,5	0,8	0,5	0,1	Remainder	–	–	Al: 3,0	1,0
FeC-2	E, T	3,0 to 3,6	2,0 to 3,5	0,8	0,5	0,1	Remainder	–	–	Al: 3,0	1,0
FeC-3	E, T	2,5 to 5,0	2,5 to 9,5	1,0	0,20	0,04	Remainder	–	–	–	1,0
FeC-4	R	3,2 to 3,5	2,7 to 3,0	0,60 to 0,75	0,50 to 0,75	0,10	Remainder	–	–	–	1,0
FeC-5	R	3,2 to 3,5	2,0 to 2,5	0,50 to 0,70	0,20 to 0,40	0,10	Remainder	1,2 to 1,6	–	Mo: 0,25 to 0,45	1,0
FeC-GF	E, T	3,0 to 4,0	2,0 to 3,7	0,6	0,05	0,015	Remainder	1,5	–	Mg: 0,02 to 0,10 Ce: 0,20	1,0
FeC-GP1	R	3,2 to 4,0	3,2 to 3,8	0,10 to 0,40	0,05	0,015	Remainder	0,50	–	Mg: 0,04 to 0,10 Ce: 0,20	1,0
FeC-GP2	E, T	2,5 to 3,5	1,5 to 3,0	1,0	0,05	0,015	Remainder	2,5	1,0	Mg: 0,02 to 0,10 Ce: 0,20	1,0
Z[e]	R, E, or T	Any other agreed composition									

[a] Single values are maximum values.

[b] The weld metal or filler metal as specified should be analysed for specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "sum of other elements" in the last column of the table.

[c] Nickel limit can include incidental cobalt.

[d] Copper limit can include incidental silver.

[e] Consumables for which the chemical composition is not listed in this table shall be symbolized indicating the chemical composition and prefixed by the letter Z. The chemical composition ranges are not specified and therefore, it is possible that two electrodes with the same Z classification might not be interchangeable.

Table 3 — Chemical composition of dissimilar rods, wire electrodes, and of dissimilar all-weld metal of covered electrodes and of tubular cored electrodes

Symbol	Product form	Chemical composition in % (by mass)[a, b, c]									
		C	Si	Mn	P	S	Fe	Ni[d]	Cu[e]	Remark	Sum of other elements
Fe-1	E, S, T	2,0	1,5	0,5 to 1,5	0,04	0,04	Remainder	—	—	—	1,0
St	E, S, T	2,0	1,0	1,0	0,04	0,04	Remainder	—	0,35	—	1,0
Fe-2	E, T	0,2	1,5	0,3 to 1,5	0,04	0,04	Remainder	—	—	Nb + V: 5,0 to 10,0	1,0
Ni-CI	E	2,0	4,0	2,5	—	0,03	8,0	min 85	2,5	Al: 1,0	1,0
	S	1,0	0,75	2,5	—	0,03	4,0	min 90	4,0	—	1,0
Ni-CI-A	E	2,0	4,0	2,5	—	0,03	8,0	min 85	2,5	Al: 1,0 to 3,0	1,0
NiFe-1	E, S, T	2,0	4,0	2,5	0,03	0,03	Remainder	45 to 75	4,0	Al: 1,0	1,0
NiFe-2	E, S, T	2,0	4,0	1,0 to 5,0	0,03	0,03	Remainder	45 to 60	2,5	Al: 1,0 Carbide producing elements: 3,0	1,0
NiFe-Cl	E	2,0	4,0	2,5	—	0,03	Remainder	45 to 60	2,5	Al: 1,0	1,0
NiFeT3-CI	T	2,0	1,0	3,0 to 5,0	—	0,03	Remainder	45 to 60	2,5	Al: 1,0	1,0
NiFe-CI-A	E	2,0	4,0	2,5	—	0,03	Remainder	45 to 60	2,5	Al: 1,0 to 3,0	1,0
NiFeMn-CI	E	2,0	1,0	10 to 14	—	0,03	Remainder	35 to 45	2,5	Al: 1,0	1,0
	S	0,50	1,0	10 to 14	—	0,03	Remainder	35 to 45	2,5	Al: 1,0	1,0
NiCu	E, S	1,7	1,0	2,5	—	0,04	5,0	50 to 75	Remainder	—	1,0
NiCu-A	E, S	0,35 to 0,55	0,75	2,3	—	0,025	3,0 to 6,0	50 to 60	35 to 45	—	1,0
NiCu-B	E, S	0,35 to 0,55	0,75	2,3	—	0,025	3,0 to 6,0	60 to 70	25 to 35	—	1,0

