BS EN ISO 3581:2016

BSI Standards Publication

Welding consumables — Covered electrodes for manual metal arc welding of stainless and heat-resisting steels — Classification (ISO 3581:2016)

bsi.

National foreword

This British Standard is the UK implementation of EN ISO 3581:2016. It supersedes BS EN ISO 3581:2012 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee WEE/39, Welding consumables.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Welding consumables - Covered electrodes for manual metal arc welding of stainless and heat-resisting steels - Classification (ISO 3581:2016)

Produits consommables pour le soudage - Électrodes enrobées pour le soudage manuel à l'arc des aciers inoxydables et résistant aux températures élevées - Classification (ISO 3581:2016)

Schweißzusätze - Umhüllte Stabelektroden zum Lichtbogenhandschweißen von nichtrostenden und hitzebeständigen Stählen - Einteilung (ISO 3581:2016)

This European Standard was approved by CEN on 15 April 2016.

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European foreword

This document (EN ISO 3581:2016) has been prepared by Technical Committee ISO/TC 44 “Welding and allied processes” in collaboration with Technical Committee CEN/TC 121 “Welding and allied processes” the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by January 2017, and conflicting national standards shall be withdrawn at the latest by January 2017.

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

This document supersedes EN ISO 3581:2012.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 3581:2016 has been approved by CEN as EN ISO 3581:2016 without any modification.

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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.

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).

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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

The committee responsible for this document is ISO/TC 44, *Welding and allied processes*, Subcommittee SC 3, *Welding consumables*.

This third edition cancels and replaces the second edition (ISO 3581:2003), which has been technically revised. It also incorporates the Technical Corrigendum ISO 3581:2003/Cor 1:2008 and the Amendment ISO 3581:2003/Amd 1:2011.

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

Introduction

This International Standard provides a classification system for stainless steel, covered welding electrodes in terms of chemical composition of deposited weld metal and type of electrode covering. Other properties of the electrodes are specified by reference to tables.

This International Standard recognizes that there are two somewhat different approaches in the global market for classifying a given stainless steel, covered electrode, and allows for either or both to be used to suit a particular need. Application of either (or both) type(s) of classification designation identifies a product as classified according to this International Standard. It is important to note that the two systems are not exactly equivalent; therefore, each system must be used independent of the other, without combining designators in any way.

The classification according to ISO 3581, system A, is mainly based upon EN 1600 while the classification according to ISO 3581, system B, is mainly based upon standards used around the Pacific Rim.

Welding consumables — Covered electrodes for manual metal arc welding of stainless and heat-resisting steels — Classification

1 Scope

This International Standard specifies requirements for classification of covered electrodes, based on the all-weld metal chemical composition, the type of electrode covering and other electrode properties, and the all-weld metal mechanical properties, in the as-welded or heat-treated conditions, for manual metal arc welding of stainless and heat-resisting steels.

This International Standard is a combined standard providing for classification utilizing a system based upon classification according to nominal composition or utilizing a system based upon classification according to alloy type.

a) Paragraphs and tables which carry the label “classification according to nominal composition” or “ISO 3581-A” are applicable only to products classified to that system.

b) Paragraphs and tables which carry the label “classification according to alloy type” or “ISO 3581-B” are applicable only to products classified to that system.

c) Paragraphs and tables which carry neither label are applicable to products classified according to either or both systems.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 6847, *Welding consumables — Deposition of a weld metal pad for chemical analysis*

ISO 6947:2011, *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 Classification

Classification designations are based upon two approaches for indicating the chemical composition of the all-weld metal deposit obtained with a given electrode.

The “nominal composition” approach uses designation components indicating directly the nominal levels of certain alloying elements, given in a particular order, and some symbols for low but significant levels of other elements, whose levels are not conveniently expressed as integers. The “alloy type” approach uses tradition-based three-digit or four-digit designations for alloy families, and occasionally an additional character or characters for compositional modifications of each original alloy within the family. Both designation approaches include additional designators for some other classification requirements, but not entirely the same classification requirements, as will be clear from the following clauses.

Table 1 lists the tests required for classification of an electrode in each approach.

In many cases, a given commercial product can be classified using both approaches. Then either or both classification designations can be used for the product.

Table 1 — Summary of test requirements

Electrode designation		**Size** [a] mm	**Position of welding**[b]					
			Chemical analysis test		**All-weld metal tension test**		**Fillet weld test**	
ISO 3581-A	ISO 3581-B		ISO 3581-A	ISO 3581-B	ISO 3581-A	ISO 3581-B	ISO 3581-A	ISO 3581-B
Coating type symbol B and position symbols 1 and 2	Position and coating type symbol - 15	2,5 (or 2,4 or 2,6)	Not required	PA	Not required	Not required	Not required	Not required
		3,2 or 3,0	PA	PA	Not required	Not required	Not required	Not required
		4,0	PA	PA	PA	PA	Not required	PB, PF, PD
		5,0 or 4,8	Not required	PA	Not required	Not required	Not required	PB
		6,0 (or 5,6 or 6,4)	Not required	PA	Not required	Not required	Not required	PB
All coating types and position symbol 3	Not applicable	3,2 or 3,0	PA	Not applicable	Not required	Not applicable	Not required	Not applicable
		4,0	PA		PA		Not required	
		5,0 or 4,8	Not required		Not required		Not required	
All coating types and position symbol 4	Position symbol - 4 and all coating types	2,5 (or 2,4 or 2,6)	Not required	PA	Not required	Not required	Not required	PG
		3,2 or 3,0	PA	PA	Not required	Not required	Not required	PG
		4,0	PA	PA	PA	PA	Not required	PG
		5,0 or 4,8	Not required	PA	Not required	Not required	Not required	PG

[a] If the size is not manufactured, the next nearest size may be substituted (provided that the substituted size is different from those specified in this table).

[b] The abbreviation PA, PB, PD, PF and PG indicate welding positions in accordance with ISO 6947, as follows:

PA = flat;

PB = horizontal vertical;

PD = horizontal overhead;

PF = vertical up;

PG = vertical down.

