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Welding consumables — Fluxes for submerged arc welding — Classification

Produits consommables pour le soudage — Flux pour le soudage à l'arc sous flux — Classification

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14174 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

Introduction

This International Standard is based on the European Standard EN 760:1996.

Requests for official interpretations of any aspect of this standard should be directed to the Secretariat of ISO/TC 44/SC 3, via your national standards body, a complete listing of which can be found at www.iso.org.

Welding consumables — Fluxes for submerged arc welding — Classification

1 Scope

This International Standard applies to fluxes for the submerged arc welding of non alloy and fine grain steels, high strength steels, creep resisting steels, and stainless and heat resisting steels, nickel and nickel alloys for joining and overlay welding using wire electrodes and strip electrodes.

2 Normative references

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

ISO 3690, *Welding and allied processes — Determination of hydrogen content in ferritic steel arc weld metal*

3 Classification

Fluxes for submerged arc welding are granular, fusible products of mineral origin, which are manufactured by various methods. Fluxes influence the chemical composition and the mechanical properties of the weld metal. The current-carrying capacity of a flux depends on various welding conditions. This property of a flux is not covered by a symbol in this flux classification.

The classification of the fluxes is divided into six parts:

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

2) the second part gives a symbol indicating the method of manufacture (see 4.2);

3) the third part gives a symbol indicating the type of flux, characteristic chemical constituents (see Table 1);

4) the fourth part gives a symbol indicating the applications, flux class (see 4.4);

5) the fifth part gives a symbol indicating the type of current (see 4.5);

6) the sixth part gives a symbol indicating the hydrogen content of all-weld metal (see Table 2).

In order to promote the use of this International Standard, the classification is divided into two sections:

a) Compulsory section

This section includes the symbols for process, method of manufacture, characteristic chemical constituents (type of flux) and applications, i.e., the symbols defined in 4.1, 4.2, 4.3 and 4.4.

b) Optional section

This section includes the symbols for the type of current and diffusible hydrogen, i.e., the symbols defined in 4.5 and 4.6.

4 Symbols

4.1 Symbol for the product/process

The symbol for the flux used in submerged arc welding processes shall be the letter S.

4.2 Symbol for method of manufacture

The symbol below indicates the method of manufacture:

— F fused flux;

— A agglomerated flux;

— M mixed flux.

Fused fluxes are made by melting and granulating. Agglomerated fluxes are bound, granular mixtures of ground raw materials. Mixed fluxes comprise all fluxes which are mixed from two or more types of flux by the manufacturer.

For particle size requirements in marking, see Clause 5.

4.3 Symbol for type of flux, characteristic chemical constituents

The symbols in Table 1 indicate the type of flux in accordance with the characteristic chemical constituents.

Table 1 — Symbol for type of flux, characteristic chemical constituents [a, b, c]

Symbol	Characteristic chemical constituents	Limit of constituent %
MS Manganese-silicate	$MnO + SiO_2$ CaO	min. 50 max. 15
CS Calcium-silicate	$CaO + MgO + SiO_2$ $CaO + MgO$	min. 55 min. 15
CG [d] Calcium-magnesium	$CaO + MgO$ CO_2 Fe	max. 50 min. 2 max. 10
CB [d] Calcium-magnesium-basic	$CaO + MgO$ CO_2 Fe	40 to 80 min. 2 max. 10
CI [d] Calcium-magnesium-iron	$CaO + MgO$ CO_2 Fe	max. 50 min. 2 15 - 60
IB [d] Calcium-magnesium-iron-basic	$CaO + MgO$ CO_2 Fe	40 to 80 min. 2 15 - 60
ZS Zirconium-silicate	$ZrO_2 + SiO_2 + MnO$ ZrO_2	min. 45 min. 15
RS Rutile-silicate	$TiO_2 + SiO_2$ TiO_2	min. 50 min. 20
AR Aluminate-rutile	$Al_2O_3 + TiO_2$	min. 40
AB Aluminate-basic	$Al_2O_3 + CaO + MgO$ Al_2O_3 CaF_2	min. 40 min. 20 max. 22
AS Aluminate-silicate	$Al_2O_3 + SiO_2 + ZrO_2$ $CaF_2 + MgO$ ZrO_2	min. 40 min. 30 min. 5
AF Aluminate-fluoride-basic	$Al_2O_3 + CaF_2$	min. 70
FB Fluoride-basic	$CaO + MgO + CaF_2 + MnO$ SiO_2 CaF_2	min. 50 max. 20 min. 15
Z	Any other composition	

[a] A description of the characteristics of each of the types of flux is given in Annex A.

