INTERNATIONAL STANDARD

ISO 3580

Fourth edition
2017-04

Welding consumables — Covered electrodes for manual metal arc welding of creep-resisting steels — Classification

Produits consommables pour le soudage — Électrodes enrobées pour le soudage manuel à l'arc des aciers résistant au fluage — Classification

Reference number
ISO 3580:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This fourth edition cancels and replaces the third edition (ISO 3580:2010), which has been technically revised with the following changes:

— the normative references have been updated;

— new classifications from the USA and Japan have been added in system B;

— revisions/corrections of chemical compositions and other values have been made in the tables;

— Footnote d) to Table 1 has been revised to clarify that elements intentionally added that do not have values listed (including Co and B) are to be reported;

— the descriptions in Table 3 have been revised;

— the range for nominal electrode efficiency for symbol 4 in Table 4 has been corrected.

Requests for official interpretations of any aspect of this document 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 document proposes a method for classification of covered electrodes, in terms of chemical composition of the all-weld metal (system A) and in terms of tensile strength and chemical composition (system B).

The mechanical properties of all-weld metal test specimens used to classify the electrodes vary from those obtained in production joints because of differences in welding procedure such as electrode diameter, width of weave, welding position and material composition.

The classification according to system A is mainly based on EN 1599[1]. The classification according to system B is mainly based upon standards used around the Pacific Rim.

Welding consumables — Covered electrodes for manual metal arc welding of creep-resisting steels — Classification

1 Scope

This document specifies requirements for classification of covered electrodes, based on the all-weld metal in the heat-treated condition, for manual metal arc welding of ferritic and martensitic creep-resisting and low alloy elevated temperature steels.

This document is a combined specification for classification utilizing a system based upon the chemical composition of the all-weld metal, with requirements for the yield strength and impact energy of the all-weld metal, or utilizing a system based upon the tensile strength and the chemical composition of the all-weld metal.

a) Paragraphs and tables which carry the suffix letter "A" are applicable only to electrodes classified to the system based upon chemical composition, with requirements for the yield strength and impact energy of the all-weld metal under this document.

b) Paragraphs and tables which carry the suffix letter "B" are applicable only to electrodes classified to the system based upon the tensile strength and the chemical composition of all-weld metal under this document.

c) Paragraphs and tables which do not have either the suffix letter "A" or the suffix letter "B" are applicable to all covered electrodes classified under this document.

For comparison purposes, some tables include requirements for electrodes classified according to both systems, placing individual electrodes from the two systems, which are similar in composition and properties, on adjacent lines in the particular table. In a particular line of the table that is mandatory in one system, the symbol for the similar electrode from the other system is indicated in parentheses. By appropriate restriction of the formulation of a particular electrode, it is often, but not always, possible to produce an electrode that can be classified in both systems, in which case the electrode, and/or its packaging, can be marked with the classification in either or both systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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 3690, *Welding and allied processes — Determination of hydrogen content in arc weld metal*

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

ISO 6947, *Welding and allied processes — Welding positions*

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

ISO 14344, *Welding consumables — Procurement of filler materials and fluxes*

ISO 15792-1:2000, *Welding consumables — Test methods — Part 1: Test methods for all-weld metal test specimens in steel, nickel and nickel alloys*. Amended by ISO 15792-1:2000/Amd 1:2011

ISO 15792-3, *Welding consumables — Test methods — Part 3: Classification testing of positional capacity and root penetration of welding consumables in a fillet weld*

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

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Classification

Classification designations are based upon two approaches to indicate the composition and properties of the all-weld metal obtained with a given electrode. The two designation approaches include additional designators for some other classification requirements, but not all. 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 covered electrode as given in 4A and 4B. The classification is based on the electrode size 4,0 mm with the exception of the symbol for welding position which is based on ISO 15792-3.

4A Classification by chemical composition

The classification is divided into six parts.

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

2) The second part gives a symbol indicating the chemical composition of the all-weld metal (see Table 1).

3) The third part gives a symbol indicating the type of electrode covering (see 5.4A).

4) The fourth part gives a symbol indicating the nominal electrode efficiency and type of current (see Table 4A).

5) The fifth part gives a symbol indicating the welding position (see Table 5A).

6) The sixth part gives a symbol indicating the hydrogen content of the deposited metal (see Table 6).

4B Classification by tensile strength and chemical composition

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 of the all-weld metal (see Table 2).

3) The third part gives a symbol indicating the type of electrode covering, the type of current, and the welding position (see Table 3B).

4) The fourth part gives a symbol indicating the chemical composition of all-weld metal (see Table 1).

5) The fifth part gives a symbol indicating the hydrogen content of deposited metal (see Table 6).

In order to facilitate the use of this document, the classification is split into two sections.

a) Compulsory section

This section includes the symbols for the type of product, the chemical composition and the type of covering, i.e. the symbols defined in 5.1, 5.2 and 5.4A.

b) Optional section

This section includes the symbols for the nominal electrode efficiency, the type of current, the welding positions for which the electrode is suitable, and the symbol for hydrogen content, i.e. the symbols defined in 5.5A, 5.6A and 5.7.

In order to facilitate the use of this document, the classification is split into two sections.

a) Compulsory section

This section includes the symbols for the type of product, the strength, the type of covering, the type of current, the welding position, and the chemical composition, i.e. the symbols defined in 5.1, 5.2, 5.3B, 5.4B and 5.6B.

b) Optional section

This section includes the symbol for the hydrogen content, i.e. the symbol defined in 5.7.

The full designation (see Clause 11) shall be used on packages and in the manufacturer's literature and data sheets. The designation system is shown in Annex A for both systems.

5 Symbols and requirements

5.1 Symbol for the product/process

The symbol for the covered electrode used in the manual metal arc welding process shall be the letter E.

5.2 Symbol for the chemical composition of all-weld metal

The symbols in Table 1 indicate the chemical composition of all-weld metal determined in accordance with Clause 7. See Annex B and Annex C for descriptions of the symbols used for chemical composition in system A and in system B, respectively.

5.3 Symbol for the mechanical properties of all-weld metal

5.3A Classification by chemical composition

No symbol shall be used for the mechanical properties of the all-weld metal. The all-weld metal obtained using the covered electrodes listed in Table 1 in accordance with Clause 6 shall also fulfil the mechanical property requirements specified in Table 2.

