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Welding consumables — Wire electrodes and wire-flux combinations for submerged arc welding of non alloy and fine grain steels — Classification

Produits consommables pour le soudage — Fils-électrodes et couples fils-flux pour le soudage à l'arc sous flux des aciers non alliés et à grains fins — Classification

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14171 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

Introduction

This International Standard recognizes that there are two somewhat different approaches in the global market to classifying a given wire-flux combination, and allows for either or both to be used, to suit a particular market need. Application of either type of classification designation (or of both where suitable) identifies a product as classified according to this International Standard.

This International Standard proposes a classification system for the designation of wire electrodes by chemical analyses and wire-flux combinations in terms of the yield strength, tensile strength and elongation of the all-weld metal. The ratio of yield to tensile strength of weld metal is generally higher than that of parent material. Users should note that matching weld metal yield strength to parent material yield strength will not necessarily ensure that the weld metal tensile strength matches that of the parent material. Thus, where the application of the material requires matching tensile strengths, selection of the consumable should be made by reference to column 3 of Table 1A or 1B.

Although combinations of wires and fluxes supplied by individual companies may have the same grading, the individual wires and fluxes from different companies are not interchangeable unless verified according to this International Standard.

It should be noted that the mechanical properties of all-weld metal test specimens used to classify the wire-flux combinations will vary from those obtained in production joints because of differences in welding procedures such as electrode size and parent material composition.

Requests for official interpretation of any aspect of this International Standard should be directed to the Secretariat of ISO/TC 44/SC 3 via the ISO member body in your country, a complete listing of which can be found at www.iso.org.

Welding consumables — Wire electrodes and wire-flux combinations for submerged arc welding of non alloy and fine grain steels — Classification

1 Scope

This International Standard specifies requirements for the classification of wire-flux combinations and all-weld metal in the as-welded condition and in the post weld heat-treated condition for submerged arc welding of non alloy and fine grain steels with a minimum yield strength of up to 500 N/mm^2 or a minimum tensile strength of up to 570 N/mm^2. One flux may be classified with different wire electrodes. The wire electrode is also classified separately based on its chemical composition.

This document constitutes a combined specification providing classification utilizing a system based upon the yield strength and the average impact energy for all-weld metal of 47 J, or utilizing a system based upon the tensile strength and the average impact energy for all-weld metal of 27 J.

1) Paragraphs and tables which carry the suffix letter “A” are applicable only to wire-flux combinations and wire electrodes classified using the system based upon the yield strength and the average impact energy for all-weld metal of 47 J, in accordance with this International Standard.

2) Paragraphs and tables which carry the suffix letter “B” are applicable only to wire-flux combinations and wire electrodes classified using the system based upon the tensile strength and the average impact energy for all-weld metal of 27 J, in accordance with this International Standard.

3) Paragraphs and tables which have neither the suffix letter “A” nor the suffix letter “B” are applicable to all wire-flux combinations and wire electrodes classified in accordance with this International Standard.

Fluxes for the single-run and two-run techniques are classified on the basis of the two-run technique.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 31-0:1992, *Quantities and units — Part 0: General principles*

ISO 544, *Welding consumables — Technical delivery conditions for welding filler metals — Type of product, dimensions, tolerances and marking*

ISO 13916, *Welding — Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature*

ISO 14174, *Welding consumables — Fluxes for submerged arc welding — Classification*

ISO 14344, *Welding and allied processes — Flux and gas shielded electrical welding processes — Procurement guidelines for consumables*

ISO 15792-1:2000, *Welding consumables — Test methods — Part 1: Test methods for all-weld metal test specimens in steel, nickel and nickel alloys*

ISO 15792-2:2000, *Welding consumables — Test methods — Part 2: Preparation of single-run and two-run technique test specimens in steel*

3 Classification

Classification designations are based upon two approaches to indicate the tensile properties and the impact properties of the all-weld metal obtained with a given wire-flux combination. The two designation approaches include additional designators for some other classification requirements, but not all, as will be clear from the following sections. In most cases, a given commercial product can be classified in both systems. Then either or both classification designations can be used for the product.