[a] Single values are maximum percentages, unless otherwise noted.

[b] The weld metal or filler metal as specified shall be analysed for specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "sum of other elements" in the last column of the table.

[c] Certain bronze filler metals are not included in this table, but can be used to braze weld cast iron very effectively. Colour match will not be the same as cast iron

[d] Nickel limit can include incidental cobalt.

[e] Copper limit can include incidental silver.

[f] Consumables for which the chemical composition is not listed in this table shall be symbolized indicating the chemical composition and prefixed by the letter Z. The chemical composition ranges are not specified and therefore, it is possible that two electrodes with the same Z classification might not be interchangeable.

Table 3 *(continued)*

Symbol	Product form	Chemical composition in % (by mass)[a, b, c]									
		C	Si	Mn	P	S	Fe	Ni[d]	Cu[e]	Remark	Sum of other elements
Z[f]	E, S, T	Any other agreed composition									

a Single values are maximum percentages, unless otherwise noted.

b The weld metal or filler metal as specified shall be analysed for specific elements for which values are shown in this table. If the presence of other elements is indicated in the course of this work, the amount of those elements shall be determined to ensure that their total does not exceed the limit specified for "sum of other elements" in the last column of the table.

c Certain bronze filler metals are not included in this table, but can be used to braze weld cast iron very effectively. Colour match will not be the same as cast iron

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e Copper limit can include incidental silver.

f Consumables for which the chemical composition is not listed in this table shall be symbolized indicating the chemical composition and prefixed by the letter Z. The chemical composition ranges are not specified and therefore, it is possible that two electrodes with the same Z classification might not be interchangeable.

4.5 Symbols for effective electrode efficiency and type of current (covered electrode)

The symbol in Table 4 indicates the effective electrode efficiency in accordance with ISO 2401 and the type of current.

Table 4 — Symbol for effective electrode efficiency and type of current

Symbol	Effective electrode efficiency %	Type of current[a]
1	≤105	a.c. and d.c.
2	≤105	d.c.
3	>105 ≤ 125	a.c. and d.c.
4	>105 ≤ 125	d.c.
5	>125 ≤ 160	a.c. and d.c.
6	>125 ≤ 160	d.c.
7	>160	a.c. and d.c.
8	>160	d.c.
9	[b]	a.c. and d.c.
0	[b]	d.c.

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

[b] Not required.

5 Mechanical tests

The mechanical properties of the all-weld metal are not part of the classification.

NOTE 1 The mechanical properties and the microstructure of similar weld metal largely correspond with those of the parent metal. They mainly depend on, for example, preheating, thermal conditions during welding, and cooling rate. The indication of compulsory mechanical properties is not possible.

NOTE 2 The tensile test is used to describe the mechanical properties of the dissimilar all-weld metal. It is performed with all-weld metal (as welded) in accordance with ISO 15792-1:2000/Amd:2011, type 1.3.

6 Chemical analysis

The chemical analysis of rod/wire electrodes shall be performed on samples of the product or the stock from which it is made.

The chemical analysis of covered electrodes and tubular cored electrodes shall be performed on any suitable all-weld metal test specimen. In case of dispute, the test specimen specified in ISO 6847 shall be used.

The test results shall meet the requirements of Table 2 or Table 3 for the classification under test. Any analytical technique can be used, but in case of dispute, reference shall be made to established published methods (see Refererences [1],[2], and [3]).