5.3B Classification by tensile strength and chemical composition

The symbol for tensile strength shall be 49 for 490 MPa minimum tensile strength, 52 for 520 MPa minimum tensile strength, 55 for 550 MPa minimum tensile strength or 62 for 620 MPa minimum tensile strength. The complete mechanical property requirements that shall be fulfilled by the various compositions are specified in Table 2.

Table 1 — Symbol for chemical composition of all-weld metal

Chemical composition symbol[a] for classification according to		Chemical composition, % (by mass)[b]								
ISO 3580-A[c]	ISO 3580-B	C	Si	Mn	P	S	Cr	Mo	V	Other elements[d]
Mo	(1M3)	0,10	0,80	0,40 to 1,50	0,030	0,025	0,2	0,40 to 0,70	0,03	—
(Mo)	1M3	0,12	0,80	1,00	0,030	0,030	—	0,40 to 0,65	—	—
MoV	—	0,03 to 0,12	0,80	0,40 to 1,50	0,030	0,025	0,30 to 0,60	0,80 to 1,20	0,25 to 0,60	—
CrMo0,5	(CM)	0,05 to 0,12	0,80	0,40 to 1,50	0,030	0,025	0,40 to 0,65	0,40 to 0,65	—	—
(CrMo0,5)	CM	0,05 to 0,12	0,80	0,90	0,030	0,030	0,40 to 0,65	0,40 to 0,65	—	—
—	C1M	0,07 to 0,15	0,30 to 0,60	0,40 to 0,70	0,030	0,030	0,40 to 0,60	1,00 to 1,25	0,05	—
CrMo1	(1CM)	0,05 to 0,12	0,80	0,40 to 1,50	0,030	0,025	0,90 to 1,40	0,45 to 0,70	—	—
(CrMo1)	1CM	0,05 to 0,12	1,00	1,00	0,030	0,030	1,00 to 1,50	0,40 to 0,65	—	—
CrMo1L	(1CML)	0,05	0,80	0,40 to 1,50	0,030	0,025	0,90 to 1,40	0,45 to 0,70	—	—
(CrMo1L)	1CML	0,05	1,00	0,90	0,030	0,030	1,00 to 1,50	0,40 to 0,65	—	—
CrMoV1	—	0,05 to 0,15	0,80	0,70 to 1,50	0,030	0,025	0,90 to 1,30	0,90 to 1,30	0,10 to 0,35	—
CrMo2	(2C1M)	0,05 to 0,12	0,80	0,40 to 1,30	0,030	0,025	2,0 to 2,6	0,90 to 1,30	—	—
(CrMo2)	2C1M	0,05 to 0,12	1,00	0,90	0,030	0,030	2,00 to 2,50	0,90 to 1,20	—	—
CrMo2L	(2C1ML)	0,05	0,80	0,40 to 1,30	0,030	0,025	2,0 to 2,6	0,90 to 1,30	—	—
(CrMo2L)	2C1ML	0,05	1,00	0,90	0,030	0,030	2,00 to 2,50	0,90 to 1,20	—	—
—	2CML	0,05	1,00	0,90	0,030	0,030	1,75 to 2,25	0,40 to 0,65	—	—
—	2CMWV	0,03 to 0,12	0,60	0,40 to 1,50	0,030	0,030	2,00 to 2,60	0,05 to 0,30	0,15 to 0,30	Nb 0,010 to 0,050 W 1,00 to 2,00
—	2C1MV	0,05 to 0,15	0,60	0,40 to 1,50	0,030	0,030	2,00 to 2,60	0,90 to 1,20	0,20 to 0,40	Nb 0,010 to 0,050
—	3C1MV	0,05 to 0,15	0,60	0,40 to 1,50	0,030	0,030	2,60 to 3,40	0,90 to 1,20	0,20 to 0,40	Nb 0,010 to 0,050
CrMo5	(5CM)	0,03 to 0,12	0,80	0,40 to 1,50	0,025	0,025	4,0 to 6,0	0,40 to 0,70	—	—
(CrMo5)	5CM	0,05 to 0,10	0,90	1,00	0,030	0,030	4,0 to 6,0	0,45 to 0,65	—	Ni 0,40
—	5CML	0,05	0,90	1,00	0,030	0,030	4,0 to 6,0	0,45 to 0,65	—	Ni 0,40
—	7CML	0,05	0,90	1,0	0,03	0,03	6,0 to 8,0	0,45 to 0,65	—	Ni 0,40
—	2C1MV	0,04 to 0,12	0,60	1,00	0,020	0,015	1,9 to 2,9	0,80 to 1,20	0,15 to 0,30	Ni 0,50 Nb 0,02 to 0,10 Ti 0,10 B 0,006 Al 0,04 Cu 0,25 N 0,07

Table 1 *(continued)*

Chemical composition symbol[a] for classification according to		Chemical composition, % (by mass)[b]								
ISO 3580-A[c]	ISO 3580-B	C	Si	Mn	P	S	Cr	Mo	V	Other elements[d]
—	2C2WV	0,04 to 0,12	0,60	1,00	0,015	0,015	1,9 to 2,9	0,30	0,15 to 0,30	Ni 0,50 W 1,50 to 2,00 Nb 0,02 to 0,10 B 0,006 Al 0,04 Cu 0,25 N 0,05
—	7CM	0,05 to 0,10	0,90	1,0	0,03	0,03	6,0 to 8,0	0,45 to 0,65	—	Ni 0,40
CrMo9	(9C1M)	0,03 to 0,12	0,60	0,40 to 1,30	0,025	0,025	8,0 to 10,0	0,90 to 1,20	0,15	Ni 1,0
(CrMo9)	9C1M	0,05 to 0,10	0,90	1,00	0,030	0,030	8,0 to 10,5	0,85 to 1,20	—	Ni 0,40
—	9C1ML	0,05	0,90	1,00	0,030	0,030	8,0 to 10,5	0,85 to 1,20	—	Ni 0,40
CrMo91[e]	(9C1MV)	0,06 to 0,12	0,60	0,40 to 1,50	0,025	0,025	8,0 to 10,5	0,80 to 1,20	0,15 to 0,30	Ni 0,40 to 1,00 Nb 0,03 to 0,10 N 0,02 to 0,07
(CrMo91)	9C1MV	0,08 to 0,13	0,30	1,20	0,01	0,01	8,0 to 10,5	0,85 to 1,20	0,15 to 0,30	Ni 0,80 Mn + Ni = 1,40 max. Cu 0,25 Al 0,04 Nb 0,02 to 0,10 N 0,02 to 0,07
(CrMo91)	9C1MV1[e]	0,03 to 0,12	0,60	0,85 to 1,80	0,025	0,025	8,0 to 10,5	0,80 to 1,20	0,15 to 0,30	Ni 1,0 Cu 0,25 Al 0,04 Nb 0,02 to 0,10 N 0,02 to 0,07
—	9C2WMV	0,08 to 0,15	0,60	1,20	0,020	0,015	8,0 to 10,0	0,30 to 0,70	0,15 to 0,30	Ni 1,00 W 1,50 to 2,00 Nb 0,02 to 0,08 B 0,006 Al 0,04 Cu 0,25 N 0,03 to 0,08
—	9CMWV-Co	0,03 to 0,12	0,60	0,40 to 1,30	0,025	0,025	8,0 to 10,5	0,10 to 0,50	0,15 to 0,50	Ni 0,30 to 1,00 Co 1,00 to 2,00 W 1,00 to 2,00 Nb 0,010 to 0,050 N 0,02 to 0,07
—	10C1MV	0,03 to 0,12	0,60	1,00 to 1,80	0,025	0,025	9,5 to 12,0	0,80 to 1,20	0,15 to 0,35	Ni 1,00 Cu 0,25 Al 0,04 Nb 0,04 to 0,12 N 0,02 to 0,07