The classification includes all-weld metal properties obtained with a manufacturer's specific wire-flux combination as given below. A wire electrode may be separately classified with the symbol for its chemical composition in Table 5A or 5B.

3A Classification by yield strength and 47 J impact energy

The classification is divided into five parts:

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

2) the second part gives a symbol indicating the strength and elongation of all-weld metal for multi-run technique or the strength of the parent material used in classification for the two-run technique (see Table 1A or 2A);

3) the third part gives a symbol indicating the impact properties of all-weld metal or welded joint (see Table 3);

4) the fourth part gives a symbol indicating the type of flux used (see Table 4);

5) the fifth part gives a symbol indicating the chemical composition of the wire electrode used (see Table 5A).

3B Classification by tensile strength and 27 J impact energy

The classification is divided into five parts:

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

2) the second part gives a symbol indicating the strength and elongation of all-weld metal in either the as-welded or post weld heat-treated condition for a multi-run technique or the strength of the parent material used in classification for the two-run technique (see Table 1B or 2B);

3) the third part gives a symbol indicating the impact properties of all-weld metal or welded joint in the same condition as specified for the tensile strength (see Table 3). The letter "U" after this designator indicates that the deposit meets an average optional requirement of 47 J at the designated Charpy test temperatures;

4) the fourth part gives a symbol indicating the type of flux used (see Table 4);

5) the fifth part gives a symbol indicating the chemical composition of the wire electrode used (see Table 5B).

4 Symbols and requirements

4.1 Symbol for the product/process

The symbol for a wire-flux combination used in the submerged arc welding process shall be the letter S at the beginning of the designation.

The symbol for a wire electrode used in the submerged arc welding process shall be the letters S or SU at the beginning of the wire electrode designation.

4.2 Symbols for tensile properties

4.2.1 Multi-run technique

4.2.1A Classification by yield strength and 47 J impact energy

For products suitable for multi-run welding, the symbol in Table 1A indicates yield strength, tensile strength and elongation of the all-weld metal in the as-welded condition determined in accordance with 5.1A.

Table 1A — Symbol for tensile properties by a multi-run technique (classification by yield strength and 47 J impact energy)

Symbol	Minimum yield strength[a] N/mm^2	Tensile strength N/mm^2	Minimum elongation[b] %
35	355	440 to 570	22
38	380	470 to 600	20
42	420	500 to 640	20
46	460	530 to 680	20
50	500	560 to 720	18

[a] For yield strength the lower yield (R_{eL}) is used when yielding occurs, otherwise the 0,2 % proof strength ($R_{p0,2}$) is used.

[b] Gauge length is equal to five times the test specimen diameter.

4.2.1B Classification by tensile strength and 27 J impact energy

For products suitable for multi-run welding, the symbol in Table 1B indicates yield strength, tensile strength and elongation of the all-weld metal in the as-welded condition or in the post weld heat treated condition determined in accordance with 5.1B.

Table 1B — Symbol for tensile properties by multi-run technique (classification by tensile strength and 27 J impact energy)

Symbol[a]	Minimum yield strength[b] N/mm^2	Tensile strength N/mm^2	Minimum elongation[c] %
43X	330	430 to 600	20
49X	390	490 to 670	18
55X	460	550 to 740	17
57X	490	570 to 770	17

[a] X is “A” or “P”, where “A” indicates testing in the as-welded condition and “P” indicates testing in the post weld heat-treated condition.

[b] For yield strength the lower yield (R_{eL}) is used when yielding occurs, otherwise the 0,2 % proof strength ($R_{p0,2}$) is used.

[c] Gauge length is equal to five times the test specimen diameter.

