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Welding consumables — Fluxes for submerged arc welding and electroslag welding — Classification

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

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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*.

This second edition cancels and replaces the first edition (ISO 14174:2004), which has been technically revised.

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

Introduction

This International Standard is based on EN 760:1996[1].

Welding consumables — Fluxes for submerged arc welding and electroslag welding — Classification

1 Scope

This International Standard specifies requirements for classification of fluxes for submerged arc welding and electroslag welding for joining and overlay welding using wire electrodes, tubular cored 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 arc weld metal*

ISO 14171, *Welding consumables — Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non alloy and fine grain steels — Classification*

ISO 14343, *Welding consumables — Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels — Classification*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

3 Classification

Fluxes for submerged arc welding and electroslag welding for joining and overlay welding are granular, fusible products of mainly mineral origin, which are manufactured by various methods. Fluxes influence the chemical composition and the mechanical properties of the weld metal.

The classification of the fluxes is divided into seven parts:

1) the first part gives a symbol indicating the product/process (see 4.1);
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 metallurgical behaviour (see 4.5);
6) the sixth part gives a symbol indicating the type of current (see 4.6);
7) the seventh part gives a symbol indicating the diffusible hydrogen content of deposited weld metal (see Table 6) — only applicable for class 1 fluxes.

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, 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 metallurgical behaviour, type of current, and diffusible hydrogen, i.e. the symbols defined in 4.5, 4.6, and 4.7.

4 Symbols

4.1 Symbol for the product/process

The symbol for the flux used in submerged arc welding for joining and overlay welding shall be the letter S and for the flux used in electroslag welding for joining and overlay welding shall be the letters ES.

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 finer raw materials. Mixed fluxes comprise all fluxes which, after fusing or agglomerating, are mixed with one or more additional components or fluxes.

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. Elemental analysis shall be performed on representative samples of the flux. Any suitable analytical technique may be used, but in cases of dispute reference shall be made to established methods. Based on the elemental analysis of the flux, the characteristic chemical constituents of the flux can be determined.

Examples of such determinations are shown in Annex A.

4.4 Symbol for applications, flux class

4.4.1 General

A given flux may carry more than one class as specified in 4.4.2 to 4.4.5.

4.4.2 Flux class 1

These are fluxes for submerged arc welding of non alloy and fine grain steels, high-strength steels, creep-resisting steels, and atmospheric corrosion-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/strip electrode and metallurgical reactions. The fluxes are suitable for joint welding and/or overlay welding. In the case of joint welding, some fluxes 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.

Table 1 — Symbol for type of flux, characteristic chemical constituents[ab]

Symbol (description)	Characteristic chemical constituents	Limit of constituent % (by mass)
MS (Manganese-silicate)	$MnO + SiO_2$ CaO	≥50 ≤15
CS (Calcium-silicate)	$CaO + MgO + SiO_2$ $CaO + MgO$	≥55 ≥15
CG (Calcium-magnesium)	$CaO + MgO$ CO_2 Fe	5 to 50 ≥2 ≤10
CB (Calcium-magnesium basic)	$CaO + MgO$ CO_2 Fe	30 to 80 ≥2 ≤10
CG-I (Calcium-magnesium with iron)	$CaO + MgO$ CO_2 Fe	5 to 45 ≥2 15 to 60
CB-I (Calcium-magnesium basic with iron)	$CaO + MgO$ CO_2 Fe	10 to 70 ≥2 15 to 60
GS (Magnesium-silicate)	$MgO + SiO_2$ Al_2O_3 $CaO + CaF_2$	≥42 ≤20 ≤14
ZS (Zirconium-silicate)	$ZrO_2 + SiO_2 + MnO$ ZrO_2	≥45 ≥15
RS (Rutile-silicate)	$TiO_2 + SiO_2$ TiO_2	≥50 ≥20
AR (Aluminate-rutile)	$Al_2O_3 + TiO_2$	≥40
BA (Basic-alumina)	$Al_2O_3 + CaF_2 + SiO_2$ CaO SiO_2	≥55 ≥8 ≤20
AAS (Acid-aluminium-silicate)	$Al_2O_3 + SiO_2$ $CaF_2 + MgO$	≥50 ≥20
AB (Aluminate-basic)	$Al_2O_3 + CaO + MgO$ Al_2O_3 CaF_2	≥40 ≥20 ≤22
AS (Aluminate-silicate)	$Al_2O_3 + SiO_2 + ZrO_2$ $CaF_2 + MgO$ ZrO_2	≥40 ≥30 ≥5
AF (Aluminate-fluoride-basic)	$Al_2O_3 + CaF_2$	≥70
FB (Fluoride-basic)	$CaO + MgO + CaF_2 + MnO$ SiO_2 CaF_2	≥50 ≤20 ≥15
Z[c]	Any other agreed composition	

[a] Calculations are made as shown in Annex A.