[b] Carbonates such as $CaCO_3$, $MgCO_3$ in agglomerated flux are converted to CaO, MgO and the constituent shall be the ratio of the remaining amount exclusive of CO_2 content in the flux (see Clause 8).

[c] E.g., all of metallic Si and Si-compound is converted to SiO_2, and all of metallic Mn and Mn-compound is converted to MnO to determine the numerical value (see Clause 8).

[d] The amount of constituent in the agglomerated flux shall be the ratio of remaining amount exclusive of Fe content in the flux (see Clause 8).

4.4 Symbol for applications, flux class

4.4.1 Flux class 1

These are fluxes for submerged arc welding of non alloy and fine grain steels, high strength steels and creep resisting steels. In general, the fluxes do not contain alloying elements, other than Mn and Si, thus the weld metal analysis is predominantly influenced by the composition of the wire electrode and metallurgical reactions. The fluxes are suitable for both joint welding and surfacing. In the case of joint welding, most of them can be applied for both multi-run and single-run and/or two-run technique.

In the flux designation, the digit 1 indicates class 1.

4.4.2 Flux class 2

These are fluxes for joint and overlay welding of stainless and heat-resisting steels and/or nickel and nickel-based alloys, and unalloyed fluxes for hard facing [1)].

In the flux designation, the digit 2 indicates class 2.

4.4.3 Flux class 3

These are fluxes mainly for overlay welding purposes yielding a wear-resisting weld metal by transfer of alloying elements from the flux, such as C, Cr or Mo.

In the flux designation, the digit 3 indicates class 3.

4.4.4 Flux class 4

These are fluxes applicable both to flux classed 1 and classed 2[1)].

In the flux designation, the digit 4 indicates class 4.

4.5 Symbol for type of current

The symbol below indicates the type of current (a.c. or d.c.) for which the flux is suitable:

— d.c. is the symbol for direct current;

— a.c. is the symbol for alternating current.

Suitability for use on a.c. generally also implies suitability for d.c.

4.6 Symbol for hydrogen content in deposited metal

The symbols in Table 2 indicate the hydrogen content determined in deposited metal in accordance with the method described in ISO 3690.

Other methods of collection and measurement of the diffusible hydrogen can be used for testing provided they possess equal reproducibility with, and are calibrated against, the method described in ISO 3690.

In case of dispute, the method described in ISO 3690 shall be used.

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1) Not all fluxes suitable for use with stainless steel filler metal are also suitable for nickel and nickel-based alloy filler metal.

Table 2 — Symbol for hydrogen content in deposited metal

Symbol	Hydrogen content ml/100 g deposited metal max.
H5	5
H10	10
H15	15

When the letter H is included in the classification, the manufacturer shall state in his literature whether the maximum hydrogen level achieved is 15 ml, 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 and polarity to remain within this limit.

If a low hydrogen weld metal is necessary in view of the parent materials to be welded, the flux manufacturer should be consulted for details of the redrying conditions specific to the flux.

A usual redrying condition for fused flux can be 2 h at (250 ± 50) °C or 2 h at (350 ± 50) °C for an agglomerated flux.

4.7 Metallurgical behaviour

The metallurgical behaviour of the flux shall be indicated in the manufacturer's literature or data sheets.

The metallurgical behaviour of a flux is characterized by the pick-up and/or burn-out of alloying elements. Pick-up or burn-out is the difference between the chemical composition of the all-weld metal deposit and the composition of the original electrode. It is described in general terms in the notes on flux types in Annex A.

5 Particle size range

The particle category is not a part of the flux designation but shall be used for information in the marking of packaging units.