Table 1 *(continued)*

Chemical composition symbol[a] for classification according to		Chemical composition, % (by mass)[b]								
ISO 3580-A[c]	**ISO 3580-B**	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**V**	**Other elements**[d]
CrMoWV12	—	0,15 to 0,22	0,80	0,40 to 1,30	0,025	0,025	10,0 to 12,0	0,80 to 1,20	0,20 to 0,40	Ni 0,8 W 0,40 to 0,60
Z[f]	G[f]	Any other agreed composition								

[a] A designation in parentheses [e.g. (CrMo1) or (1CM)] indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one without parentheses. A given product may, by having a more restricted chemical composition which fulfils both sets of designation requirements, be assigned both designations independently, provided that the mechanical property requirements of Table 2 are also satisfied.

[b] Single values shown in this table are maximum values.

[c] If not specified, contents are: Ni < 0,3 % (by mass), Cu < 0,3 % (by mass), Nb < 0,01 % (by mass).

[d] If intentionally added, elements listed without specified values, including Co and B, shall be reported. The total of these unspecified elements and all other elements found in the course of routine chemical analysis shall not exceed 0,50 % (by mass).

[e] The combination of Ni + Mn tends to lower the Ac1 temperature to the point where the PWHT temperature required for proper tempering may approach or exceed the Ac1 of the weld metal.

[f] Consumables for which the chemical composition is not listed shall be symbolized similarly and prefixed by the letter Z or G. The chemical composition ranges are not specified and it is possible that two electrodes with the same Z or G classification are not interchangeable).

Table 2 — Mechanical properties of all-weld metal

Chemical composition symbol[a] for classification according to		Minimum yield strength[c]	Minimum tensile strength	Minimum[d] elongation	Impact energy J at +20 °C		Heat treatment of all-weld metal		
					Minimum average from three test specimens	Minimum single value[e]	Preheat and interpass temperature	Post-weld heat treatment of test assembly	
ISO 3580-A	ISO 3580-B[b]	MPa	MPa	%			°C	Temperature[f] °C	Time min
Mo	(1M3)	355	510	22	47	38	<200	570 to 620	60 ± 10
(Mo)	49XX-1M3	390	490	22	—	—	90 to 110	605 to 645	60^{+10}_{0} g
(Mo)	49YY-1M3	390	490	20	—	—	90 to 110	605 to 645	60^{+10}_{0} g
MoV	—	355	510	18	47	38	200 to 300	690 to 730	60 ± 10
CrMo0,5	(55XX-CM)	355	510	22	47	38	100 to 200	600 to 650	60 ± 10
(CrMo0,5)	55XX-CM	460	550	17	—	—	160 to 190	675 to 705	60^{+10}_{0} g
—	55XX-C1M	460	550	17	—	—	160 to 190	675 to 705	60^{+10}_{0} g
CrMo1	(55XX-1CM) (5513-1CM)	355	510	20	47	38	150 to 250	660 to 700	60 ± 10
(CrMo1)	55XX-1CM	460	550	17	—	—	160 to 190	675 to 705	60^{+10}_{0} g
(CrMo1)	5513-1CM	460	550	14	—	—	160 to 190	675 to 705	60^{+10}_{0} g
CrMo1L	(52XX-1CML)	355	510	20	47	38	150 to 250	660 to 700	60 ± 10
(CrMo1L)	52XX-1CML	390	520	17	—	—	160 to 190	675 to 705	60^{+10}_{0} g
CrMoV1	—	435	590	15	24	19	200 to 300	680 to 730	60 ± 10
CrMo2	(62XX-2C1M) (6213-2C1M)	400	500	18	47	38	200 to 300	690 to 750	60 ± 10
(CrMo2)	62XX-2C1M	530	620	15	—	—	160 to 190	675 to 705	60^{+10}_{0} g
(CrMo2)	6213-2C1M	530	620	12	—	—	160 to 190	675 to 705	60^{+10}_{0} g
CrMo2L	(55XX-2C1ML)	400	500	18	47	38	200 to 300	690 to 750	60 ± 10
(CrMo2L)	55XX-2C1ML	460	550	15	—	—	160 to 190	675 to 705	60^{+10}_{0} g
—	55XX-2CML	460	550	15	—	—	160 to 190	675 to 705	60^{+10}_{0} g
—	57XX-2CMWV	490	570	15	—	—	160 to 190	700 to 730	120^{+10}_{0}
—	83XX-10C1MV	740	830	12	—	—	205 to 260	675 to 705	480^{+10}_{0}