Table 1 *(continued)*

Electrode designation		Size [a] mm	Position of welding[b]					
			Chemical analysis test		All-weld metal tension test		Fillet weld test	
ISO 3581-A	ISO 3581-B		ISO 3581-A	ISO 3581-B	ISO 3581-A	ISO 3581-B	ISO 3581-A	ISO 3581-B
All coating types and position symbol 5	Not applicable	3,2 (or 3,0)	PA	Not applicable	Not required	Not applicable	Not required	Not applicable
		4,0	PA		PA		Not required	
		5,0 (or 4,8)	Not required		Not required		Not required	
Coating type symbol R and position symbols 1 and 2	Position and coating type symbols - 16 and - 17	2,5 (or 2,4 or 2,6)	Not required	PA	Not required	Not required	Not required	Not required
		3,2 (or 3,0)	PA	PA	Not required	Not required	Not required	Not required
		4,0	PA	PA	PA	PA	Not required	PB, PF, PD
		5,0 (or 4,8)	Not required	PA	Not required	Not required	Not required	PB
		6,0 (or 5,6 or 6,4)	Not required	PA	Not required	Not required	Not required	PB
Not applicable	Position and coating type symbols - 26 and - 27	2,5 (or 2,4 or 2,6)	Not applicable	PA	Not applicable	Not required	Not applicable	Not required
		3,2 (or 3,0)		PA		Not required		Not required
		4,0		PA		PA		PB
		5,0 (or 4,8)		PA		Not required		PB
		6,0 (or 5,6 or 6,4)		PA		Not required		PB

[a] If the size is not manufactured, the next nearest size may be substituted (provided that the substituted size is different from those specified in this table).

[b] The abbreviation PA, PB, PD, PF and PG indicate welding positions in accordance with ISO 6947, as follows:

PA = flat;

PB = horizontal vertical;

PD = horizontal overhead;

PF = vertical up;

PG = vertical down.

3A Classification according to nominal composition

The classification includes all-weld metal properties obtained with a covered electrode as given below. The classification is based on an electrode diameter of 4 mm with the exception of testing for welding position. When 4 mm diameter electrodes are not manufactured, the next closest diameter shall be tested.

The classification is divided into the following five parts:

3B Classification according to alloy type

The classification includes all-weld metal properties obtained with a covered electrode as given below. The classification is based on an electrode diameter of 4 mm for mechanical properties, with the exception of testing for welding position and for chemical analysis of the weld metal. When 4 mm diameter electrodes are not manufactured, the next closest diameter shall be tested.

The classification is divided into the following four parts:

1) the first part gives a symbol indicating the product/process to be identified (see 4.1A);

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

3) the third part gives a symbol indicating the type of electrode covering (see 4.3A);

4) the fourth part gives a symbol indicating the effective electrode efficiency and type of current (see Table 4A);

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

In order to promote the use of this International Standard, the classification to ISO 3581-A is split into two sections.

— **Compulsory section**

This section includes the symbols for the type of product, the chemical composition and the type of covering, i.e. symbols defined in 4.1A, 4.2 and 4.3A.

— **Optional section**

This section includes the symbols for the weld metal recovery, the type of current and the welding positions for which the electrode is suitable, i.e. the symbols defined in 4.4A and Table 5A.

The full designation (compulsory and optional sections) shall be used on packages and in the manufacturer's literature and data sheets.

1) the first part gives a symbol indicating the product/process to be identified (see 4.1B);

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

3) the third part gives a symbol indicating the welding position (see Table 5B);

4) the fourth part gives a symbol indicating the type of electrode covering. This also serves to define the type of current which can be used with the electrode classified (see 4.3B).

In classifying welding electrodes to ISO 3581-B, the symbols for all four parts (product/process, alloy type, welding position and type of electrode covering) as defined in 4.1B, 4.2, 4.3 and Table 5B, are compulsory.

The full designation shall be used on packages and in the manufacturer's literature and data sheets.

NOTE The composition of the core wire, which can be substantially different from the weld metal composition, is not considered a classification criterion.

4 Symbols and requirements

4.1 Symbol for the product/process

4.1A Classification according to nominal composition

The symbol for the covered electrode used in the manual metal arc welding process for stainless and heat-resisting steels in accordance with ISO 3581-A shall be the letter E.

4.1B Classification according to alloy type

The symbol for the covered electrode used in the manual metal arc welding process for stainless and heat-resisting steels in accordance with ISO 3581-B shall be the letters ES. The initial letter "E" indicates a covered electrode while the letter "S" indicates stainless and heat-resisting steels.

4.2 Symbol for the chemical composition of all-weld metal

The symbol in Table 2 indicates the chemical composition of all-weld metal determined in accordance with Clause 5. The all-weld metal obtained with the covered electrodes in Table 2, in accordance with

Clause 6, shall also fulfil the mechanical property requirements for that electrode as specified in Table 3.

4.3 Symbol for type of electrode covering

The type of covering of the electrodes determines, to a large extent, usability characteristics of the electrode and properties of the weld metal. See Annex A for information on coating types.

4.3A Classification according to nominal composition

The following two symbols are used to describe the type of covering:

- B denotes a basic covering;
- R denotes a rutile based covering.

4.3B Classification according to alloy type

The following three symbols are used to define the type of covering on the electrode:

- 5 denotes a basic covering, intended for DC welding;
- 6 denotes a rutile based coating, intended for DC or AC welding (except that position and coating type -46 is DC);
- 7 denotes a modified rutile based coating containing a considerable amount of silica, intended for DC or AC welding (except that position and coating type -47 is DC).

Table 2 — Chemical composition requirements

Symbol classification by		Chemical composition[a, e, f] % (by mass)											
Nominal composition-[b,c,d] (ISO 3581-A)	Alloy type[d] (ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N	Others
Martensitic/ferritic types													
—	409Nb	0,12	1,00	1,00	0,040	0,030	11,0 to 14,0	0,60	0,75	0,75	0,50 to 1,50	—	—
13	(410)	0,12	1,0	1,5	0,030	0,025	11,0 to 14,0	0,60	0,75	0,75	—	—	—
(13)	410	0,12	0,90	1,0	0,04	0,03	11,0 to 14,0	0,70	0,75	0,75	—	—	—
13 4	(410NiMo)	0,06	1,0	1,5	0,030	0,025	11,0 to 14,5	3,0 to 5,0	0,4 to 1,0	0,75	—	—	—
(13 4)	410NiMo	0,06	0,90	1,0	0,04	0,03	11,0 to 12,5	4,0 to 5,0	0,40 to 0,70	0,75	—	—	—
17	(430)	0,12	1,0	1,5	0,030	0,025	16,0 to 18,0	0,60	0,75	0,75	—	—	—
(17)	430	0,10	0,90	1,0	0,04	0,03	15,0 to 18,0	0,6	0,75	0,75	—	—	—
—	430Nb	0,10	1,00	1,00	0,040	0,030	15,0 to 18,0	0,60	0,75	0,75	0,50 to 1,50	—	—
Austenitic types													
—	209	0,06	1,00	4,0 to 7,0	0,04	0,03	20,5 to 24,0	9,5 to 12,0	1,5 to 3,0	0,75	—	0,10 to 0,30	V 0,10 to 0,30
—	219	0,06	1,00	8,0 to 10,0	0,04	0,03	19,0 to 21,5	5,5 to 7,0	0,75	0,75	—	0,10 to 0,30	—
—	240	0,06	1,00	10,5 to 13,5	0,04	0,03	17,0 to 19,0	4,0 to 6,0	0,75	0,75	—	0,10 to 0,30	—
19 9	(308)	0,08	1,2	2,0	0,030	0,025	18,0 to 21,0	9,0 to 11,0	0,75	0,75	—	—	—
(19 9)	308	0,08	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	9,0 to 11,0	0,75	0,75	—	—	—
19 9 H	(308H)	0,04 to 0,08	1,2	2,0	0,03	0,025	18,0 to 21,0	9,0 to 11,0	0,75	0,75	—	—	—
(19 9 H)	308H	0,04 to 0,08	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	9,0 to 11,0	0,75	0,75	—	—	—
19 9 L	(308L)	0,04	1,2	2,0	0,030	0,025	18,0 to 21,0	9,0 to 11,0	0,75	0,75	—	—	—
(19 9 L)	308L	0,04	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	9,0 to 12,0	0,75	0,75	—	—	—
19 9 N L	308LN	0,035	0,90	0,5 to 2,0	0,025	0,025	18,00 to 21,00	9,00 to 11,00	0,50	0,75	—	0,06 to 0,10	—
(20 10 3)	308Mo	0,08	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	9,0 to 12,0	2,0 to 3,0	0,75	—	—	—
—	308LMo	0,04	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	9,0 to 12,0	2,0 to 3,0	0,75	—	—	—
—	308N	0,10	0,90	1,0 to 4,0	0,04	0,03	21,0 to 25,0	7,0 to 10,0	—	—	—	0,12 to 0,30	—