7 Rounding procedure

For the purposes of determining compliance with the requirements of this International Standard, the actual test values obtained shall be subject to ISO 80000-1:2009, B.3, Rule A. If the measured values are obtained by equipment calibrated in units other than those of this International Standard, the measured values shall be converted to the units of this International Standard before rounding.

If an arithmetic average value is to be compared to the requirements of this International Standard, rounding shall be done only after calculating the arithmetic average. If the test method cited in Clause 2 contains instructions for rounding that conflict with the instructions of this International Standard, the rounding requirements of the test method standard shall apply. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

8 Retests

If the results of any test fail to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for retest could be taken from the original test assembly or from a new test assembly using parent metals of the same type, welding consumables from the same production lot, and the same welding procedure as used for the first test assembly. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement.

If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that during preparation or after completion of any test it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test assembly or test specimen(s) or in conducting the test, the test shall be considered invalid without regard to whether the test was actually completed or whether the test results met or failed to meet the requirement. That test shall be repeated following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

9 Technical delivery conditions

The technical delivery conditions shall meet the requirements in ISO 544. The requirements for the cast rod and for the covered electrode with cast core rod shall be defined separately.

10 Designation

The designation of the consumables shall follow the principle given in the examples below.

EXAMPLE 1 A cast rod for oxy-fuel gas welding (R) with a chemical composition within the limits for the alloy symbol FeC-1 of Table 2 is designated as follows:

Cast rod ISO 1071 – R C FeC-1

EXAMPLE 2 A wire electrode for gas shielded metal arc welding (S) with a chemical composition within the limits for the alloy symbol NiFe-2 of Table 3 is designated as follows:

Wire electrode ISO 1071 – S C NiFe-2

EXAMPLE 3 A tubular cored electrode for gas shielded metal arc welding (T) deposits an all-weld metal with a chemical composition within the limits for the alloy symbol NiFe-1 of Table 3. The electrode was tested under mixed gas (M21). The designation will be:

Tubular cored electrode ISO 1071 – T C NiFe-1 M21

EXAMPLE 4 A tubular cored electrode for metal arc welding (T) deposits an all-weld metal with a chemical composition within the limits for the alloy symbol FeC-2 of Table 2. The electrode was tested without a shielding gas (NO). The designation will be:

Tubular cored electrode ISO 1071 – T C FeC-2 NO

EXAMPLE 5 A covered electrode for manual metal arc welding (E) deposits all-weld metal with a chemical composition within the limits for the alloy symbol NiFe-1 of Table 3. The electrode can be used with alternating current or direct current and has an effective electrode efficiency of 120 % (3). The designation will be:

Covered electrode ISO 1071 – E C NiFe-1 3

EXAMPLE 6 A wire electrode for gas shielded metal arc welding (S) with a chemical composition 78 % Ni, 20 % Fe, and 0,8 % Ti. The designation will be:

Wire electrode ISO 1071 – S C Z NiFe20Ti

Annex A
(informative)

Description of the consumable

A.1 General

In the following, each consumable for unalloyed cast irons is described and examples for the intended applications of the different alloy types are given.

A.2 Similar weld metal

A.2.1 FeC-1

Consumables of this alloy type are used as cast welding rods and as covered electrodes with cast core rods of grey cast iron with lamellar graphite. The rods for oxy-fuel gas welding can be bare or thin covered with flux. The covering of the electrodes is basic-graphitic. The all-weld metal consists of grey cast iron with lamellar graphite.

Preferred application: Welding of grey cast irons.

A.2.2 FeC-2

Consumables of this alloy type are used as basic-graphitic covered electrodes and as self-shielded tubular cored electrodes. The core rod and the tube respectively consist of unalloyed steel. The consumables produce a weld metal of grey cast iron with lamellar graphite.

Preferred application: Welding of grey cast irons.