4.2.2 Two-run technique

For products suitable for two-run welding only, the symbol in Table 2A or 2B indicates strength of the welded joint in relation to strength of the parent material used in two-run welding tests satisfactorily completed in accordance with 5.2.

Table 2A — Symbol for tensile properties by two-run technique (classification by yield strength and 47 J impact energy)

Symbol	Minimum parent material yield strength N/mm^2	Minimum tensile strength of the welded joint N/mm^2
2T	275	370
3T	355	470
4T	420	520
5T	500	600

Table 2B — Symbol for tensile properties by two-run technique (classification by tensile strength and 27 J impact energy)

Symbol	Minimum tensile strength of the base metal and of the welded joint N/mm^2
43S	430
49S	490
55S	550
57S	570

4.3 Symbols for impact properties of all-weld metal or two-run welded joint

4.3A Classification by yield strength and 47 J impact energy

The symbols in Table 3 indicate the temperature at which an impact energy of 47 J is achieved under the conditions given in clause 5. Three test specimens shall be tested. Only one individual value may be lower than 47 J but not lower than 32 J.

4.3B Classification by tensile strength and 27 J impact energy

The symbols in Table 3 indicate the temperature at which an impact energy of 27 J is achieved in the as-welded condition or in the post weld heat-treated condition under the conditions given in clause 5. Five test specimens shall be tested. The lowest and highest values obtained shall be disregarded. Two of the three remaining values shall be greater than the specified 27 J level, one of the three may be lower but shall be no less than 20 J. The average of the three remaining values shall be at least 27 J. Three test specimens shall be tested when the optional supplemental designator “U” is used to indicate that the weld deposit shall meet a minimum impact energy of 47 J at the test temperature. The impact value shall be determined by the average of the three test specimens. The average of the three values shall be 47 J or greater.

When an all-weld metal or a welded joint has been classified for a certain temperature, it automatically covers any higher temperature listed in Table 3.

Table 3 — Symbol for impact properties of all-weld metal or welded joint

Symbol	Temperature for minimum average impact energy of 47 J[a, b] or 27 J[b] °C
Z	No requirements
A[a] or Y[b]	+ 20
0	0
2	− 20
3	− 30
4	− 40
5	− 50
6	− 60
7	− 70
8	− 80
9	− 90
10	− 100

[a] See 4.3A.

[b] See 4.3B.

4.4 Symbols for type of welding flux

The symbols in Table 4 indicate the types of welding flux as described in ISO 14174.

Table 4 — Symbol for type of welding flux

Type of flux	Symbol
Manganese-silicate	MS
Calcium-silicate	CS
Calcium-magnesium	CG
Calcium-magnesium-basic	CB
Calcium-magnesium-iron	CI
Calcium-magnesium-iron-basic	IB
Zirconium-silicate	ZS
Rutile-silicate	RS
Aluminate-rutile	AR
Aluminate-basic	AB
Aluminate-silicate	AS
Aluminate-fluoride-basic	AF
Fluoride-basic	FB
Any other type	Z

4.5 Symbols for the chemical composition of wire electrodes

The symbols in Tables 5A and 5B indicate the chemical composition of the wire electrode and include an indication of characteristic alloying elements.

The chemical composition of the weld metal is dependent on the chemical composition of the wire electrode and the metallurgical behaviour of the flux (see ISO 14174).

Table 5A — Chemical composition of wire electrodes for submerged arc welding (classification by yield strength and 47 J impact energy)