Table 2 *(continued)*

Chemical composition symbol[a] for classification according to		Minimum yield strength[c]	Minimum tensile strength	Minimum[d] elongation	Impact energy J at +20 °C		Heat treatment of all-weld metal		
					Minimum average from three test specimens	Minimum single value[e]	Preheat and interpass temperature	Post-weld heat treatment of test assembly	
ISO 3580-A	ISO 3580-B[b]	MPa	MPa	%			°C	Temperature[f] °C	Time min
—	62XX-2C1MV	530	620	15	—	—	180 to 250	725 to 755	120^{+10}_{0}
—	62XX-2C2WV	530	620	15	—	—	180 to 250	725 to 755	120^{+10}_{0}
—	62XX-3C1MV	530	620	15	—	—	160 to 190	725 to 755	60^{+10}_{0} g
CrMo5	(55XX-5CM)	400	590	17	47	38	200 to 300	730 to 760	60 ± 10
(CrMo5)	55XX-5CM	460	550	17	—	—	175 to 230	725 to 755	60^{+10}_{0} g
—	55XX-5CML	460	550	17	—	—	175 to 230	725 to 755	60^{+10}_{0} g
—	55XX-7CML	460	550	15	—	—	180 to 230	725 to 755	60^{+10}_{0} g
—	55XX-7CM	460	550	15	—	—	180 to 230	725 to 755	60^{+10}_{0} g
CrMo9	(62XX-9C1M)	435	590	18	34	27	200 to 300	740 to 780	120 ± 10
(CrMo9)	55XX-9C1M	460	550	17	—	—	205 to 260	725 to 755	60^{+10}_{0} g
—	55XX-9C1ML	460	550	17	—	—	205 to 260	725 to 755	60^{+10}_{0} g
CrMo91	(62XX-9C1MV)	415	585	17	47	38	200 to 315	745 to 775	120 to 180
(CrMo91)	62XX-9C1MV	530	620	15	—	—	200 to 315	745 to 775	120^{+10}_{0} g
—	62XX-9C2W-MV	530	620	15	—	—	200 to 315	725 to 755	120 ± 10 g
—	69XX-9CM-WV-Co	600	690	15	—	—	205 to 260	725 to 755	480^{+10}_{0}

Table 2 *(continued)*

Chemical composition symbol[a] for classification according to		Minimum yield strength[c]	Minimum tensile strength	Minimum[d] elongation	Impact energy J at +20 °C		Heat treatment of all-weld metal		
					Minimum average from three test specimens	Minimum single value[e]	Preheat and interpass temperature	Post-weld heat treatment of test assembly	
ISO 3580-A	ISO 3580-B[b]	MPa	MPa	%			°C	Temperature[f] °C	Time min
CrMoWV12	—	550	690	15	34	27	250 to 350[h] or 400 to 500[h]	740 to 780	120 ± 10
Z[i]	G[i]	As agreed between purchaser and supplier							

[a] A designation in parentheses [e.g. (CrMo1) or (1CM)] indicates a near match in the other designation system, but not an exact match. The correct designation for a given composition range is the one without parentheses. A given product may, by having a more restricted chemical composition that fulfils both sets of mechanical property requirements, be classified in both systems independently, provided that the chemical composition requirements of Table 1 are also satisfied.

[b] XX stands for covering types 15, 16 or 18. YY stands for covering types 10, 11, 19, 20 or 27. See Table 3B.

[c] For yield strength, the lower yield strength, R_{eL}, shall be used when yielding occurs; otherwise, the 0,2 % proof strength, $R_{p0,2}$, shall be used.

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

[e] Only one single value lower than the minimum average is permitted.

[f] The test assembly shall be cooled in the furnace to 300 °C at a rate not exceeding 200 °C/h.

[g] The heating rate in the furnace shall be 85 °C/h to 275 °C/h.

[h] Immediately after welding, allow the specimen to cool to 120 °C to 100 °C and maintain at this temperature for at least 1 h.

[i] Consumables for which the chemical composition is not listed shall be symbolized similarly and prefixed by the letter Z or G. The chemical composition ranges are not specified and it is possible that two electrodes with the same Z or G classification are not interchangeable).

5.4 Symbol for type of electrode covering

The type of covering of the electrodes determines, to a large extent, the usability characteristics of the electrode and properties of the weld metal.

5.4A Classification by chemical composition

Two symbols are used to denote the type of covering:

R rutile covering

B basic covering

NOTE A description of the characteristics of each of the types of covering is given in Annex D.

5.4B Classification by tensile strength and chemical composition

The type of covering of a covered electrode depends substantially on the type of slag-forming components. The type of covering also determines the positions suitable for welding and the type of current, according to Table 3B.

NOTE A description of the characteristics of each of the types of covering is given in Annex E.

Table 3B — Symbol for type of covering (classification by tensile strength and chemical composition)

Symbol	Type of covering	Welding positions[a]	Type of current[b]
10[c]	Cellulosic	All	DC (+)
11[c]	Cellulosic	All	AC or DC (+)
13	High titania potassium	All[d]	AC or DC (±)
15	Basic	All[d]	DC (+)
16	Basic	All[d]	AC or DC (+)
18	Basic + metal powders	All except PG	AC or DC (+)

Table 3B *(continued)*

19[c]	Iron oxide titania potassium	All[d]	AC or DC (±)
20[c]	Iron oxide	PA, PB	AC or DC (–)
27[c]	Iron oxide + iron powder	PA, PB	AC or DC (–)

[a] Positions are defined in ISO 6947. PA = flat, PB = horizontal vertical fillet, PG = vertical down.

[b] AC means alternating current; DC means direct current.

[c] Composition designator 1M3 only.

[d] All positions may or may not include vertical down welding. This shall be specified in the manufacturer's trade literature.

5.5 Symbol for nominal electrode efficiency and type of current

5.5A Classification by chemical composition

The symbols in Table 4A indicate nominal electrode efficiency determined in accordance with ISO 2401, with the type of current shown in Table 4A.

5.5B Classification by tensile strength and chemical composition

There is no specific symbol for nominal electrode efficiency and type of current. Type of current is included in the symbol for type of covering (see Table 3B). Nominal electrode efficiency is not addressed.

Table 4A — Symbol for nominal electrode efficiency and type of current (classification by chemical composition)

Symbol	Nominal electrode efficiency, η %	Type of current[a,b]
1	$\eta \leq 105$	AC and DC
2	$\eta \leq 105$	DC
3	$105 < \eta \leq 125$	AC and DC
4	$105 < \eta \leq 125$	DC

[a] AC means alternating current; DC means direct current.

[b] In order to demonstrate operability on alternating current, tests shall be carried out with a no load voltage no higher than 65 V.

5.6 Symbol for welding position

5.6A Classification by chemical composition

The symbols in Table 5A indicate the positions for which the electrode is tested in accordance with ISO 15792-3.