The particle size range shall be measured by a suitable technique. The size range to be stated on the packaging shall be the range of particle diameters that includes 70 % of the flux. Particle sizes shall be expressed to the nearest 0,1 mm, e.g. a particle size range of 0,2 mm to 1,6 mm.

6 Technical delivery conditions

The flux shall be granular and so constituted that it can be conveyed freely by the flux feed system. The particle size distribution shall be uniform and consistent in the different packaging units. The fluxes are obtainable in different granulations.

The fluxes shall be supplied packaged. Subject to proper transportation and storage, the packaging shall be sufficiently robust to provide the contents with a high standard of protection against damage.

7 Marking

The packaging shall be clearly marked with the following details:

a) trade name;

b) designation in accordance with this International Standard (see Clause 8);

c) production lot number;

d) net weight;

e) manufacturer or supplier;

f) particle size range in accordance with Clause 5.

8 Designation

The designation of a flux shall follow the principle of the example given below.

EXAMPLE

A flux for submerged-arc welding (S) manufactured by fusion (F), calcium-silicate-type (CS) for class 1 applications (1), useable with a.c. or d.c. (AC) and producing a weld metal with a maximum of 10 ml hydrogen in 100 g deposited metal (H10) is designated as follows:

Welding flux ISO 14174 - S F CS 1 AC H10

and the compulsory section:

Welding flux ISO 14174 - S F CS 1

where:

ISO 14174	represents the number of this International Standard;
S	represents the flux for submerged arc welding (see 4.1);
F	represents the fused flux (see 4.2);
CS	represents the type of flux (see Table 1)
1	represents the application, flux class (see 4.4);
AC	represents the type of current (see 4.5);
H10	represents the hydrogen content (see Table 2).

a) **Carbonates**

Carbonates such as $CaCO_3$, $MgCO_3$ in agglomerated flux are converted to CaO, MgO and the constituent shall be the ratio of remaining amount exclusive of CO_2 content in the flux.

[see Table 1, Note b]

An example of agglomerated flux: ($CaCO_3$ and/or $MgCO_3$ are commonly contained in CG, CB, CI and IB in Table 1).

SiO_2 (20 %), MnO (10 %), $CaCO_3$ (25 %), $MgCO_3$ (15 %), Al_2O_3 (15 %), CaF_2 (15 %)

25 % $CaCO_3$ consists of 14 % CaO and 11 % CO_2 because the molecular weights of $CaCO_3$, CaO and CO_2 are 100, 56 and 44 respectively.

15 % $MgCO_3$ consists of 7,1 % MgO and 7,9 % CO_2 because the molecular weights of $MgCO_3$, MgO and CO_2 are 84, 40 and 44 respectively.

The remaining amount exclusive of CO_2 content in the flux:

$$20(SiO_2) + 10(MnO) + 14(CaO) + 7{,}1(MgO) + 15(Al_2O_3) + 10(CaF_2) = 81{,}1\ \%$$

The amount of constituent:

SiO_2 (20/81,1 = 24,7 %), MnO (10/81,1 = 12,3 %), CaO (14/81,1 = 17,3 %), MgO (7,1/81,1 = 8,8 %), Al_2O_3 (15/81,1 = 18,5 %), CaF_2 (15/81,1 = 18,5 %)

This flux is concluded to be type CG, as given in Table 1.

b) **Silicon and its compounds**

All metallic Si and Si-compounds are converted to SiO_2, and all metallic Mn and Mn-compounds are converted to MnO to determine the numerical value [see Table 1, Notes b, c and d].

An example of agglomerated flux: (Si and Si-compounds and/or Mn and Mn-compounds are usually contained in CG, CB, CI and IB in Table 1).

SiO_2 (15 %), MnO (10 %), $CaCO_3$ (37 %), $MgCO_3$ (23 %), CaF_2 (7 %), Fe-Si (5 %), Metallic Mn (3 %)

37 % $CaCO_3$ consists of 20,7 % CaO and 16,3 % CO_2 because the molecular weights of $CaCO_3$, CaO and CO_2 are 100, 56 and 44 respectively.

23 % $MgCO_3$ consists of 11,0 % MgO and 12,0 % CO_2 because the molecular weights of $MgCO_3$, MgO and CO_2 are 84, 40 and 44 respectively.