Symbol	Chemical composition (% by mass) [a, b, c]							
	C	Si	Mn	P	S	Mo	Ni	Cr
S0	Any agreed composition							
S1	0,05 to 0,15	0,15	0,35 to 0,60	0,025	0,025	0,15	0,15	0,15
S2	0,07 to 0,15	0,15	0,80 to 1,30	0,025	0,025	0,15	0,15	0,15
S3	0,07 to 0,15	0,15	1,30 to 1,75	0,025	0,025	0,15	0,15	0,15
S4	0,07 to 0,15	0,15	1,75 to 2,25	0,025	0,025	0,15	0,15	0,15
S1Si	0,07 to 0,15	0,15 to 0,40	0,35 to 0,60	0,025	0,025	0,15	0,15	0,15
S2Si	0,07 to 0,15	0,15 to 0,40	0,80 to 1,30	0,025	0,025	0,15	0,15	0,15
S2Si2	0,07 to 0,15	0,40 to 0,60	0,80 to 1,30	0,025	0,025	0,15	0,15	0,15
S3Si	0,07 to 0,15	0,15 to 0,40	1,30 to 1,85	0,025	0,025	0,15	0,15	0,15
S4Si	0,07 to 0,15	0,15 to 0,40	1,85 to 2,25	0,025	0,025	0,15	0,15	0,15
S1Mo	0,05 to 0,15	0,05 to 0,25	0,35 to 0,60	0,025	0,025	0,45 to 0,65	0,15	0,15
S2Mo	0,07 to 0,15	0,05 to 0,25	0,80 to 1,30	0,025	0,025	0,45 to 0,65	0,15	0,15
S3Mo	0,07 to 0,15	0,05 to 0,25	1,30 to 1,75	0,025	0,025	0,45 to 0,65	0,15	0,15
S4Mo	0,07 to 0,15	0,05 to 0,25	1,75 to 2,25	0,025	0,025	0,45 to 0,65	0,15	0,15
S2Ni1	0,07 to 0,15	0,05 to 0,25	0,80 to 1,30	0,020	0,020	0,15	0,80 to 1,20	0,15
S2Ni1,5	0,07 to 0,15	0,05 to 0,25	0,80 to 1,30	0,020	0,020	0,15	1,20 to 1,80	0,15
S2Ni2	0,07 to 0,15	0,05 to 0,25	0,80 to 1,30	0,020	0,020	0,15	1,80 to 2,40	0,15
S2Ni3	0,07 to 0,15	0,05 to 0,25	0,80 to 1,30	0,020	0,020	0,15	2,80 to 3,70	0,15
S2Ni1Mo	0,07 to 0,15	0,05 to 0,25	0,80 to 1,30	0,020	0,020	0,45 to 0,65	0,80 to 1,20	0,20
S3Ni1,5	0,07 to 0,15	0,05 to 0,25	1,30 to 1,70	0,020	0,020	0,15	1,20 to 1,80	0,20
S3Ni1Mo	0,07 to 0,15	0,05 to 0,25	1,30 to 1,80	0,020	0,020	0,45 to 0,65	0,80 to 1,20	0,20
S3Ni1,5Mo	0,07 to 0,15	0,05 to 0,25	1,20 to 1,80	0,020	0,020	0,30 to 0,50	1,20 to 1,80	0,20

a Finished product chemical composition, Cu (including a copper coating) $\leqslant$ 0,30 %, Al $\leqslant$ 0,030 %.

b Single values shown in the table are maximum values.

c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with annex B, Rule A of ISO 31-0:1992.

Table 5B — Chemical composition of wire electrodes for submerged arc welding (classification by tensile strength and 27 J impact energy)