5.6B Classification by tensile strength and chemical composition

There is no specific symbol for welding position. The welding position requirements are included with the symbol for type of covering (see Table 3B).

Table 5A — Symbol for welding position (classification by chemical composition)

Symbol	Welding positions in accordance with ISO 6947
1	PA, PB, PC, PD, PE, PF, PG
2	PA, PB, PC, PD, PE, PF
3	PA, PB
4	PA, PB, PG

5.7 Symbol for hydrogen content of deposited metal

The symbols in Table 6 indicate the hydrogen content as determined in deposited metal from an electrode of size 4,0 mm in accordance with the method described in ISO 3690. The current used shall be 70 % to 90 % of the maximum value recommended by the manufacturer. Electrodes recommended for use with alternating current shall be tested using alternating current; electrodes recommended for direct current only shall be tested using direct current with electrode positive.

The manufacturer shall provide information on the recommended type of current and drying conditions for achieving the hydrogen levels.

Table 6 — Symbol for hydrogen content of deposited metal

Symbol	Hydrogen content ml/100 g of deposited weld metal, maximum
H5	5
H10	10
H15	15

See Annex F for additional information about diffusible hydrogen.

5.8 Rounding procedure

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 document, the measured values shall be converted to the units of this document before rounding. If an average value is to be compared to the requirements of this document, rounding shall be done only after calculating the average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

6 Mechanical tests

6.1 General

Tensile and impact tests shall be carried out in the post-weld heat-treated condition specified in Table 2, using an all-weld metal test assembly type 1.3 in accordance with ISO 15792-1:2000 with 4,0 mm electrodes and welding conditions as described 6.2 and 6.3.

6.2 Preheating and interpass temperature

Preheating and interpass temperatures shall be selected for the appropriate type of weld metal as listed in Table 2.

The interpass temperature shall be measured using temperature indicator crayons, surface thermometers or thermocouples in accordance with ISO 13916.

The interpass temperature shall not exceed the maximum temperature indicated in Table 2 when deposition of any pass begins. If, after any pass, the interpass temperature is exceeded, the test assembly shall be cooled in air to within the limits of the interpass temperature.

6.3 Pass sequence

The pass sequence shall be as indicated in Table 7.

The direction of welding to complete a pass shall not vary. Each pass shall be executed with a welding current of 70 % to 90 % of the maximum current recommended by the manufacturer. Regardless of the type of covering, welding shall be performed with alternating current when both alternating current and direct current are recommended and with direct current using the recommended polarity when only direct current is recommended.

Table 7 — Pass sequence

Electrode diameter mm	**Split weave**		
	Layer number	Passes per layer	Number of layers
4,0	1 to top	2[a]	7 to 9
[a] The top two layers may be completed with three passes per layer.			

7 Chemical analysis

Chemical analysis may be performed on any suitable all-weld metal test piece, but in cases of dispute, specimens in accordance with ISO 6847 shall be used. Any analytical technique may be used, but in cases of dispute, reference shall be made to established published methods. The results of the chemical analysis shall fulfil the requirements of Table 1.

8 Fillet weld test

The fillet weld test assembly shall be as shown in ISO 15792-3.

8A Classification by chemical composition

The plate material shall be selected from the range of materials for which the electrode is recommended by the manufacturer, or shall be unalloyed steel of 0,30 % (by mass) C maximum. The surface shall be free of scale, rust, and other contaminants. The plate thickness, *t*, shall be 10 mm to 12 mm, the width, *w*, shall be 75 mm minimum, and the length, *l*, shall be 300 mm minimum. The electrode sizes to be tested for each covering type, the test positions, and the required test results are given in Table 8A.

8B Classification by tensile strength and chemical composition

The plate material shall be unalloyed steel of 0,30 % (by mass) C maximum. The surfaces to be welded shall be clean. The test plate thickness, *t*, width, *w*, and length, *l*, the test positions for each covering type, and the required test results are given in Table 8B.

Table 8A — Test requirements for fillet welds (classification by chemical composition)

Dimensions in millimetres

Symbol of position for classification	Type of covering	Test position	Electrode size[a]	Fillet theoretical throat	Leg length difference	Convexity
1 or 2	R or B	PB	6,0	5,0 min.	2,0 max.	3,0 max.
4	R B	PB	6,0 5,0	4,5 min.	1,5 max.	2,5 max.
1 or 2	R B	PF	4,0	4,5 max. 5,5 max.	NS[b]	2,0 max.
1, 2 or 4	R B	PD	4,0	4,5 max. 5,5 max.	1,5 max. 2,0 max.	2,5 max. 3,0 max.
4	B	PG	4,0	5,0 min.	NS[b]	1,5 max.[c]

[a] Where the largest size claimed for positional welding is smaller than that specified, use the largest size and adjust criteria pro rata. Otherwise, electrode sizes not shown are not required to be tested.

[b] Not specified.

[c] Maximum concavity.

Table 8B — Test requirements for fillet welds (classification by tensile strength and chemical composition)

Dimensions in millimetres

Type of covering	Current and polarity	Electrode size[a]	Test position	Plate thickness *t*	Plate width *w*	Minimum plate length[b] *l*	Fillet weld size	Max. leg length difference	Max. convexity
10	DC (+)	5,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 6,5 min.	3,5 2,5	1,5 2,0
11	AC	5,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 6,5 min.	3,5 2,5	1,5 2,0
13	AC	5,0 6,0	PF, PD PB	12 12	75	300 400	10,0 max. 8,0 min.	2,0 3,5	1,5 2,0
15	DC (+)	4,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 8,0 min.	3,5 3,5	2,0 2,0
16	AC	4,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 8,0 min.	3,5 3,5	2,0 2,0
18	AC	4,0 6,0	PF, PD PB	10 12	75	300 400	8,0 max. 8,0 min.	3,5 3,5	2,0 2,0
19	AC	5,0 6,0	PF, PD PB	12 12	75	300 400	10,0 max. 8,0 min.	2,0 3,5	1,5 2,0
20	AC	6,0	PB	12	75	400	8,0 min.	3,5	2,0
27	AC	6,0	PB	12	75	400 or 650[c]	8,0 min.	3,5	2,0

[a] Where the largest size recommended for positional welding is smaller than that specified, use the largest size and adjust criteria pro rata. Otherwise, electrode sizes not shown are not required to be tested.

[b] For 300 mm electrode length, *l* shall be 250 mm minimum; for 350 mm electrode length, *l* shall be 300 mm minimum.