Table 2 *(continued)*

Symbol classification by		Chemical composition[a, e, f] % (by mass)											
Nominal composition-[b,c,d] (ISO 3581-A)	Alloy type[d] (ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N	Others
—	349	0,13	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	8,0 to 10,0	0,35 to 0,65	0,75	0,75 to 1,20	—	V 0,10 to 0,30 Ti 0,15 W 1,25 to 1,75
19 9 Nb	(347)	0,08	1,2	2,0	0,030	0,025	18,0 to 21,0	9,0 to 11,0	0,75	0,75	8 × C to 1,1	—	—
(19 9 Nb)	347	0,08	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	9,0 to 11,0	0,75	0,75	8 × C to 1,00	—	—
—	347L	0,04	1,00	0,5 to 2,5	0,040	0,030	18,0 to 21,0	9,0 to 11,0	0,75	0,75	8 × C to 1,00	—	—
19 12 2	(316)	0,08	1,2	2,0	0,030	0,025	17,0 to 20,0	10,0 to 13,0	2,0 to 3,0	0,75	—	—	—
(19 12 2)	316	0,08	1,00	0,5 to 2,5	0,04	0,03	17,0 to 20,0	11,0 to 14,0	2,0 to 3,0	0,75	—	—	—
(19 12 2)	316H	0,04 to 0,08	1,00	0,5 to 2,5	0,04	0,03	17,0 to 20,0	11,0 to 14,0	2,0 to 3,0	0,75	—	—	—
(19 12 3 L)	316L	0,04	1,00	0,5 to 2,5	0,04	0,03	17,0 to 20,0	11,0 to 14,0	2,0 to 3,0	0,75	—	—	—
19 12 3 L	(316L)	0,04	1,2	2,0	0,030	0,025	17,0 to 20,0	10,0 to 13,0	2,5 to 3,0	0,75	—	—	—
19 12 3 N L	316LN	0,035	0,90	0,5 to 2,0	0,025	0,025	18,0 to 20,0	12,0 to 13,0	2,5 to 3,0	0,75	—	0,06 to 0,10	Co 0,20
—	316LCu	0,04	1,00	0,5 to 2,5	0,040	0,030	17,0 to 20,0	11,0 to 16,0	1,20 to 2,75	1,00 to 2,50	—	—	—
—	317	0,08	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	12,0 to 14,0	3,0 to 4,0	0,75	—	—	—
—	317L	0,04	1,00	0,5 to 2,5	0,04	0,03	18,0 to 21,0	12,0 to 14,0	3,0 to 4,0	0,75	—	—	—
19 12 3 Nb	(318)	0,08	1,2	2,0	0,030	0,025	17,0 to 20,0	10,0 to 13,0	2,5 to 3,0	0,75	8 × C to 1,1	—	—
(19 12 3 Nb)	318	0,08	1,00	0,5 to 2,5	0,04	0,03	17,0 to 20,0	11,0 to 14,0	2,0 to 3,0	0,75	6 × C to 1,00	—	—
19 13 4 N L	—	0,04	1,2	1,0 to 5,0	0,030	0,025	17,0 to 20,0	12,0 to 15,0	3,0 to 4,5	0,75	—	0,20	—
—	320	0,07	0,60	0,5 to 2,5	0,04	0,03	19,0 to 21,0	32,0 to 36,0	2,0 to 3,0	3,0 to 4,0	8 × C to 1,00	—	—
—	320LR	0,03	0,30	1,5 to 2,5	0,020	0,015	19,0 to 21,0	32,0 to 36,0	2,0 to 3,0	3,0 to 4,0	8 × C to 0,40	—	—
Ferritic-austenitic types (sometimes referred to as austenitic-ferritic types)													
22 9 3 N L	(2209)	0,04	1,2	2,5	0,030	0,025	21,0 to 24,0	7,5 to 10,5	2,5 to 4,0	0,75	—	0,08 to 0,20	—
(22 9 3 N L)	2209	0,04	1,00	0,5 to 2,0	0,04	0,03	21,5 to 23,5	7,5 to 10,5	2,5 to 3,5	0,75	—	0,08 to 0,20	—