If Si content in Fe-Si is 60 %, then 5 % Fe-Si in the flux consists of 2 % Fe and 3 % Si. 3 % Si is converted to 6,4 % SiO_2 because the molecular weights of Si and SiO_2 are 28 and 60 respectively.

3 % metallic Mn is converted to 3,9 % MnO because the molecular weights of Mn and MnO are 55 and 71 respectively.

The remaining amount exclusive of CO_2 and Fe content in the flux:

$$15(SiO_2) + 10(MnO) + 20{,}7(CaO) + 11{,}0(MgO) + 7(CaF_2) + 6{,}4(SiO_2) + 3{,}9(MnO) = 74{,}0\ \%$$

The amount of constituent:

SiO_2 (15/74,0 + 6,4/74,0 = 28,9 %), MnO (10/74,0 + 3,9/74,0 = 18,8 %), CaO (20,7/74,0 = 28,0 %), MgO (11,0/74,0 = 14,9 %), CaF_2 (7/74,0 = 9,5 %)

The flux is concluded to be type CB as given in Table 1.

c) **Iron content**

The amount of constituent in the agglomerated flux shall be the ratio of remaining amount exclusive of Fe in the flux [see Table 1, Note b, c and d].

An example of agglomerated flux: (a lot of iron powder is contained in CI and IB in Table 1 to increase deposited metal).

SiO_2 (20 %), MnO (10 %), $CaCO_3$ (25 %), $MgCO_3$ (15 %), CaF_2 (7 %), Fe (20 %), metallic Si (3 %)

25 % $CaCO_3$ consists of 14 % CaO and 11 % CO_2 because the molecular weights of $CaCO_3$, CaO and CO_2 are 100, 56 and 44 respectively.

15 % $MgCO_3$ consists of 7,1 % MgO and 7,9 % CO_2 because the molecular weights of $MgCO_3$, MgO and CO_2 are 84, 40 and 44 respectively.

3 % metallic Si is converted to 6,4 % SiO_2 because the molecular weights of Si and SiO_2 are 28 and 60 respectively.

The remaining amount exclusive of CO_2 and Fe content in the flux:

$$20(SiO_2) + 10(MnO) + 14(CaO) + 7{,}1(MgO) + 7(CaF_2) + 6{,}4(SiO_2) = 64{,}5\ \%$$

The amount of constituent:

SiO_2 (20/64,5 + 6,4/64,5 = 40,9 %), MnO (10/64,5 = 15,5 %), CaO (14/64,5 = 21,7 %), MgO (7,1/64,5 = 11,0 %), CaF_2 (7/64,5 = 10,9 %)

The flux is concluded to be type CI as given in Table 1.

When $CaCO_3$, $MgCO_3$, metallic Si, Si-compounds, metallic Mn, Mn-compounds and Fe are contained in agglomerated flux at the same time, $CaCO_3$ and $MgCO_3$ are converted to CaO and MgO respectively, metallic Si, Si-compounds and metallic Mn, Mn-compounds are converted to SiO_2 and MnO respectively, and the amount of constituent in the agglomerated flux shall be the ratio of remaining amount exclusive of CO_2 and Fe as explained in a), b) and c) above.

Annex A
(informative)

Description of flux types

A.1 Manganese-silicate type, MS

Welding fluxes of this type contain essentially MnO and SiO_2. Generally, they are characterized by a high manganese transfer to the weld metal, so that they are used preferably in combination with low-manganese wire electrodes. Silicon pick-up by the weld metal is also high. Many fluxes of this type give weld metals of limited toughness which is partly attributable to a high oxygen content.

Manganese-silicate fluxes have a relatively high current-carrying capacity and are suitable for high welding speeds. The weld metal shows good resistance to porosity, even on rusty plate. The weld contour is regular and the weld interface free from undercut.

Toughness limitations usually preclude the use of these fluxes in multipass welding of thick sections, but they are well suited to fast welding of thinner materials and to fillet welding.

A.2 Calcium-silicate type, CS

Welding fluxes of this type are composed essentially of CaO, MgO and SiO_2. The group comprises a range of types, the more acid ones having the highest current-carrying capacity of all fluxes and contributing high amounts of silicon to the weld metal. These fluxes are suitable for two-pass welding of thick sections where mechanical property requirements are not too stringent.