[c] For 450 mm electrode length, *l* shall be 400 mm minimum; for 700 mm electrode length, *l* shall be 650 mm minimum.

9 Retesting

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 one or two new test assemblies. For chemical analysis, retesting need only be for those specific elements that failed to meet their testing 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 requirements. That test shall be repeated, following proper prescribed procedures. In this case, the requirement for doubling the number of test specimens does not apply.

10 Technical delivery conditions

Technical delivery conditions shall meet the requirements in ISO 544 and in ISO 14344.

11 Examples of designation

The designation of the covered electrode shall follow the principles given in the examples below.

11A Classification by chemical composition

The designation of the covered electrode is indicated by the suffix letter A given after the number of this document and shall follow the principle given in the example below.

EXAMPLE 1A

A covered electrode for manual metal arc welding deposits weld metal with a chemical composition of 1,1 % (by mass) Cr and 0,6 % (by mass) Mo, i.e. chemical composition symbol CrMo1 in accordance with Table 1. The electrode has a basic covering (B) and can be used with direct current and with a nominal electrode efficiency of 120 % (4) in flat butt and flat fillet welds (4). Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100 g deposited metal (H5).

The designation is:

ISO 3580-A - E CrMo1 B 4 4 H5

Compulsory section:

ISO 3580-A - E CrMo1 B

where

ISO 3580-A is the number of this document and classification by chemical composition;

E is the symbol for a covered electrode/manual metal arc welding (see 5.1);

11B Classification by tensile strength and chemical composition

The designation of the covered electrode is indicated by the suffix letter B given after the number of this document and shall follow the principle given in the example below.

EXAMPLE 1B

A covered electrode for manual metal arc welding deposits weld metal with a chemical composition of 1,1 % (by mass) Cr and 0,6 % (by mass) Mo, i.e. chemical composition symbol 1CM in accordance with Table 1. The post-weld heat-treated deposit tensile strength exceeds 550 MPa (55). The electrode has a basic covering containing iron powder and can be used with direct current or alternating current (18) in all positions except vertical down. Hydrogen is determined in accordance with ISO 3690 and does not exceed 5 ml/100 g deposited metal (H5).

The designation is:

ISO 3580-B - E5518-1CM H5

Compulsory section:

ISO 3580-B - E5518-1CM

where

ISO 3580-B is the number of this document and classification by tensile strength and chemical composition;

E is the symbol for a covered electrode/manual metal arc welding (see 5.1);

CrMo1	is the chemical composition of all-weld metal (see Table 1);
B	is the type of electrode covering (see 5.4A);
4	is the recovery and type of current (see Table 4A);
4	is the welding position (see 5.6A);
H5	is the hydrogen content (see Table 6).

EXAMPLE 2A

A covered electrode for manual metal arc welding deposits weld metal with a chemical composition of 1,1 % (by mass) Cr and 0,6 % (by mass) Mo and 0,3 % (by mass) Ti, i.e. the chemical composition symbol Z in accordance with Table 1 and the mechanical properties have to be agreed between manufacturer and customer (see Table 2). The electrode has a basic covering (B) and can be used with direct current and with a nominal electrode efficiency of 120 % (4) in flat butt and flat fillet welds (4).

The designation is:

ISO 3580-A - E Z CrMo1Ti B 4 4

Compulsory section:

ISO 3580-A - E Z CrMo1Ti B

where

ISO 3580-A	is the number of this document and classification by chemical composition;
E	is the symbol for a covered electrode/ manual metal arc welding (see 5.1);
Z	is the chemical composition of all-weld metal is agreed between manufacturer and customer (see Table 1);
CrMo1Ti	is the chemical composition of the all-weld metal;
B	is the type of electrode covering (see 5.4A);
4	is the recovery and type of current (see Table 4A);
4	is the welding position (see 5.6A).

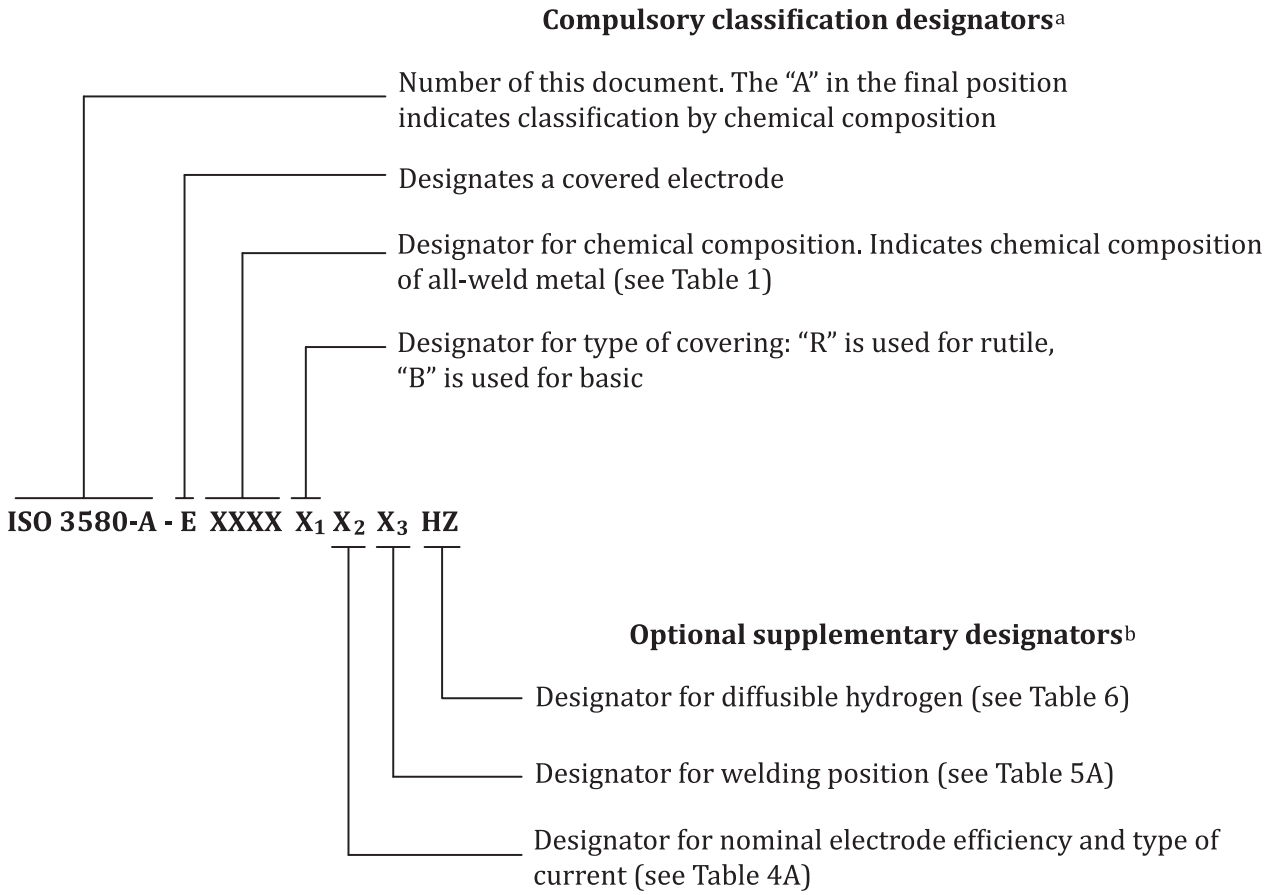
55	is the deposited weld metal tensile strength (see 5.3B and Table 2);
18	is the type of covering (see 5.4B and Table 3B);
1CM	is the chemical composition of all-weld metal (see Table 1);
H5	is the hydrogen content (see Table 6).

