Welding consumables Fluxes for submerged arc welding Classification

The European Standard EN 760 : 1996 has the status of a British Standard

ICS 25.160.20

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee WEE/39, Welding consumables, upon which the following bodies were represented:

Aluminium Federation
Association of Welding Distributors
British Association for Brazing and Soldering
British Compressed Gases Association
British Constructional Steelwork Association Ltd.
British Iron and Steel Producers' Association
Electricity Association
Engineering Equipment and Materials Users' Association
Lloyds Register of Shipping
Magnesium Industry Council
Power Generation Contractors' Association (PGCA (BEAMA Ltd.))
Process Plant Association
SAFed
Stainless Steel Wire Industry Association
Welding Institute
Welding Manufacturers' Association (BEAMA Ltd.)

This British Standard, having been prepared under the direction of the Engineering Sector Board, was published under the authority of the Standards Board and comes into effect on
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The following BSI references relate to the work on this standard:
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Contents

National foreword

This British Standard has been prepared by Technical Committee WEE/39 and is the English language version of EN 760 : 1996 *Welding consumables — Fluxes for submerged arc welding — Classification* published by the European Committee for Standardization (CEN).

This standard was produced as a result of international discussions in which the United Kingdom took an active part.

This standard together with BS EN 756 : 1996 supersedes BS 4165 : 1984 which is withdrawn.

Cross-references

Publication referred to	Corresponding British Standard
EN 756 : 1996	BS EN 756 : 1996 *Welding consumables. Wire electrodes and wire-flux combinations for submerged arc welding of non alloy and fine grain steels. Classification*

Compliance with a British Standard does not of itself confer immunity from legal obligations.

EUROPEAN STANDARD
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EN 760

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English version

Welding consumables — Fluxes for submerged arc welding — Classification

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

Schweißzusätze — Pulver zum Unterpulverschweißen — Einteilung

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 121, Welding, the secretariat of which is held by DS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 1996, and conflicting national standards shall be withdrawn at the latest by September 1996.

Annex A is informative and contains 'Description of flux types'.

In normative references reference is made to ISO 3690. It should be noted that a European Standard is under preparation for the same subject in CEN/TC 121/SC 3.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

1 Scope

This standard applies to fluxes for the submerged arc welding of non-alloyed, low alloy and high alloy steels such as stainless and heat resisting steels and of nickel and nickel alloys using wire electrodes and strip electrodes.

2 Normative references

This European Standard incorporates by dated or undated references, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 756	*Welding consumables — Wire electrodes and wire-flux combinations for submerged arc welding of non alloy and fine grain steels — Classification*
prEN 1597-1	*Welding consumables — Testing for classification — Part 1: Test assembly for all-weld metal test specimens in steel, nickel and nickel alloys*
ISO 3690	*Welding — Determination of hydrogen in deposited weld metal arising from the use of covered electrodes for welding mild and low alloy steels*

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 welded 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 (see **4.8**).

The classification of the fluxes is divided into seven parts:

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

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

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

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

5) the fifth part gives a symbol indicating the metallurgical behaviour;

6) the sixth part gives a symbol indicating the type of current;

7) the seventh part gives a symbol indicating the hydrogen content of all-weld metal.

In order to promote the use of this 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 metallurgical behaviour, type of current and controlled hydrogen, i.e. the symbols defined in **4.5**, **4.6** and **4.7**.

Where a flux is usable for more than one application dual classification is acceptable.

4 Symbols and requirements

4.1 Symbol for the product/process

Symbol for the flux used in submerged arc welding process 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.

Particle size requirement in marking, see clause **5**.

4.3 Symbol for type of flux, characteristic chemical constituents

The symbol in table 1 indicates the type of flux in accordance with the characteristic chemical constituents.

4.4 Symbol for applications, flux class

4.4.1 *Flux class 1*

Fluxes for submerged-arc welding of non alloy and low alloy steels such as structural steels, high tensile 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.

Table 1. Symbol for type of flux, characteristic chemical constituents

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
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	
NOTE. A description of the characteristics of each of the types of flux is given in annex A.		

4.4.2 ***Flux class 2***

Fluxes for joint welding and surfacing of stainless and heat resisting chromium and chromium-nickel steels and/or nickel and nickel-based alloys.

In the flux designation the digit 2 indicates class 2.

4.4.3 ***Flux class 3***

Fluxes mainly for surfacing 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.