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

[c] Fluxes for which the chemical composition is not listed shall be symbolized similarly and prefixed by the letter Z. The chemical composition ranges are not specified and it is possible that two fluxes with the same Z classification are not interchangeable.

4.4.3 Flux classes 2 and 2B

These are fluxes for joint welding of stainless and heat-resisting steels and/or nickel and nickel alloys and corrosion-resistant overlay welding[1)]. Fluxes of these classes can contain alloying elements compensating for the burn-out.

In the flux designation, the digit 2 is used to indicate class 2 fluxes mainly suited for joint welding, but which can also be used for strip cladding. 2B is used for fluxes especially designed for strip cladding.

4.4.4 Flux class 3

These are fluxes mainly for hardfacing overlay welding by transfer of alloying elements from the flux, such as C, Cr or Mo.

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

4.4.5 Flux class 4

These are other fluxes for which classes 1 to 3 are not applicable, e.g. fluxes for copper alloys.

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

4.5 Symbol for metallurgical behaviour

4.5.1 General

The metallurgical behaviour of a flux is characterized by the contribution (pick-up and/or burn-out) of alloying elements. Concerning fluxes for joining, the contribution is the difference between the chemical composition of the all-weld metal deposit and the composition of the specified electrode. Concerning fluxes for overlay welding, the contribution is the difference between the chemical composition of the deposited weld metal of the last bead/layer and the chemical composition of the specified wire/strip electrode.

4.5.1.1 Metallurgical behaviour, flux class 1

For determining the pick-up and burn-out behaviour, a wire electrode ISO 14171-A - S2 or ISO 14171-B - SU22 shall be used in accordance with 4.5.2. The pick-up or burn-out of the elements Si and Mn shall be stated in this sequence.

The symbols in Table 2 indicate the metallurgical behaviour of a welding flux class 1.

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

Table 2 — Symbol for metallurgical behaviour of class 1 fluxes

Metallurgical behaviour	Symbol	Contribution from flux on all-weld metal % (by mass)
Burn-out[a]	1	>0,7
	2	0,5 to 0,7
	3	0,3 to 0,5
	4	0,1 to 0,3
Neutral	5	0,0 to 0,1
Pick-up	6	0,1 to 0,3
	7	0,3 to 0,5
	8	0,5 to 0,7
	9	>0,7
[a] For Si, symbols 1, 2, 3 and 4 are not used.		

4.5.1.2 Metallurgical behaviour, flux classes 2 and 2B

For determining the pick-up or burn-out behaviour, wire or strip electrodes shall be selected in accordance with Table 3 and shall be used in accordance with 4.5.2.

Table 3 — Electrodes used for determination of metallurgical behaviour for class 2 and class 2B fluxes

Product/process	Class	Electrode to be used[a]	
		ISO 14343-A	ISO 14343-B
S	2	S 19 9 L	SS308L
ES	2	S 19 9 L	SS308L
S	2B	B 19 9 L	BS308L
ES	2B	B 19 9 L	BS308L
[a] To determine carbon burn-out, electrodes with minimum 0,04 % (by mass) C shall be used. To determine niobium burn-out, 19 9 Nb/347 electrodes shall be used.			

The pick-up or burn-out of the elements C, Si, Cr, and Nb shall be stated in this sequence. If the flux adds other elements, these shall be indicated by stating the corresponding chemical symbols (e.g. Ni, Mo) immediately after the symbols for C, Si, Cr, and Nb.

The symbols in Table 4 indicate the metallurgical behaviour for class 2 and class 2B fluxes.

4.5.1.3 Metallurgical behaviour, flux class 3

The pick-up of alloying elements shall be indicated by stating the corresponding chemical symbols (e.g. C, Cr, Mo) and approximate amount without the % symbol. For determining the pick-up behaviour a wire electrode, ISO 14171-A - S2 or ISO 14171-B - SU22, shall be used in accordance with 4.5.2.

4.5.1.4 Metallurgical behaviour, flux class 4

The pick-up of alloying elements shall be indicated by stating the corresponding chemical symbols.