A.2.3 FeC-3

Consumables of this alloy type are used as basic-graphitic covered electrodes and as self-shielded tubular cored electrodes. The core rod consists of the alternative of grey cast iron or of unalloyed steel. The consumables produce a weld metal of grey cast iron with lamellar graphite.

Preferred application: Welding of grey cast irons.

A.2.4 FeC-4

Consumables of this type are cast welding rods used for oxy-fuel gas welding of grey cast iron with lamellar graphite. This rod will melt before the cast grey iron and will flow very well. A separate iron oxide flux could be needed to obtain sound weld metal. Properly made welds match the properties of low strength grey iron in the 150 MPa to 250 MPa range including colour of grey cast iron. Such welds are generally machinable unless iron phosphides have formed due to insufficient dilution of the weld rod with enough base metal.

A.2.5 FeC-5

Consumables of this low-alloy type are cast iron welding rods used for oxy-fuel gas welding of medium-strength grey cast iron. Properly made welds with these rods develop higher strength than those of the FeC-4 type and are suitable for grey cast iron in the range of 250 MPa to 300 MPa. The deposit generally remains more machinable since iron phosphides do not form even in undiluted weld metal.

A.2.6 FeC-GP1

Consumables of this low-alloy type are cast iron welding rods used for oxy-fuel gas welding of spheroidal graphite cast irons and grey irons. Properly made, most of the graphite in the weld deposit is spheroidal unless the welder's technique has oxidized the Mg and Ce additions from the filler rod. The deposit has improved ductility as compared to the deposits made with FeC-4 and FeC-5 type rods and improves even more with post weld heat treatment. Matching strength to nodular iron of 400 MPa tensile strength is possible.

A.2.7 FeC-GF and FeC-GP2

Consumables of this alloy type are used as basic-graphitic covered electrodes and as self-shielded tubular cored electrodes. The core rod and the tube respectively consist of unalloyed steel. The consumables produce a weld metal of cast iron with spheroidal graphite. Depending on thermal conditions and chemical composition, the type FeC-GF has a mainly ferritic microstructure and the type FeC-GP2 mainly a pearlitic microstructure.

Preferred application: Welding of cast irons with spheroidal graphite and neutral tempered malleable cast irons.

A.3 Dissimilar weld metal

A.3.1 Fe-1

Consumables of this alloy type are used as covered electrodes. They have a special covering and they are suitable for one-layer surfacing on corroded or scaled cast irons to get a good fusion with the parent metal. This type of electrode is not suited for filler layers because of the risk of hardening.

Basic covered electrodes in accordance with ISO 2560, wire electrodes in accordance with ISO 14341, and tubular cored electrodes in accordance with ISO 17632 can be used for welding of malleable cast iron with a ferritic surface area. Consumables producing a weld metal of low strength should be preferred.

A.3.2 St

Consumables of this alloy type are covered non-alloy steel electrodes, the covering of which has a very low melting temperature, as well as solid wires and rods or tubular electrodes. They are primarily used for repair of small pits and cracks in cast iron. The weld deposit due to carbon pickup from the cast iron tends to become largely martensite and is machinable only by grinding.

A.3.3 Fe-2

Consumables of this alloy type are used as covered electrodes and as tubular cored electrodes. The core rod and the tube respectively consist of unalloyed steel. The covering and the core respectively contain carbide-producing elements. By welding of cast iron, the microstructure of the first layer will be ferritic with much carbide. As carbon combines with the carbide-producing elements, too much hardening by formation of martensite is avoided.

Preferred application: Surfacing of grey and nodular cast irons and malleable cast irons. Buffer layers on aged cast irons will produce a good fusion to the parent metal.

A.3.4 Ni-Cl

Consumables of this alloy type are used as covered electrodes, wire electrodes, wires, and rods. They deposit a high nickel alloy containing some graphite. Single pass weld deposits on cast iron are more ductile and machinable than deposits from nickel-iron electrodes and rods, but are less resistant to hot cracking due to high phosphorus in the cast iron.