4.5 Symbol for metallurgical behaviour

4.5.1 ***General***

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.

The symbol in table 2 indicates the metallurgical behaviour of a welding flux class 1.

4.5.1.1 *Metallurgical behaviour, flux class 1*

For determining the pick-up and burn-out behaviour a wire electrode EN 756 − S2 shall be used in accordance with **4.5.2**. The pick-up or burn-out of the elements silicon and manganese shall be stated in this sequence.

Table 2. Symbol for metallurgical behaviour of fluxes class 1

Metallurgical behaviour	Symbol	Contribution from flux on all-weld metal % (m/m)
Burn-out	1 2 3 4	over 0,7 over 0,5 up to 0,7 over 0,3 up to 0,5 over 0,1 up to 0,3
Pick-up and/or burn-out	5	0 up to 0,1
Pick-up	6 7 8 9	over 0,1 up to 0,3 over 0,3 up to 0,5 over 0,5 up to 0,7 over 0,7

4.5.1.2 *Metallurgical behaviour, flux class 2*

The pick-up of alloying elements other than Si and Mn shall be indicated by stating the corresponding chemical symbols (e.g. Cr).

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).

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

4.5.2 ***Determination of symbol***

For the determination of symbols for Class 1 fluxes an all-weld metal test assembly type 3 in accordance with prEN 1597-1 or an all-weld metal pad with not less than 8 layers with minimum 2 beads per layer shall be prepared in accordance with table 3. The sampling for analysis shall be made from the all-weld metal test piece surface or from the middle of the all-weld metal pad.

Table 3. Welding conditions for preparation of an all-weld metal pad

Welding conditions for multi-run single wire[1)2)]	**Wire diameter** 4,0 mm
Electrode extension, mm	30 ± 5
Length of weld deposit, mm	min. 200
Type of current	d.c.
Welding current, A	580 ± 20
Welding voltage, V	29 ± 1
Welding speed, mm/min	550 ± 50
Interpass temperature range, °C	150 ± 50

[1)] If a.c. and d.c. operations are claimed, test welding shall be carried out using a.c. only.

[2)] a.c. means alternating current; d.c. means direct current.

4.6 Symbol for type of current

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

DC is the symbol for direct current;

AC is the symbol for alternating current.

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

In order to demonstrate operability on a.c., tests shall be carried out with a no-load voltage not higher than 70 V.

4.7 Symbol for hydrogen content in all-weld metal

The symbol in table 4 indicates the hydrogen content determined in all-weld metal in accordance with the method given in ISO 3690.

Table 4. Symbol for hydrogen content in all-weld metal

Symbol	**Hydrogen content** ml/100 g **all-weld metal max.**
H5	5
H10	10
H15	15

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.

4.8 Current-carrying capacity

The current-carrying capacity of a flux depends on various welding conditions and is not indicated in the flux designation.

NOTE. For purposes of comparison the manufacturer indicates in his literature or data sheets the current-carrying capacity of the flux. This is assessed as being the maximum current carried by a 4,0 mm diameter wire under standard conditions such that a regular and uniform weld bead is obtained. The standard conditions for such a test are defined as follows:

– travel speed	550 mm/min
– electrode extension	30 ± 5 mm
– type of current and electrode polarity	d.c.+
– arc voltage	consistent with current value
– plate thickness	20 mm minimum

Whilst the maximum current value may be defined in this manner it should be recognized that this value may increase in certain instances, e.g. multi-wire systems.

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 sizes in accordance with table 5 or directly expressed in millimetres.

Table 5. Particle size

Particle sizes mm	**Symbol**
2,5	25
2,0	20
1,6	16
1,25	12
0,8	8
0,5	5
0,315	3
0,2	2
0,1	1
< 0,1	D

Example of a typical symbol for particle size range is 2 to 16 or 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:

- trade name;
- designation in accordance with this standard;
- production lot number;
- net weight;
- manufacturer or supplier;
- 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), of calcium-silicate-type (CS) for class 1 applications (1), with pick-up 0,2 % for silicon (6) and 0,5 % for manganese (7), may be used on a.c. or d.c. (AC) and produces a weld metal with 8 ml hydrogen in 100 g all-weld metal (H10).