Table 4 — Symbols for metallurgical behaviour for class 2 and class 2B fluxes

Metallurgical behaviour	Symbol	Contribution from flux on all-weld metal % (by mass)			
		C	Si	Cr	Nb
Burn-out	1	>0,020	>0,7	>2,0	>0,20
	2	symbol not used	0,5 to 0,7	1,5 to 2,0	0,15 to 0,20
	3	0,010 to 0,020	0,3 to 0,5	1,0 to 1,5	0,10 to 0,15
	4	symbol not used	0,1 to 0,3	0,5 to 1,0	0,05 to 0,10
Neutral	5	0,000 to 0,010	0,0 to 0,1	0,0 to 0,5	0,00 to 0,05
Pick-up	6	symbol not used	0,1 to 0,3	0,5 to 1,0	0,05 to 0,10
	7	0,010 to 0,020	0,3 to 0,5	1,0 to 1,5	0,10 to 0,15
	8	symbol not used	0,5 to 0,7	1,5 to 2,0	0,15 to 0,20
	9	>0,020	>0,7	>2,0	>0,20

4.5.2 Determination of symbols for metallurgical behaviour

For the determination of symbols for class 1 and 2 fluxes, a weld metal pad shall be prepared in accordance with Table 5. For class 3 and 4 fluxes, the weld pad shall be prepared as recommended by the manufacturer.

The surface oxide on the sampling portion of the specimen for chemical analysis shall be removed by machining or grinding. When taking chips from a milling, a shaping or a drilling machine, the use of cutting fluid shall be avoided. The specimen for chemical analysis shall be taken from the weld metal of the highest layer. The specimen shall not include the start or the crater.

Any suitable analytical technique may be used, but in cases of dispute reference shall be made to established methods.

Table 5 — Welding conditions for preparation of a weld metal pad

Product/process	S			ES
Flux class	1	2	2B	2B
Electrode dimension, mm	4,0	3,0	60 × 0,5	60 × 0,5
Runs per layer	2		1	
Number of layers	8		3	2
Length of weld deposit, mm	≥200			
Electrode extension, mm	30 ± 5	27 ± 3		
Type of current[a]	Direct current electrode positive (d.c.e.p.)			
Welding current, A	580 ± 20	420 ± 20	750 ± 25	1 250 ± 30
Welding voltage, V	29 ± 2	27 ± 2	28 ± 2	25 ± 2
Welding speed, mm/min	550 ± 50	500 ± 50	120 ± 10	160 ± 15
Interpass temperature, °C	150 ± 50	≤150		

[a] If a.c. only or a.c. and d.c. operations are claimed, the test welding shall be carried out using a.c. only (a.c. = alternating current; d.c. = direct current).

4.6 Symbol for type of current

The symbols below indicate the type of current (alternating or direct) for which the flux is suitable:

— DC is the symbol for direct current;

— AC is the symbol for alternating current.

Suitability for use with alternating current (a.c.) generally also implies suitability for use with direct current (d.c.).

4.7 Symbol for diffusible hydrogen content in deposited weld metal (class 1 fluxes only)

The symbols in Table 6 indicate the diffusible hydrogen content in deposited weld metal determined in accordance with the method specified in ISO 3690 using a wire electrode ISO 14171-A - S2 or ISO 14171-B - SU22.

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 specified in ISO 3690.

In cases of dispute, the method specified in ISO 3690 shall be used.

Table 6 — Symbol for diffusible hydrogen content in deposited weld metal

Symbol	Diffusible hydrogen content ml/100 g deposited weld metal max.
H2	2
H4	4
H5	5
H10	10

If a diffusible hydrogen symbol is indicated, the manufacturer shall provide information on the recommended type of current and redrying conditions for achieving that hydrogen limit.

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 indicated by the symbol for the smallest and largest particle size in accordance with Table 7 or directly expressed in millimetres.

Table 7 — Particle size

Particle size mm	Symbol
2,5	25
2,0	20
1,6	16
1,4	14
1,25	12
0,8	8
0,5	5
0,4	4
0,315	3
0,2	2
0,1	1
<0,1	0

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 min. 90 % (by mass) of the flux.

An example of a typical symbol for particle range is 2 to 16 or 0,2 mm to 1,6 mm.

6 Rounding procedure

For purposes of determining compliance with the requirements of this International Standard, the actual test values obtained shall be subjected 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 standard 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.

7 Retest

If any test fails to meet the requirement, that test shall be repeated twice. The results of both retests shall meet the requirement. Specimens for the retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retests need be only for those specific elements that failed to meet their 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 tests, 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 properly prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

8 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 can be obtainable in different particle size distributions.

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.