More basic fluxes within the group give less silicon pick-up and may be used for multipass welding where strength and toughness requirements are more stringent. The current-carrying capacity of the fluxes tends to decease with increasing flux basicity but the weld profile should be smooth and free from undercut.

A.3 Calcium-magnesium, CG

Welding fluxes of this type are composed essentially of CaO, MgO, CaF_2 and SiO_2 and are supplied as a form of agglomerated type flux. $CaCO_3$, which generates CO_2 gas during welding and reduces the diffusible hydrogen, is generally used as a source of CaO. These fluxes are widely applied to non alloy and fine grain steels, high strength steels and creep-resisting steels by multi-pass or high heat input welding methods.

A.4 Calcium-magnesium-basic, CB

Welding fluxes of this type contain essentially CaO, MgO, CaF_2 and Al_2O_3 and are supplied as a form of agglomerated flux. $CaCO_3$, which generates CO_2 gas during welding and reduces the diffusible hydrogen, is generally added as a source of CaO. These fluxes usually give low oxygen and consequently high toughness weld metal and may be used when the toughness requirement is stringent. These fluxes are suitable for both multi-pass and high heat input welding of the plate but are not suitable for high speed welding because of heavy undercutting.

A.5 Calcium-magnesium-iron, CI

Welding fluxes of this type are composed essentially of CaO, MgO, CaF_2, SiO_2 and a lot of iron powder to increase deposited metal. These fluxes are supplied as a form of agglomerated type flux. $CaCO_3$, which generates CO_2 gas during welding and reduces the diffusible hydrogen, is generally used as a source of CaO. These fluxes are mainly applied for large heat input welding of thick plate where mechanical property requirements are not too stringent.

A.6 Calcium-magnesium-iron-basic, IB

Welding fluxes of this type contain essentially CaO, MgO, CaF_2 and Al_2O_3 and a lot of iron powder for increasing deposited metal. These fluxes are supplied as a form of agglomerated type flux. $CaCO_3$, which generates CO_2 gas during welding and reduces the diffusible hydrogen, is generally added as a source of CaO. The weld metals with these fluxes usually have less silicon pick-up and low oxygen content and show high toughness. These fluxes are mainly applied for large heat input welding of thick plate where strength and toughness requirements are more stringent.

A.7 Zirconium-silicate type, ZS

Welding fluxes of this type have of ZrO_2 and SiO_2 as their main constituents.

These fluxes are recommended for making high speed, single pass welds on clean plate and sheet steel. The good wetting action of the slag provides the characteristics needed to make uniform welds at high speed without undercut.

A.8 Rutile-silicate type, RS

Welding fluxes of this type have TiO_2 and SiO_2 as their main constituents. Besides a high manganese burn-out, these fluxes produce a high silicon pick-up in the weld deposit, thus, they can be used in conjunction with wire electrodes having a medium or high manganese content. The toughness of the weld remains limited due to a relatively high oxygen content.

Their current-carrying capacity is reasonably high, which permits single- and multi-wire welding at high travel speeds. A typical field of application is two-run welds (one run from each side of the joint) in fabrication of large diameter pipes.

A.9 Aluminate-rutile type, AR

These fluxes contain essentially Al_2O_3 and TiO_2. They give rise to an average manganese and silicon transfer to the weld metal. Due to their high slag viscosity, this type features a large number of advantageous operating characteristics, such as good weld appearance, high welding speed and very good slag detachability, especially in fillet welds. The fluxes are suitable for operation with d.c. and a.c. and thus are suitable for single and multi wire welding. Due to their relatively high oxygen content they produce medium mechanical properties.

Their main fields of application include the welding of thin-walled containers and pipes, tube-web-tube joints of finned tubes, fillet welds in steel constructions and ship-building.

A.10 Aluminate-basic type, AB

Besides Al_2O_3 as their main constituent, these fluxes contain essentially MgO and CaO. They give rise to a medium manganese transfer to the weld deposit. Due to the high Al_2O_3 content the liquid slag is “short” and