Designation:

Welding flux EN 760 − S F CS 1 67 AC H10

Compulsory section:

Welding flux EN 760 − S F CS 1

where:

EN 760	=	standard number;
S	=	flux for submerged arc welding (see **4.1**);
F	=	fused flux (see **4.2**);
CS	=	type of flux (see table 1);
1	=	application, flux class (see **4.4**);
67	=	metallurgical behaviour (see table 2);
AC	=	type of current (see **4.6**);
H10	=	hydrogen content (see table 4).

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 preferably used 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 weld 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 multi-pass 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 multi-pass welding where strength and toughness requirements are more stringent. The current-carrying capacity of the fluxes tends to decrease with increasing flux basicity but the weld profile should be smooth and free from undercut.

A.3 Zirconium-silicate type, ZS

Welding fluxes of this type are composed 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.4 Rutile-silicate type, RS

Welding fluxes of this type are composed of 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.5 Aluminate-rutile type, AR

These fluxes contain essentially Al_2O_3 and TiO_2. There is 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 on d.c and a.c. thus are suitable for single and multi wire welding. Due to their relatively high oxygen content they produce medium mechanical properties.

The 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.6 Aluminate-basic type, AB

Besides Al_2O_3 as their main constituent, these fluxes contain essentially MgO and CaO. They produce a medium manganese transfer to the weld deposit. Due to the high Al_2O_3 content the liquid slag is 'short' and there is an optimum balance of weld metal performance and operability characteristics. Operating properties of these fluxes are good and on account of their basic slag characteristics (medium oxygen-content) good toughness of the weld metal is achieved especially in two-run welding.

They are used extensively for the welding of unalloyed and low-alloyed structural steels in various fields of application. They can be used on d.c. and a.c. employing the multi-pass or two-run technique.

A.7 Aluminate-silicate type, AS

Fluxes of this type are characterized by a moderate high level of basic compounds, such as MgO and CaF_2, balanced with substantial amounts of silicates, Al_2O_3 and ZrO_2. The metallurgical behaviour of these fluxes is mostly neutral but manganese burn-out is also possible. Thus, wire electrodes with higher manganese level, such as S3-types, are preferably used.

As a result of their moderately high slag basicity, a low oxygen high-purity weld is obtained. On account of the basic flux characteristics, together with a low slag viscosity, these fluxes feature corresponding operating characteristics such as limited current-carrying capacity and welding speed. Slag release and weld bead performance are good also if narrow-gap process is applied. Although welding on d.c. is preferred (low weld hydrogen content) some of these fluxes can also be used on a.c. and, thus, on multi-wire systems.

These types of fluxes, as the fluoride-basic fluxes, are recommended for multi-pass welding, in particular when high toughness requirements should be met. Therefore, the preferred application is the welding of high-tensile fine grain steels, such as in the fields of pressure vessels, nuclear components or offshore constructions.

A.8 Aluminate-fluoride-basic type, AF

Fluxes of this type are composed with Al_2O_3 and CaF_2 as main constituents. These fluxes are primarily applied in combination with alloyed wires as stainless steel and Ni-base alloys. The weld deposit is neutral with respect to Mn, Si and other alloying elements. Due to the high fluoride content these fluxes provide a good wetting action and weld surface appearance. The arc voltage is to be set at a higher level, compared to an aluminate-basic type.

A.9 Fluoride-basic type, FB

Fluxes of this type are characterized by a high level of basic compounds, such as CaO, MgO, MnO and of CaF_2 but the level of SiO_2 is low. The metallurgical behaviour is mainly neutral but manganese burn-off is also possible. Thus, it is preferable to use wire electrodes with higher manganese level, e.g. S3-types.

As a result of high slag basicity, a low oxygen high-purity weld is obtained. A maximum weld metal toughness down to very low temperatures can be achieved. On account of the basic flux characteristics, together with a low slag viscosity, they have corresponding operating characteristics such as limited current-carrying capacity and welding speed. Slag release and weld bead performance are good even if the narrow-gap process is applied. Although welding on d.c. is preferred to produce a low weld hydrogen content, some of these fluxes can also be used on a.c. and thus on multi-wire systems.

They are recommended for multi-pass welding, in particular when there are high toughness requirements. The preferred application is the welding of high-tensile fine grain steels, e.g. pressure vessels, nuclear components or offshore constructions.

Fluxes of this type may also be applicable to welding stainless steel and nickel base alloys.

A.10 Types with other compositions, Z

Other types not covered by this description.

List of references

See national foreword.

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