9 Marking

The packaging shall be clearly marked with the following details:

a) trade name;

b) classification in accordance with this International Standard (see Clause 3);

c) production lot number;

d) net mass;

e) manufacturer or supplier;

f) particle size range in accordance with Clause 5;

g) health and safety warnings in accordance with local, national and regional standards and regulations as required.

10 Designation

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

EXAMPLE 1

A flux for submerged-arc welding (S) manufactured by fusion (F), calcium-silicate-type (CS) for class 1 applications (1), with pick-up 0,2 % (by mass) for Si (6) and 0,4 % (by mass) for Mn (7), usable with a.c. or d.c. (AC) and producing a weld metal with a maximum of 10 ml diffusible hydrogen in 100 g deposited weld metal (H10) is designated as follows:

ISO 14174 - S F CS 1 67 AC H10

and the compulsory section:

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);
67	represents the metallurgical behaviour (see 4.5);
AC	represents the type of current (see 4.6);
H10	represents the hydrogen content (see Table 6).

EXAMPLE 2

A flux for submerged-arc welding (S) manufactured by agglomeration (A), aluminium-fluoride type (AF) for class 2 applications (2), with pick-up 0,008 % (by mass) for C (5), pick-up 0,2 % (by mass) for Si (6), burn-out 0,7 % (by mass) for Cr (4), burn-out 0,08 % (by mass) for Nb (4) and usable with d.c. (DC) is designated as follows:

ISO 14174 - S A AF 2 56 44 DC

and the compulsory section:

ISO 14174 - S A AF 2

EXAMPLE 3

A flux for electroslag welding (ES) manufactured by agglomeration (A), aluminium-fluoride type (AF) for class 2B applications (2B), with pick-up 0,002 % (by mass) for C (5), pick-up 0,2 % (by mass) for Si (6), burn-out 0,2 % (by mass) for Cr (5), burn-out 0,07 % (by mass) for Nb (4) and usable with d.c. (DC) is designated as follows:

ISO 14174 - ES A AF 2B 56 54 DC

and the compulsory section:

ISO 14174 - ES A AF 2B

EXAMPLE 4

A flux for submerged-arc hardfacing (S) manufactured by agglomeration (A), zirconium silicate type (ZS) for class 3 applications, with carbon pickup of 3 % (by mass), chromium pickup of 20 % (by mass), usable with d.c. (DC), is designated as follows:

ISO 14174 - S A ZS 3 C3 Cr20 DC

and the compulsory section:

ISO 14174 - S A ZS 3

Annex A
(informative)

Characteristic chemical constituents of flux — Determination from elemental analysis

A.1 General

Based on the results of the elemental analysis of a flux sample, determination of the chemical constituents shall be performed as follows.

A.2 General case

Respective elements detected in the flux shall be converted to the following oxides and used to determine the flux type:

Al_2O_3, CaO, MgO, MnO, SiO_2, TiO_2, and ZrO_2

A.3 Fluorspar present in the flux

F detected in the flux shall be reported as CaF_2, and the amount of CaO shall be calculated according to the following equation:

$$CaO_{rest} = CaO_{tot} - (0{,}718\,2 \times CaF_2)$$

If the resultant value of CaO is less than zero, it shall be disregarded in determining the flux type.

A.4 Carbonate present in the flux

Deliberately added carbonate in the flux shall be analysed and the percentage by mass of CO_2 shall be used to determine the flux type.

A.5 Deliberately added metallic Fe in the flux

Deliberately added metallic Fe in the flux shall be analysed and the percentage by mass of Fe in the flux shall be used to determine the flux type.

A.6 Examples of determinations

A flux containing fluorspar, magnesite, carbonate and Fe-powder giving a chemical analysis in accordance with Table A.1.

Table A.1 — Example 1, flux chemical analysis

Chemical analysis, % (by mass)				
F	Ca_{tot}	Mg	Fe	CO_2
1,6	7,9	12,0	32	4,6

All the quantity of F shall be converted to the amount of CaF_2 and the amount of CaO shall be calculated from the rest of Ca according to the following equation:

$$CaO_{rest} = CaO_{tot} - (0{,}718\ 2 \times CaF_2)$$

All the quantity of Mg shall be converted to the amount of MgO. Thus, the flux composition, applicable for the requirements of flux type CG-I, will be as shown in Table A.2.

Table A.2 — Example 1, flux composition, applicable for the requirements of flux type CG-I

Chemical composition, % (by mass)					
CaF_2	CaO_{rest}	MgO	CaO + MgO	Fe	CO_2
3,2	8,7	19,8	28,5	32	4,6

This flux is concluded to be type CG-I, in accordance with Table 1.