Symbol	Chemical composition (% by mass) [a, b, c]								
	C	Si	Mn	P	S	Mo	Ni	Cr	Cu
SU0	Any other agreed composition								
SU11	0,15	0,15	0,20 to 0,90	0,025	0,025	0,15	0,15	0,15	0,40
SU12	0,15	0,10 to 0,60	0,20 to 0,90	0,025	0,025	0,15	0,15	0,15	0,40
SU21	0,05 to 0,15	0,10 to 0,35	0,80 to 1,25	0,025	0,025	0,15	0,15	0,15	0,40
SU22	0,15	0,15	0,80 to 1,40	0,025	0,025	0,15	0,15	0,15	0,40
SU23	0,18	0,15 to 0,60	0,80 to 1,40	0,025	0,025	0,15	0,15	0,15	0,40
SU24 [d]	0,06 to 0,19	0,35 to 0,75	0,90 to 1,40	0,025	0,025	0,15	0,15	0,15	0,40
SU25	0,06 to 0,16	0,35 to 0,75	0,90 to 1,40	0,030	0,030	0,15	0,15	0,15	0,40
SU31	0,06 to 0,15	0,80 to 1,15	1,40 to 1,85	0,030	0,030	0,15	0,15	0,15	0,40
SU32	0,15	0,05 to 0,60	1,30 to 1,90	0,025	0,025	0,15	0,15	0,15	0,40
SU33	0,15	0,15	1,30 to 1,90	0,025	0,025	0,15	0,15	0,15	0,40
SU41	0,20	0,15	1,60 to 2,30	0,025	0,025	0,15	0,15	0,15	0,40
SU42	0,15	0,15 to 0,65	1,50 to 2,30	0,025	0,025	0,15	0,15	0,15	0,40
SU51	0,15	0,15	2,20 to 2,80	0,025	0,025	0,15	0,15	0,15	0,40
SU1M3	0,15	0,25	0,20 to 1,00	0,025	0,025	0,40 to 0,65	0,15	0,15	0,40
SU2M1	0,15	0,25	0,80 to 1,40	0,025	0,025	0,15 to 0,40	0,15	0,15	0,40
SU3M1	0,15	0,25	1,30 to 1,90	0,025	0,025	0,15 to 0,40	0,15	0,15	0,40
SU2M3	0,17	0,25	0,80 to 1,40	0,025	0,025	0,40 to 0,65	0,15	0,15	0,40
SU3M3	0,17	0,25	1,20 to 1,90	0,025	0,025	0,40 to 0,65	0,15	0,15	0,40
SU4M1	0,15	0,25	1,60 to 2,30	0,025	0,025	0,15 to 0,40	0,15	0,15	0,40

Table 5B (*continued*)

Symbol	Chemical composition (% by mass) [a, b, c]								
	C	Si	Mn	P	S	Mo	Ni	Cr	Cu
SU4M3	0,17	0,25	1,60 to 2,30	0,025	0,025	0,40 to 0,65	0,15	0,15	0,40
SU4M31	0,05 to 0,15	0,50 to 0,80	1,60 to 2,10	0,025	0,025	0,40 to 0,60	0,15	0,15	0,40
SU5M3	0,15	0,25	2,20 to 2,80	0,025	0,025	0,40 to 0,65	0,15	0,15	0,40
SUN2	0,15	0,30	0,75 to 1,40	0,020	0,020	0,15	0,75 to 1,25	0,20	0,40
SUN21	0,12	0,40 to 0,80	0,80 to 1,40	0,020	0,020	0,15	0,75 to 1,25	0,20	0,40
SUN3	0,15	0,25	0,80 to 1,40	0,020	0,020	0,15	1,20 to 1,80	0,20	0,40
SUN31	0,15	0,25	1,30 to 1,90	0,020	0,020	0,15	1,20 to 1,80	0,20	0,40
SUN5	0,15	0,30	0,75 to 1,40	0,020	0,020	0,15	1,80 to 2,90	0,20	0,40
SUN7	0,15	0,30	0,60 to 1,40	0,020	0,020	0,15	2,40 to 3,80	0,20	0,40
SUCC	0,15	0,30	0,80 to 1,90	0,030	0,030	0,15	0,15	0,30 to 0,60	0,20 to 0,45
SUNCC1	0,12	0,20 to 0,35	0,35 to 0,65	0,025	0,030	0,15	0,40 to 0,80	0,50 to 0,80	0,30 to 0,80
SUNCC3	0,15	0,30	0,80 to 1,90	0,030	0,030	0,15	0,05 to 0,80	0,50 to 0,80	0,30 to 0,55
SUN1M3	0,10 to 0,18	0,20	1,70 to 2,40	0,025	0,025	0,40 to 0,65	0,40 to 0,80	0,20	0,35
SUN2M1	0,12	0,05 to 0,30	1,20 to 1,60	0,020	0,020	0,10 to 0,30	0,75 to 1,25	0,20	0,40
SUN2M3	0,15	0,25	0,80 to 1,40	0,020	0,020	0,40 to 0,65	0,80 to 1,20	0,20	0,40
SUN2M31	0,15	0,25	1,30 to 1,90	0,020	0,020	0,40 to 0,65	0,80 to 1,20	0,20	0,40
SUN2M32	0,15	0,25	1,60 to 2,30	0,020	0,020	0,40 to 0,65	0,80 to 1,20	0,20	0,40
SUN3M3	0,15	0,25	0,80 to 1,40	0,020	0,020	0,40 to 0,65	1,20 to 1,80	0,20	0,40
SUN3M31	0,15	0,25	1,30 to 1,90	0,020	0,020	0,40 to 0,65	1,20 to 1,80	0,20	0,40
SUN4M1	0,12 to 0,19	0,10 to 0,30	0,60 to 1,00	0,015	0,030	0,10 to 0,30	1,60 to 2,10	0,20	0,35