Table 2 *(continued)*

Symbol classification by		Chemical composition[a, e, f] % (by mass)											
Nominal composition-[b,c,d] (ISO 3581-A)	Alloy type[d] (ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N	Others
23 7 N L	—	0,04	1,0	0,4 to 1,5	0,030	0,020	22,5 to 25,5	6,5 to 10,0	0,8	0,5	—	0,10 to 0,20	—
25 7 2 N L[c]	—	0,04	1,2	2,0	0,035	0,025	24,0 to 28,0	6,0 to 8,0	1,0 to 3,0	0,75	—	0,20	—
25 9 3 Cu N L	(2593)	0,04	1,2	2,5	0,030	0,025	24,0 to 27,0	7,5 to 10,5	2,5 to 4,0	1,5 to 3,5	—	0,10 to 0,25	—
25 9 4 N L[c]	(2593)	0,04	1,2	2,5	0,030	0,025	24,0 to 27,0	8,0 to 11,0	2,5 to 4,5	1,5	—	0,20 to 0,30	W 1,0
25 9 4 W N L	2594W	0,04	1,0	0,5 to 2,5	0,04	0,03	23,0 - 27,0	8,0 to 11,0	3,0 to 4,5	1,0	—	0,08 to 0,30	W 2,5
—	2553	0,06	1,0	0,5 to 1,5	0,04	0,03	24,0 to 27,0	6,5 to 8,5	2,9 to 3,9	1,5 to 2,5	—	0,10 to 0,25	—
(25 9 3 Cu N L)	2593	0,04	1,0	0,5 to 1,5	0,04	0,03	24,0 to 27,0	8,5 to 10,5	2,9 to 3,9	1,5 to 3,0	—	0,08 to 0,25	—
Fully austenitic types													
—	383	0,03	0,90	0,5 to 2,5	0,02	0,02	26,5 to 29,0	30,0 to 33,0	3,2 to 4,2	0,6 to 1,5	—	—	—
(20 25 5 Cu N L)	385	0,03	0,90	1,0 to 2,5	0,03	0,02	19,5 to 21,5	24,0 to 26,0	4,2 to 5,2	1,2 to 2,0	—	—	—
18 15 3 L	—	0,04	1,2	1,0 to 4,0	0,030	0,025	16,5 to 19,5	14,0 to 17,0	2,5 to 3,5	0,75	—	—	—
18 16 5 N L[c]	—	0,04	1,2	1,0 to 4,0	0,035	0,025	17,0 to 20,0	15,5 to 19,0	3,5 to 5,0	0,75	—	0,20	—
20 25 5 Cu N L	(385)	0,04	1,2	1,0 to 4,0	0,030	0,025	19,0 to 22,0	24,0 to 27,0	4,0 to 7,0	1,0 to 2,0	—	0,25	—
20 16 3 Mn N L[c]	—	0,04	1,2	5,0 to 8,0	0,035	0,025	18,0 to 21,0	15,0 to 18,0	2,5 to 3,5	0,75	—	0,20	—
21 10 N	—	0,06 to 0,09	1,0 to 2,0	0,3 to 1,0	0,02	0,01	20,5 to 22,5	9,5 to 11,0	0,5	0,3	—	0,10 to 0,20	Ce 0,05
25 22 2 N L	—	0,04	1,2	1,0 to 5,0	0,030	0,025	24,0 to 27,0	20,0 to 23,0	2,0 to 3,0	0,75	—	0,20	—
27 31 4 Cu L	—	0,04	1,2	2,5	0,030	0,025	26,0 to 29,0	30,0 to 33,0	3,0 to 4,5	0,6 to 1,5	—	—	—
Special types — Often used for dissimilar metal joining													
18 8 Mn[c]	—	0,20	1,2	4,5 to 7,5	0,035	0,025	17,0 to 20,0	7,0 to 10,0	0,75	0,75	—	—	—
18 9 Mn Mo[c]	(307)	0,04 to 0,14	1,2	3,0 to 5,0	0,035	0,025	18,0 to 21,5	9,0 to 11,0	0,5 to 1,5	0,75	—	—	—
(18 9 Mn Mo)	307	0,04 to 0,14	1,00	3,30 to 4,75	0,04	0,03	18,0 to 21,5	9,0 to 10,7	0,5 to 1,5	0,75	—	—	—
20 10 3	(308Mo)	0,10	1,2	2,5	0,030	0,025	18,0 to 21,0	9,0 to 12,0	1,5 to 3,5	0,75	—	—	—
23 12 L	(309L)	0,04	1,2	2,5	0,030	0,025	22,0 to 25,0	11,0 to 14,0	0,75	0,75	—	—	—
(23 12 L)	309L	0,04	1,00	0,5 to 2,5	0,04	0,03	22,0 to 25,0	12,0 to 14,0	0,75	0,75	—	—	—
(22 12)	309	0,15	1,00	0,5 to 2,5	0,04	0,03	22,0 to 25,0	12,0 to 14,0	0,75	0,75	—	—	—
23 12 Nb	(309Nb)	0,10	1,2	2,5	0,030	0,025	22,0 to 25,0	11,0 to 14,0	0,75	0,75	8 × C to 1,1	—	—

Table 2 *(continued)*

Symbol classification by		Chemical composition[a, e, f] % (by mass)											
Nominal composition-[b,c,d] (ISO 3581-A)	Alloy type[d] (ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N	Others
—	309LNb	0,04	1,00	0,5 to 2,5	0,040	0,030	22,0 to 25,0	12,0 to 14,0	0,75	0,75	0,70 to 1,00	—	—
(23 12 Nb)	309Nb	0,12	1,00	0,5 to 2,5	0,04	0,03	22,0 to 25,0	12,0 to 14,0	0,75	0,75	0,70 to 1,00	—	—
—	309Mo	0,12	1,00	0,5 to 2,5	0,04	0,03	22,0 to 25,0	12,0 to 14,0	2,0 to 3,0	0,75	—	—	—
23 12 2 L	(309LMo)	0,04	1,2	2,5	0,030	0,025	22,0 to 25,0	11,0 to 14,0	2,0 to 3,0	0,75	—	—	—
(23 12 2 L)	309LMo	0,04	1,00	0,5 to 2,5	0,04	0,03	22,0 to 25,0	12,0 to 14,0	2,0 to 3,0	0,75	—	—	—
29 9[c]	(312)	0,15	1,2	2,5	0,035	0,025	27,0 to 31,0	8,0 to 12,0	0,75	0,75	—	—	—
(29 9)	312	0,15	1,00	0,5 to 2,5	0,04	0,03	28,0 to 32,0	8,0 to 10,5	0,75	0,75	—	—	—
Heat resisting types													
16 8 2	(16–8-2)	0,08	0,60	2,5	0,030	0,025	14,5 to 16,5	7,5 to 9,5	1,5 to 2,5	0,75	—	—	—
(16 8 2)	16–8-2	0,10	0,60	0,5 to 2,5	0,03	0,03	14,5 to 16,5	7,5 to 9,5	1,0 to 2,0	0,75	—	—	—
25 4	—	0,15	1,2	2,5	0,030	0,025	24,0 to 27,0	4,0 to 6,0	0,75	0,75	—	—	—
22 12	(309)	0,15	1,2	2,5	0,030	0,025	20,0 to 23,0	10,0 to 13,0	0,75	0,75	—	—	—
25 20	(310)	0,06 to 0,20	1,2	1,0 to 5,0	0,030	0,025	23,0 to 27,0	18,0 to 22,0	0,75	0,75	—	—	—
(25 20)	310	0,08 to 0,20	0,75	1,0 to 2,5	0,03	0,03	25,0 to 28,0	20,0 to 22,5	0,75	0,75	—	—	—
25 20 H	(310H)	0,35 to 0,45	1,2	2,5	0,030	0,025	23,0 to 27,0	18,0 to 22,0	0,75	0,75	—	—	—
(25 20 H)	310H	0,35 to 0,45	0,75	1,0 to 2,5	0,03	0,03	25,0 to 28,0	20,0 to 22,5	0,75	0,75	—	—	—
—	310Nb	0,12	0,75	1,0 to 2,5	0,03	0,03	25,0 to 28,0	20,0 to 22,0	0,75	0,75	0,70 to 1,00	—	—
—	310Mo	0,12	0,75	1,0 to 2,5	0,03	0,03	25,0 to 28,0	20,0 to 22,0	2,0 to 3,0	0,75	—	—	—
18 36	(330)	0,25	1,2	2,5	0,030	0,025	14,0 to 18,0	33,0 to 37,0	0,75	0,75	—	—	—
(18 36)	330	0,18 to 0,25	1,00	1,0 to 2,5	0,04	0,03	14,0 to 17,0	33,0 to 37,0	0,75	0,75	—	—	—
—	330H	0,35 to 0,45	1,00	1,0 to 2,5	0,04	0,03	14,0 to 17,0	33,0 to 37,0	0,75	0,75	—	—	—