Annex A
(informative)

Classification systems

A.1 ISO 3580-A

The ISO 3580 classification system for covered electrodes based upon chemical composition is shown in Figure A.1.



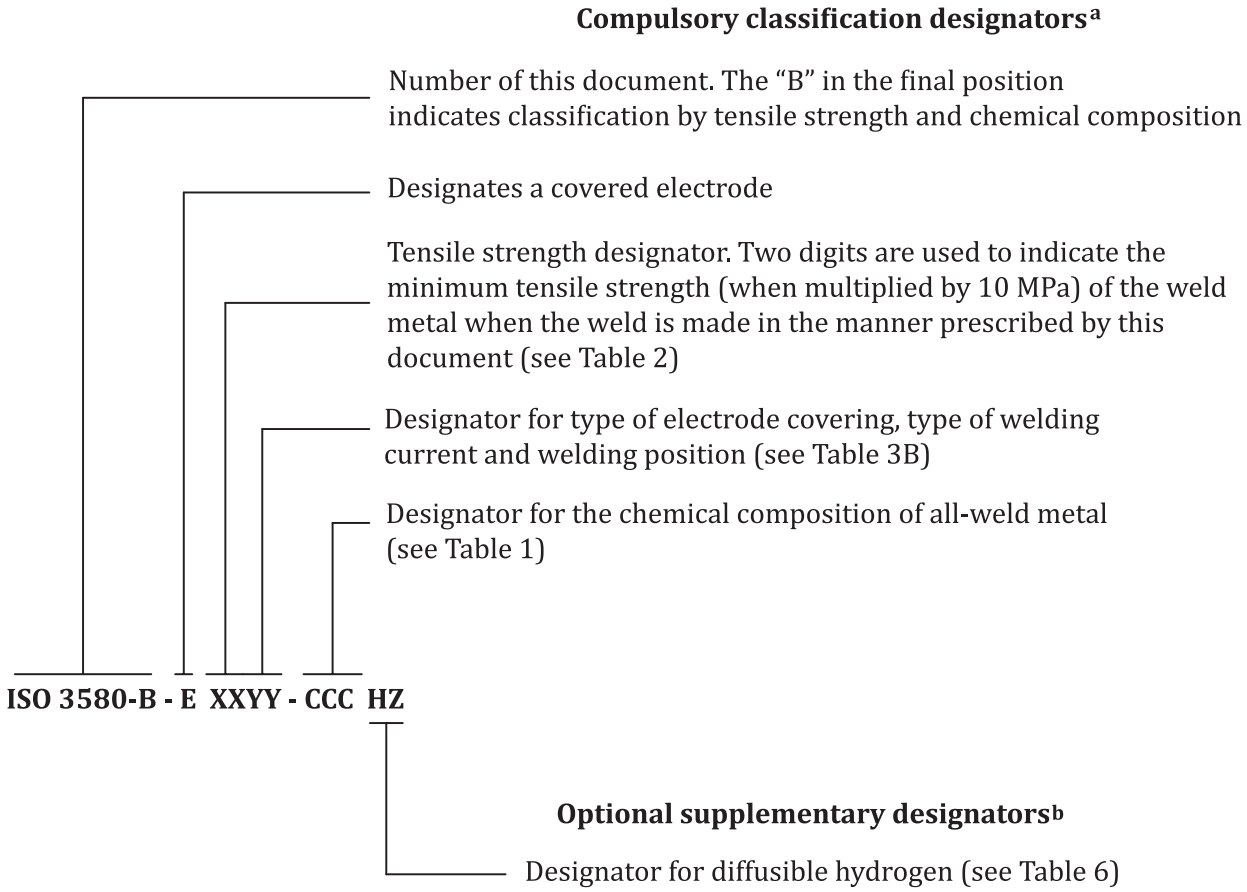
[a] The combination of these designators constitutes the covered electrode classification.

[b] These designators are optional and do not constitute a part of the covered electrode classification.

Figure A.1 — ISO 3580-A designation of covered electrodes for creep-resisting steels (classification by chemical composition)

A.2 ISO 3580-B

The ISO 3580 classification system for covered electrodes based upon tensile strength and chemical composition is shown in Figure A.2.



[a] The combination of these designators constitutes the covered electrode classification.

[b] These designators are optional and do not constitute a part of the covered electrode classification.

Figure A.2 — ISO 3580-B designation of covered electrodes for creep-resisting steels (classification by tensile strength and chemical composition)

Annex B
(informative)

Description of chemical composition designators (classification by chemical composition)

The designation lists the principal alloying elements using the chemical symbols Cr (chromium), Mo (molybdenum), V (vanadium), and W (tungsten). For chromium-containing alloys, this is followed by the numbers 1, 2, 5, 9 or 12 to indicate the nominal percentage by mass of chromium present. In the particular case of the "modified 9 % (by mass) Cr" alloy, CrMo91, the suffix "1" is added to indicate the additional complex alloying compared to CrMo9.

Low carbon grades are identified by a suffix "L" indicating a maximum carbon content of 0,05 % (by mass).