a The total amount of the elements (excluding iron) that are not shown in this table shall not exceed 0,50 %.

b Single values shown in this table are maximum values.

c The results shall be rounded to the same number of significant figures as in the specified value using the rules in accordance with annex B, Rule A of ISO 31-0:1992.

d Ti: 0,03 % to 0,17 %.

5 Mechanical tests

5.1 Multi-run technique

5.1A Welding conditions in the classification by yield strength and 47 J impact energy

Tensile and impact tests and any required retests shall be carried out on weld metal in the as-welded condition using an all-weld metal test assembly type 1.3 in accordance with ISO 15792-1:2000 using 4,0 mm or 3,2 mm (3,0 mm) diameter wire electrodes whichever is the larger size being supplied.

Welding conditions (single wire welding) and details of the test assembly shall be selected from Table 6A.

Preheating is not required; welding may start from room temperature.

The interpass temperature shall be measured using temperature indicator crayons, surface thermometers or thermocouples (see ISO 13916).

The interpass temperature shall not exceed the interpass temperature indicated in Table 6A. If, after any pass, the interpass temperature is exceeded, the test assembly shall be cooled in air to a temperature within the indicated range.

5.1B Welding conditions in the classification by tensile strength and 27 J impact energy

Tensile and impact tests shall be carried out on weld metal in the as-welded condition or in the post weld heat-treated condition using an all-weld metal test assembly type 1.3 in accordance with ISO 15792-1:2000 using 4,8 mm, 4,0 mm or 3,2 mm diameter wire electrodes.

Welding conditions (single wire welding) and details of the test assembly shall be selected from Table 6B.

The interpass temperature shall be measured using temperature indicator crayons, surface thermometers or thermocouples (see ISO 13916).

The interpass temperature shall not exceed the interpass temperature indicated in Table 6B. If, after any pass, the interpass temperature is exceeded, the test assembly shall be cooled in air to a temperature below that limit. If below the indicated interpass temperature, the test assembly shall be reheated into interpass range.

Test assemblies made with electrodes classified in the PWHT condition shall be heat-treated at 620 °C ± 15 °C for 1 h (– 0, + 15 minutes). The furnace shall be at a temperature no higher than 315 °C when the test assembly is placed in it. The heating rate, from that point to the 620 °C ± 15 °C holding temperature, shall not exceed 220 °C/h. When the holding time has been completed, the assembly shall be allowed to cool in the furnace to a temperature below 315 °C at a rate not exceeding 195 °C/h. The assembly may be removed from the furnace at any temperature below 315 °C and allowed to cool in still air to room temperature.