Table 2 *(continued)*

Symbol classification by		Chemical composition[a, e, f] % (by mass)											
Nominal composition[b,c,d] (ISO 3581-A)	**Alloy type**[d] (ISO 3581-B)	C	Si	Mn	P	S	Cr	Ni	Mo	Cu	Nb + Ta	N	Others
Precipitation hardening type													
—	630	0,05	0,75	0,25 to 0,75	0,04	0,03	16,00 to 16,75	4,5 to 5,0	0,75	3,25 to 4,00	0,15 to 0,30	—	—

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

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

[c] The sum of P and S may not exceed 0,050 %, except for 25 7 2 N L; 18 16 5 N L; 20 16 3 Mn N L; 18 8 Mn; 18 9 Mn Mo and 29 9.

[d] A designation in parentheses [e.g. (308L) or (19 9 L)] 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 not in parentheses. A given product, by having a more restricted chemical composition that fulfils both sets of designation requirements, may be assigned both designations independently.

[e] Analysis shall be made for the elements for which specific values are shown in this table. If, however, the presence of other elements is indicated in the course of routine analysis, further analysis shall be made in order to determine that the total of these other elements, iron excepted, is not present in excess of 0,50 %.

[f] For alloys intended for high temperature, Bi should be restricted to 20 ppm maximum.

Table 3 — Mechanical property requirements

Nominal composition (ISO 3581-A)	Alloy symbol (ISO 3581-B)	Minimum proof strength $R_{p0,2}$ MPa	Minimum tensile strength R_m MPa	Minimum elongation[a] %	Post weld heat treatment
—	409Nb	—	450	13	760 °C to 790 °C for 2 h[b]
13	(410)	250	450	15	840 °C to 870 °C for 2 h[c]
(13)	410	—	520	15	730 °C to 760 °C for 1 h[d]
13 4	(410NiMo)	500	750	15	580 °C to 620 °C for 2 h[e]
(13 4)	410NiMo	—	760	10	595 °C to 620 °C for 1 h[e]
17	(430)	300	450	15	760 °C to 790 °C for 2 h[c]
(17)	430	—	450	15	760 °C to 790 °C for 2 h[b]
—	430Nb	—	450	13	760 °C to 790 °C for 2 h[b]
19 9	(308)	350	550	30	none
(19 9)	308	—	550	25	none
19 9 H	(308H)	350	550	30	none
(19 9 H)	308H	—	550	25	none
19 9 L	(308L)	320	510	30	none
(19 9 L)	308L	—	520	25	none
19 9 N L	308LN	210	520 to 670	30	none
—	308Mo	—	550	25	none
—	308LMo	—	520	25	none
—	308N	—	690	20	none
—	349	—	690	23	none
19 9 Nb	(347)	350	550	25	none
(19 9 Nb)	347	—	520	25	none
—	347L	—	510	25	none
19 12 2	(316)	350	550	25	none
(19 12 2)	316	—	520	25	none
—	316H	—	520	25	none
19 12 3 L	(316L)	320	510	25	none
(19 12 3 L)	316L	—	490	25	none
19 12 3 N L	316LN	210	520 to 670	30	none
—	316LCu	—	510	25	none
—	317	—	550	20	none
—	317L	—	520	20	none
19 12 3 Nb	(318)	350	550	25	none
(19 12 3 Nb)	318	—	550	20	none
19 13 4 N L	—	350	550	25	none
—	320	—	550	28	none
—	320LR	—	520	28	none
22 9 3 N L	(2209)	450	550	20	none
(29 9 3 N L)	2209	—	690	15	none
23 7 N L	—	450	570	20	none
25 7 2 N L	—	500	700	15	none
25 9 3 Cu N L	—	550	620	18	none
25 9 4 N L	—	550	620	18	none
25 9 4 W N L	2594W	—	690	15	none

Table 3 *(continued)*

Nominal composition (ISO 3581-A)	Alloy symbol (ISO 3581-B)	Minimum proof strength $R_{p0,2}$ MPa	Minimum tensile strength R_m MPa	Minimum elongation[a] %	Post weld heat treatment
—	2553	—	760	13	none
—	2593	—	760	13	none
18 15 3 L	—	300	480	25	none
18 16 5 N L	—	300	480	25	none
20 25 5 Cu N L	—	320	510	25	none
20 16 3 Mn N L	—	320	510	25	none
21 10 N	—	350	550	30	none
25 22 2 N L	—	320	510	25	none
27 31 4 Cu L	—	240	500	25	none
18 8 Mn	—	350	500	25	none
18 9 Mn Mo	(307)	350	500	25	none
(18 9 Mn Mo)	307	—	590	25	none
20 10 3	—	400	620	20	none
—	309	—	550	25	none
23 12 L	(309L)	320	510	25	none
(23 12 L)	309L	—	520	25	none
23 12 Nb	(309Nb)	350	550	25	none
(23 12 Nb)	309Nb	—	550	25	none
—	309Mo	—	550	25	none
23 12 2 L	(309LMo)	350	550	25	none
(23 12 2 L)	309LMo	—	520	25	none
—	309LNb	—	510	25	none
29 9	(312)	450	650	15	none
(29 9)	312	—	660	15	none
16 8 2	(16-8-2)	320	510	25	none
(16 8 2)	16-8-2	—	550	25	none
25 4	—	400	600	15	none
—	209	—	690	15	none
—	219	—	620	15	none
—	240	—	690	15	none
22 12	—	350	550	25	none
25 20	(310)	350	550	20	none
(25 20)	310	—	550	25	none
25 20 H	(310H)	350	550	10[f]	none
(25 20 H)	310H	—	620	8	none
—	310Nb	—	550	23	none
—	310Mo	—	550	28	none
18 36	(330)	350	510	10[f]	none
(18 36)	330	—	520	23	none
—	330H	—	620	8	none
—	383	—	520	28	none
—	385	—	520	28	none

Table 3 *(continued)*

Nominal composition (ISO 3581-A)	Alloy symbol (ISO 3581-B)	Minimum proof strength $R_{p0,2}$ MPa	Minimum tensile strength R_m MPa	Minimum elongation[a] %	Post weld heat treatment
—	630	—	930	6	1 025 °C to 1 050 °C for 1 h[g]
NOTE All-weld metal can have elongation and toughness lower than those of the parent metal.					