Annex C
(informative)

Description of chemical composition designators (classification by tensile strength and chemical composition)

C.1 1M3 type

For electrodes containing Mo (molybdenum) as the only alloying element which differentiates it from unalloyed steel electrodes, the designation consists of an integer approximately equal to twice the nominal Mn (manganese) content, followed by the letter "M" to indicate molybdenum, and a digit to indicate the nominal Mo level, as follows:

3 = about 0,5 % (by mass) **Mo = high Mo**

C.2 XCXMX type

For chromium-molybdenum steels, the designation consists of "C", preceded by an integer to indicate the nominal Cr (chromium) level, and "M" preceded by an integer to indicate the nominal Mo level. For either chromium or molybdenum, if the nominal level is appreciably less than 1 % (by mass), there is no preceding integer. If tungsten and/or vanadium is added, the corresponding letter "W" and/or "V", in that order, would be added after the chromium and molybdenum symbols. Deliberately high carbon would be indicated by "H" at the end of the designation, while deliberately low carbon would be indicated by "L" at the end of the designation. Variations of a basic composition would be indicated by an arbitrary integer following the last letter.

Annex D
(informative)

Description of types of electrode covering (classification by chemical composition)

D.1 Rutile covered electrodes

The covering of this type contains, as an essential component, titanium dioxide, usually as rutile, together with silicates and carbonates.

Electrodes of this type give a smooth droplet transfer, which ensures that these electrodes are suitable for welding in all positions except the vertical down position.

D.2 Basic covered electrodes

The covering of this type contains large quantities of alkaline-earth carbonates and fluorspar (calcium fluoride). These electrodes are capable of giving low hydrogen content deposits when used in accordance with the manufacturer's instructions.

Electrodes with basic covering are usually suitable only for direct current, electrode positive.

Basic electrodes are preferred for the welding of thick sections and for joints with gaps. The arc should be kept as short as possible.

Annex E
(informative)

Description of types of electrode covering (classification by tensile strength and chemical composition)

E.1 General

The properties of a covered electrode, i.e. both its welding characteristics and mechanical properties of the weld metal, are decisively influenced by the covering. This homogeneous mixture of substances generally contains the following six main components:

a) slag-forming materials;

b) deoxidants;

c) shielding gas-forming materials;

d) ionizing agents;

e) binders;

f) alloying elements (if necessary).

In addition, metal powders, which may affect the positional welding properties, may be added to increase the nominal electrode efficiency and/or to achieve the intended deposit composition. When a covering is described as being a metal powder type, it is understood that relatively large amounts [greater than 15 % (by mass) of the coating] of metal powders are included in the covering.

Certain electrode designs, while usable on both alternating current and direct current (either or both polarities), may be optimized by their manufacturer for one particular current type for a particular market need.

E.2 Covering type 10

Electrodes of this type contain a large quantity of combustible organic substances, particularly cellulose, in the covering. Owing to the intensive arc, such electrodes are especially suitable for welding in the vertical downward position. Arc stabilization is primarily by sodium, so the electrodes are mainly suitable for DC welding, normally with electrode positive.

E.3 Covering type 11

Electrodes of this type contain a large quantity of combustible organic substances, particularly cellulose, in the covering. Owing to the intensive arc, such electrodes are especially suitable for welding in the vertical downward position. Arc stabilization is primarily by potassium, so the electrodes are suitable for both AC and DC welding, electrode positive.

E.4 Covering type 13

Electrodes of this type contain a large quantity of titanium dioxide (rutile) and are heavily stabilized with potassium. They produce a soft quiet arc, and are especially suitable for thin base metals.

E.5 Covering type 15

Electrodes of this type have a covering that is highly basic, consisting largely of lime (calcium oxide) and fluorspar (calcium fluoride). Arc stabilization is provided mainly by sodium, and they are generally suitable for use on DC electrode positive only. They produce weld metal of high metallurgical quality with low diffusible hydrogen.

E.6 Covering type 16

Electrodes of this type have a covering that is highly basic, consisting largely of lime and fluorspar. Arc stabilization with potassium is responsible for their ability to weld with alternating current. They produce weld metal of high metallurgical quality with low diffusible hydrogen.

E.7 Covering type 18

Electrodes of this type are similar to electrodes of covering type 16, except that they have a somewhat thicker covering with a metal powder addition. The metal powder increases their current-carrying capacity and deposition rate, as compared to electrodes of covering type 16.

E.8 Covering type 19

Electrodes of this type contain oxides of titanium and iron, usually combined in the form of the mineral ilmenite (iron titanium oxide). Although they are not low hydrogen basic electrodes, they are capable of producing weld metal of relatively high toughness.

E.9 Covering type 20

Electrodes of this type contain large amounts of iron oxide. The slag is very fluid, so that welding is generally suitable only in flat and horizontal positions. They are primarily designed for fillet and lap welds.

E.10 Covering type 27

Electrodes of this type are similar to electrodes of covering type 20, except that the covering is thicker and contains large amounts of iron powder in addition to the iron oxide of covering type 20. Electrodes of covering type 27 are primarily designed for high speed fillet and lap welds.

Annex F
(informative)

Notes on diffusible hydrogen

Assuming that the external conditions are satisfactory (i.e. weld areas are clean and dry), the hydrogen in the weld metal stems from hydrogen-containing compounds in the consumables. In the case of basic covered electrodes, the water taken up by the covering is the main source. The water dissociates in the arc and gives rise to atomic hydrogen, which is absorbed by the weld metal. Under given material and stress conditions, the risk of cold cracking diminishes with decreasing hydrogen content of the weld metal.

In practice, the appropriate hydrogen level depends on the particular application and, to ensure that this is achieved, the relevant handling, storage and drying conditions recommended by the electrode manufacturer should be followed.

Other methods of collection and measurement of diffusible hydrogen may be used for batch testing, provided they possess equal reproducibility with, and are calibrated against, the method given in ISO 3690. The weld metal hydrogen content is influenced by the type of current.

Cracks in welded joints may be caused or significantly influenced by hydrogen. The risk of hydrogen-assisted-cracking increases with increasing alloy content and stress level. Such cracks generally develop after the joint has become cold and are therefore termed cold cracks.

Bibliography

[1] EN 1599:1997, *Welding consumables — Covered electrodes for manual metal arc welding of creep-resisting steels — Classification*

ICS 25.160.20

Price based on 24 pages

This page has been left intentionally blank.