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

[b] Furnace cooling at a rate not exceeding 55 °C/h down to 595 °C then air cooling to ambient.

[c] Furnace cooling down to 600 °C then air cooling.

[d] Furnace cooling at a rate not exceeding 110 °C/h down to 315 °C then air cooling to ambient.

[e] Air cooling.

[f] These electrodes have high carbon in the all-weld metal for service at high temperatures. Room temperature elongation has little relevance to such applications.

[g] Air cool to ambient, followed by precipitation hardening at 610 °C to 630 °C for 4 h then air cool to ambient.

4.4 Symbol for effective electrode efficiency and type of current

4.4A Classification according to nominal composition

The symbol in Table 4A indicates effective electrode efficiency, determined in accordance with ISO 2401, with the type of current shown in Table 4A.

4.4B Classification according to alloy type

No specific symbol is used to indicate effective electrode efficiency in this classification system. Type of current is included in the coating type, as given in 4.3B.

Table 4A — Symbol for effective electrode efficiency and type of current (classification according to nominal composition)

Symbol	Effective electrode efficiency %	Type of current[a]
1	≤105	AC and DC
2	≤105	DC
3	>105 but ≤125	AC and DC
4	>105 but ≤125	DC
5	>125 but ≤160	AC and DC
6	>125 but ≤160	DC
7	>160	AC and DC
8	>160	DC

[a] In order to demonstrate operability on alternating current, tests shall be carried out with load voltages higher than 65 V (AC means alternating current; DC means direct current).

4.5 Symbol for welding position

The symbols for welding position shall be as shown in Table 5A or in Table 5B. The symbol in Table 5B shall be determined in accordance with Clause 7.

Table 5A — Symbol for welding position (classification according to nominal composition)

Symbol	Welding positions[a]
1	PA, PB, PD, PF, PG
2	PA, PB, PD, PF
3	PA, PB
4	PA
5	PA, PB, PG

[a] Positions are defined in ISO 6947.

PA = Flat position

PB = Horizontal vertical position

PD = Horizontal overhead position

PF = Vertical up position

PG = Vertical down position

Table 5B — Symbol for welding position (classification according to alloy type)

Symbol	Welding positions[a]
−1	PA, PB, PD, PF
−2	PA, PB
−4	PA, PB, PD, PF, PG

[a] Positions are defined in ISO 6947.

PA = Flat position

PB = Horizontal vertical position

PD = Horizontal overhead position

PF = Vertical up position

PG = Vertical down position

5 Chemical analysis

Chemical analysis is performed on any suitable all-weld metal test specimen. In case of dispute, the test specimen specified in ISO 6847 shall be used. The test results shall meet the requirements of Table 2 for the classification under test.

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

6 Mechanical property tests

6.1 General

Tensile tests and any required retests shall be carried out in the condition specified in Table 3 (as-welded or after post-weld heat treatment). An all-weld metal test assembly type 1.3 shall be prepared in accordance with ISO 15792-1:2000, using welding conditions described in 6.2 and 6.3.

6.2 Preheat and interpass temperatures

The preheat and interpass temperatures shall be selected for the appropriate type of weld metal as shown in Table 6A or in Table 6B.

Table 6A — Preheat and interpass temperatures (classification according to nominal composition)

Alloy symbol	Type of weld metal	Preheat and interpass temperature °C
13 17	Martensitic and ferritic chromium stainless steel	200 to 300
13 4	Soft martensitic stainless steel	100 to 180
All others	Austenitic and duplex ferritic-austenitic stainless steel	150 max.

Table 6B — Preheat and interpass temperatures (classification according to alloy type)

Alloy symbol	Type of weld metal	Preheat and interpass temperature °C
410	Martensitic and ferritic chromium stainless steel	200 to 300
409Nb 430 430Nb	Soft martensitic stainless steel	150 to 260
410NiMo 630		100 to 260
All others	Austenitic and duplex ferritic-austenitic stainless steel	150 max.

The interpass temperature shall be measured using temperature indicating crayons, surface thermometers or thermocouples (see ISO 13916) measured at the mid-point of the assembly approximately 25 mm from the groove edge.

The interpass temperature shall not exceed the temperature indicated in the applicable Table 6A or 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.

6.3 Pass sequence

For a 4 mm diameter electrode and test plate type 1.3 (ISO 15792-1:2000), the pass sequence shall be two passes per layer. The number of layers shall be limited to a range of seven to nine.

The direction of welding to complete a pass shall not vary. Each pass shall be welded 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 with electrode positive when only direct current is recommended.

7 Fillet weld test

7A Classification according to nominal composition

Not required.

7B Classification according to alloy type

The fillet weld test assembly shall be as shown in ISO 15792-3. The fillet weld test plate thickness, *t*, and required test results are specified in Table 7B. The test plate length, *l*, shall be 250 mm and the test plate width, *w*, shall be 50 mm.

Table 7B — Fillet weld test plate thickness and test results required (classification according to alloy type)

ISO 3581-B symbols for position and coating type	Electrode diameter mm	Type of current	Nominal plate thickness *t* mm	Test position	Fillet size (length of leg) (maximum) mm	Maximum leg length difference mm	Maximum convexity mm
−15	4,0	DC+	6 or 8 or 10	PF	8,0	Not specified	2,0
	4,0		6 or 8 or 10	PB and PD	6,0	1,5	1,5
	4,8 or 5,0		10	PB	8,0	1,5	2,0
	5,6 or 6,0 or 6,4		10	PB	10,0	2,0	2,0
−16	4,0	AC	6 or 8 or 10	PF	8,0	Not specified	2,0
	4,0		6 or 8 or 10	PB and PD	6,0	1,5	1,5
	4,8 or 5,0		10	PB	8,0	1,5	2,0
	5,6 or 6,0 or 6,4		10	PB	10,0	2,0	2,0
−17	4,0	AC	6 or 8 or 10	PF	12,0	Not specified	2,0
	4,0		6 or 8 or 10	PB and PD	8,0	1,5	1,5
	4,8 or 5,0		10	PB	8,0	1,5	2,0
	5,6 or 6,0 or 6,4		10	PB	10,0	2,0	2,0
−25	4,0	DC+	10 or 12	PB	8,0	1,5	1,5
	4,8 or 5,0				8,0	1,5	2,0
	5,6 or 6,0 or 6,4				10,0	2,0	2,0
−26 or −27	4,0	AC	10 or 12	PB	8,0	1,5	1,5
	4,8 or 5,0				8,0	1,5	2,0
	5,6 or 6,0 or 6,4				10,0	2,0	2,0
−45, −46 or −47	2,4 or 2,5	DC+	6 or 8 or 10	PG	5,0	Not specified	2,0[a]
	3,0 or 3,2			PG	6,0		3,0[a]
	4,0			PG	8,0		4,0[a]
	4,8 or 5,0			PG	10,0		5,0[a]

[a] Maximum concavity.

8 Rounding procedure

For purposes of determining compliance with the requirements of this International Standard, the 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 International Standard, the measured values shall be converted to the units of this International Standard before rounding. If an arithmetic average value is to be compared to the requirements of this International Standard, rounding shall be done only after calculating the arithmetic average. The rounded results shall fulfil the requirements of the appropriate table for the classification under test.

9 Retests

If any test fails to meet the requirements, that test shall be repeated twice. The results of both retests shall meet the requirements. Specimens for the retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retests need be only for those specific elements that failed to meet their test requirement. If the results of one or both retests fail to meet the requirement, the material under test shall be considered as not meeting the requirements of this specification for that classification.

In the event that, during preparation or after completion of any test, it is clearly determined that prescribed or proper procedures were not followed in preparing the weld test assembly or test specimen(s) or in conducting the tests, the test shall be considered invalid without regard to whether the test was actually completed or whether the test results met, or failed to meet, the requirement. That test shall be repeated following 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 specified in ISO 544 and ISO 14344.

11 Examples of designation

The designation of covered electrodes shall follow the principles given in the respective examples in 11.A and 11.B.

11A Classification according to nominal composition

EXAMPLE 1A

A covered electrode (E) for manual metal arc welding deposits weld metal with a chemical composition 19 % Cr, 12 % Ni and 2 % Mo (19 12 2) in Table 2. The electrode has a rutile covering (R) and can be used with alternating current or direct current and with an effective electrode efficiency of 120 % (3) in flat butt and flat fillet welds (4) is designated as follows:

ISO 3581-A - E 19 12 2 R 3 4

Compulsory section:

ISO 3581-A - E 19 12 2 R

where

ISO 3581	is the standard number, with A indicating classification according to nominal composition;
E	is the covered electrode for manual metal arc welding (see 4.1A);
19 12 2	is the chemical composition of all-weld metal (see Table 2);
R	is the type of electrode covering (see 4.3A);

11B Classification according to alloy type

EXAMPLE 1B

A covered electrode (E) for manual metal arc welding of stainless and heat-resisting steels (S) deposits weld metal with a chemical composition 19 % Cr, 12 % Ni and 2 % Mo (a type 316) in Table 2. The electrode has a rutile covering (6), and can be used with alternating current or direct current electrode positive, and may be used for welding flat butt and flat fillet welds (2) is designated as follows:

ISO 3581-B - ES316 - 26

where

ISO 3581	is the standard number, with B indicating classification according to alloy type;
ES	is the covered electrode for manual metal arc welding of stainless and heat-resisting steel (see 4.1B);
316	is the chemical composition of all-weld metal (see Table 2);
2	is the positions in which welding may be carried out (see Table 5B);

3 is for use with AC or DC and effective electrode efficiency of 120 % (see Table 4A).

6 is the type of electrode covering (see 4.3B).

EXAMPLE 2A

A covered electrode (E) for manual metal arc welding deposits weld metal with a nominal chemical composition of 25 % Cr, 30 % Ni and 1,3 % Ti (21 30 Ti) not specified in Table 2. The electrode has a basic covering (B). designated as follows:

ISO 3581-A - E Z 25 30 Ti B

where

ISO 3581 is the standard number, with A indicating classification according to nominal composition;

E is the covered electrode for manual metal arc welding (see 4.1A);

Z indicates the chemical composition of all weld metal is not specified (see Table 2);

25 30 Ti is the nominal chemical composition of all weld metal with limits as agreed between manufacturer and customer;

B is the type of electrode covering (see 4.3A).

Annex A
(informative)

Types of covering

A.1 General

The flux covering, sometimes referred to as coating, on a manual metal arc electrode can vary quite dramatically from one classification to another. Both classification approaches referenced in this International Standard use symbols to indicate the major ingredients in the flux. A brief description of each, with the major characteristics, is given below.

A.2A Classification according to nominal composition

Under this approach, there are two symbols used to designate the flux system of the electrode covering.

A.2.1A Basic covering, represented by a B

This indicates a covering containing large quantities of basic minerals or chemicals, such as limestone (calcium carbonate), dolomite (calcium magnesium carbonate) and fluorspar (calcium fluoride). The electrodes can generally be used only with DC electrode positive.

A.2.2A Rutile covering, represented by an R

This indicates a covering with a large proportion of the mineral rutile, which is largely titanium dioxide (titania). Other chemicals and minerals that are easily ionized are also used. Electrodes using this flux system can be used with AC and DC

A.2B Classification according to alloy type

Under this approach, there are three symbols used to designate the flux system of the electrode covering.

A.2.1B Basic covering, represented by a 5

This indicates a covering containing large quantities of basic minerals or chemicals, such as limestone (calcium carbonate), dolomite (calcium magnesium carbonate) and fluorspar (calcium fluoride). They can generally be used only with DC electrode positive.

A.2.2B Rutile covering, represented by a 6

This indicates a covering with a large proportion of the mineral rutile, which is largely titanium dioxide (titania). Other chemicals and minerals that are easily ionized are also used. Electrodes using this flux system can be used with AC and DC

A.2.3B Acid covering, represented by a 7

This indicates a modified rutile type covering where some of the titania has been replaced with silica. It is characterized by a highly fluid slag and allows greater ease of use when using a drag technique. The arc tends more towards a spray transfer. It may be more difficult to weld in the vertical up position on thinner material.

NOTE Under approach A (classification according to nominal composition), no distinction is made between the rutile and acid coverings in approach B (classification according to alloy type).

Annex B
(informative)

Considerations on weld metal ferrite contents

B.1 General

This Annex is based on Reference [3].

The ferrite content in stainless steel weld metals plays an important role in determining the fabrication and service performance of a welded construction. To prevent problems, a certain ferrite level is often specified. Originally, ferrite level was described in terms of ferrite percent but currently, the Ferrite Number (FN) concept is used, as described in ISO 8249.

B.2 Effects of ferrite

The most important beneficial effect of ferrite in nominally austenitic stainless steel weldments is the well-established relationship between a reduced sensitivity to hot cracking and the presence of ferrite. The minimum ferrite limit necessary to ensure freedom from cracking depends, among other factors, on the weld metal composition. The upper limit results from possible impairment of either mechanical or corrosion properties, or both. The required amount of ferrite can be ascertained by adjusting the ratio of ferrite formers (such as chromium) to austenite promoters (such as nickel) within the limits allowed by the applicable specification.

B.3 Relation between composition and structure

As discussed below, ferrite is normally measured by means of magnetic instruments and stated in terms of Ferrite Number (FN). Ferrite can also be estimated by means of constitutional diagrams. The most accurate version recommended is the Welding Research Council, (WRC) Diagram Text.[4] The composition is related to the structure through grouping the elements which promote ferrite in the so-called “chromium equivalent” and austenitizing elements in the “nickel equivalent”. By using the WRC-1992 Diagram, the structure can be predicted to an accuracy of approximately ±4 Ferrite Number (FN) at a calculated level of up to 18 FN. It can be used for FN up to 100 (i.e. it can be used for duplex alloys).

B.4 Ferrite formation

It is generally agreed that hot cracking is governed by the solidification mode. The final ferrite content and morphology result from reactions during solidification and, subsequently, in the solid state. The hot cracking sensitivity decreases in the following order of solidification mode: single-phase austenitic, primary austenitic, mixed-type and single phase ferritic, primary ferritic. Although both Ferrite Number and solidification mode depend mainly on composition, the relationship is not always unambiguous. However, the system is standardized and it is more practical to specify and to measure ferrite on this basis.

B.5 Effects of welding conditions

The ferrite content of weld metal is not determined solely by the selected filler metal. Apart from the effects of dilution from the base material, the ferrite content can be significantly affected by the welding conditions. Several factors can change the chemical composition of the weld metal. The most important of these is nitrogen, which can enter the weld metal through the welding arc. A high arc voltage can result in a significantly decreased Ferrite Number. Another factor is the reduction of chromium by oxidizing materials in the coating or the increase of carbon from CO_2. Very high heat input can also have an effect, especially with duplex steels. When the ferrite content in undiluted weld metal is found to be significantly different from that quoted in the manufacturer's certification, one or more of the above factors are most likely to be the cause of the difference.

B.6 Effect of heat treatment

Stainless steel base metals are generally supplied in the solution annealed and quenched condition. In contrast, most welded joints are put into service in the as-welded condition. In some cases, however, a postweld heat treatment can, or should, be applied. This can reduce the magnetically determined FN to some extent, even to zero. The effects of heat treatment on mechanical and corrosion properties can be significant, but are beyond the scope of this brief discussion.

B.7 Determination of ferrite content

B.7.1 The several parties concerned with the integrity of a stainless steel weldment should all be able to agree upon the ferrite content. These parties could include the manufacturer of the filler material, the fabricator of the weldment, a code or regulatory body, and an insurance company. It is therefore essential that the method for the determination of ferrite be reproducible. Early observations of ferrite in stainless steel weld metals were largely by metallography. Depending on the etchant, either the ferrite or the austenite is preferentially attacked, distinguishing the ferrite from the austenite matrix. Unfortunately, the ferrite phase is extremely fine and very irregular in shape, and is also not uniformly distributed in the matrix. The reliability and reproducibility of this method of estimation was poor. In addition, metallographic examination is a destructive test, which is not suitable for in-process quality assurance monitoring.

B.7.2 As ferrite is ferromagnetic, it is easily distinguishable from austenite. The magnetic response of an otherwise austenitic weld metal is approximately proportional to the amount of ferrite present. The magnetic response is also affected by the composition of the ferrite (a more highly alloyed ferrite will have a smaller magnetic response than an equivalent amount of lower alloyed ferrite). This property can therefore be used for ferrite determination if it is possible to establish a calibration procedure for magnetic instruments.

Of course, it would have been desirable to establish a magnetic calibration procedure in such a fashion that the results would be directly convertible into "percent ferrite". However, because of the composition effect noted above and because agreement on the true "percent ferrite" proved to be impossible to achieve, an arbitrary "Ferrite Number" scale was adopted. The Ferrite Number was initially believed to be a reasonable approximation of the "percent ferrite" in a 19 9 or type 308 weld metal, but later studies indicate that FN appreciably overstates the "percent ferrite" in a weld metal. From a practical standpoint, this is unimportant. Of much greater import is the ability of numerous measuring agencies to reproduce the same value for ferrite content within a small scatter band on a given weldment, and this the Ferrite Number measurement system accomplishes.

B.7.3 In the Ferrite Number system, calibration of certain laboratory instruments is established using, as primary standards, coating thickness standards consisting of a non-magnetic coating over a carbon steel substrate. These standards are available from the US National Institute of Standards and Technology (NIST). To each coating thickness standard, a Ferrite Number is assigned according to ISO 8249:2000, Table 1. Further, in the Ferrite Number system, instruments calibrated by primary standards can be used to assign Ferrite Numbers to weld metal samples which can in turn be used as secondary standards for the calibration of numerous other instruments more suitable for a shop or field environment.

B.7.4 Using either primary or secondary calibration, round robin tests established that the reproducibility of Ferrite Number determination on given samples of weld metal was within ±1 FN or less over the range 0 FN to 28 FN provided in ISO 8249. This is far better reproducibility than could be achieved using metallographic measurements. Principles for the extension of the system to ferrite levels appropriate to duplex steels have been establishe, and this extension has been published in ISO 8249. Secondary standards are also now available from National Institute for Standards and Technology (NIST, Gaithersburg, MD, 20899, USA.). Previously, secondary standards were available from The Welding Institute (TWI, Abington Hall, Abington, Cambridge, CB1 6AL, U.K.).

B.8 Implementation of FN measurement

For both specification and determination of ferrite, it is important to be realistic about what can be expected in a weldment. It is not realistic to specify, and expect to measure, zero FN in nominally fully austenitic weld metal. Specification of 0,5 FN maximum is realistic and achievable. It is not realistic to specify, and expect to measure, a Ferrite Number within a range that approaches the reproducibility of the welding operation and of measurement. Thus, specification of 5 FN to 10 FN, or 40 FN to 70 FN, is realistic and achievable. However, specification of 5 FN to 6 FN is not realistic, nor is specification of 45 FN to 55 FN.

It is not realistic to specify, and expect to measure, a narrow Ferrite Number range for all points in a weld deposit because reheating of the overlap areas between passes constitutes a heat treatment and generally reduces the local ferrite content; neither is it realistic to specify, and expect to measure, the same Ferrite Number range on curved surfaces, surfaces very close to edges or to strongly magnetic materials, or on rough surfaces (including those containing the ripples of a normal weld deposit surface), as would be measured along the centreline of a weld run that is properly prepared smooth and flat after welding.

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