BRITISH STANDARD

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Welding consumables — Test methods and quality requirements —

Part 2: Supplementary methods and conformity assessment of consumables for steel, nickel and nickel alloys

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ICS 25.160.20

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee WEE/39, Welding consumables, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

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Produits consommables pour le soudage - Méthodes d'essai et exigences de qualité - Partie 2: Méthodes complémentaires et évaluation de la conformité des produits consommables pour l'acier, le nickel et les alliages de nickel

Schweißzusätze - Prüfverfahren und Qualitätsanforderungen - Teil 2: Ergänzende Prüfungen und Konformitätsbewertung von Schweißzusätzen für Stahl, Nickel und Nickellegierungen

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Contents

Foreword

This document (EN 14532-2:2004) has been prepared by Technical Committee CEN/TC 121 “Welding”, 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of an identical text or by endorsement, at the latest by May 2005, and conflicting national standards shall be withdrawn at the latest by May 2005.

This document consists of the following parts:

EN 14532-1, *Welding consumables — Test methods and quality requirements — Part 1: Primary methods and conformity assessment of consumables for steel, nickel and nickel alloys.*

EN 14532-2, *Welding consumables — Test methods and quality requirements — Part 2: Supplementary methods and conformity assessment of consumables for steel, nickel and nickel alloys.*

EN 14532-3, *Welding consumables — Test methods and quality requirements — Part 3: Conformity assessment of wire electrodes, wires and rods for welding of aluminium alloys.*

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

Introduction

Responsibility for identifying the extent of qualification lies with the manufacturer/supplier on the basis of his assessment of market requirements.

A product that has been qualified in accordance with the primary methods e.g. in EN 14532-1 may need evaluation through one or more supplementary tests for some fields of application.

1 Scope

This document applies to welding consumables for which supplementary qualification is required. It contains the technical requirements to be fulfilled.

These supplementary tests apply for welding consumables, where the primary qualification is available in accordance with EN 14532-1. The supplementary tests can be carried out at any time without the need to repeat the primary tests.

This document describes the testing methods, the amount of testing and the requirements for supplementary qualification of welding consumables.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 876, *Destructive tests on welds in metallic materials — Longitudinal tensile test on weld metal in fusion welded joints.*

EN 1597-1:1997, *Welding consumables — Test methods — Part 1: Test piece for all-weld metal test specimens in steel, nickel and nickel alloys.*

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Methods of test at ambient temperature.*

EN 10002-5, *Metallic materials — Tensile testing — Part 5: method of testing at elevated temperature.*

EN 10291, *Metallic materials — Uniaxial creep testing in tension — Method of test.*

EN 14532-1:2004, *Welding consumables — Test methods and quality requirements — Part 1: Primary methods and conformity assessment of consumables for steel, nickel and nickel alloys.*

prEN 14700, *Welding consumables — Welding consumables for hard-facing.*

EN ISO 3690, *Welding and allied processes – Determination of hydrogen content in ferritic arc weld metal (ISO 3690:2000).*

CR ISO 15608:2000, *Welding — Guidelines for a metallic material grouping system (ISO/TR 15608:2000).*

3 Terms and definitions

For the purposes of this document, the terms and definitions of EN 14532-1:2004 apply.

4 Supplementary tests

4.1 General

An overview of supplementary tests is listed in Annex A.

4.2 All-weld metal

All-weld metal test pieces and test specimens shall be prepared in accordance with 6.1.2 of EN 14532–1:2004, and with test piece type 1.3 of EN 1597-1:1997 or Figure D.1 for oxyacetylene welding. Welding shall be carried out in the flat position, except where the consumable is designed exclusively for other position(s). One type of test piece with one consumable size and batch may be selected by the manufacturer, in accordance with the consumables used for primary qualification testing to EN 14532-1.

4.2.1 Post weld heat treatment

4.2.1.1 General

Post weld heat treatment of the all-weld metal - if required by the manufacturer for the particular range of application - shall be applied to the test assembly. If the entire test assembly is too large for the furnace, it may be divided into suitable parts but not into individual test specimens.

Post weld heat treatment conditions shall be stated in the report.

4.2.1.2 Stress relief

For welding consumables for non-alloy, fine grain high strength and creep resisting steels the holding time shall be at least 3 h at the highest stress relief temperature (+0/-20) ºC for the parent material groups (see Annex B) given in the required range of application for the qualification. When qualification is applied for wall thickness over 75 mm the holding time shall be at least 3 h + 1 h/25 mm wall thickness exceeding 75 mm.

NOTE 1 Users may consider longer times to allow for the possibility of repair and multiple heat treatment.

The test assembly shall be cooled in the furnace to a temperature 300 °C or lower. Subsequent cooling may be carried out in still air.

For stress relief or tempering, heating/cooling rates above 300 ºC shall not exceed 100 °C/h.

NOTE 2 Welding consumables for austenitic and austenitic-ferritic stainless steels and austenitic welding consumables used for dissimilar welds and overlays are not normally subject to stress relief.

4.2.1.3 Normalising

When qualification is specifically required for a weld metal that will be normalised, the holding time shall be ½ h at the highest normalising temperature (+0/-30) °C for the parent material groups (see Annex B) mentioned in the required range of application for the qualification. The test assembly shall be cooled within 3 h to a temperature of 300 °C (+0/-20)°C. Subsequent cooling may be carried out in still air. If tempering is to be applied, it shall be as described in 4.2.1.5.

4.2.1.4 Quenching

When qualification is specifically required for a weld metal that will be quenched and tempered, quenching of the test assembly shall be carried out as required for the parent material groups (see Annex B) mentioned in the required range of qualification.

4.2.1.5 Tempering

When tempering is applied after either normalising or quenching, the holding time shall be 1 h/25 mm wall thickness at the highest tempering temperature (+0/-20) °C for the parent material groups (see Annex B) mentioned in the required range of application for the qualification. The test assembly shall be cooled in the furnace to a temperature of 300 °C or lower. Subsequent cooling may be carried out in still air.

4.2.1.6 Solution heat treatment

The holding time shall be ½ h at the lowest solution heat treatment temperature (+30/-0) °C for the parent metal groups (see Annex B) mentioned in the required range of qualification. Higher temperatures may be used if required by the welding consumable but shall be within the temperature range recommended for the parent metal. In this case the lowest temperature qualified shall be that used for the test. The test assembly shall be cooled in still air or otherwise if required.

4.2.2 Tensile tests

4.2.2.1 General

Where appropriate, consumables shall be qualified for high temperature application either by high temperature tensile testing in accordance with 4.2.2.3 for maximum application temperatures within the ranges defined in Table 1, or by creep rupture testing in accordance with 4.2.3 for higher application temperatures.

4.2.2.2 Tensile tests at room temperature

Two tensile tests at room temperature (23 ± 5) °C shall be carried out for each heat treatment condition. This can be reduced to one test if the manufacturer can document results of at least two previous tests.

4.2.2.3 Tensile tests at elevated temperature

Two tensile tests shall be carried out at the maximum application temperature, within the range defined in Table 1, for which qualification is required.

Table 1 — Requirements for tensile tests at elevated temperature

Consumable type	Group according to CR ISO 15608:2000 [a]	Application temperature range
Ferritic and martensitic steels	1, 3, 4, 5, 6	350 °C to 500 °C
Austenitic stainless steels	8	400 °C to 500 °C
Nickel alloys	41 to 48	400 °C to 550 °C
[a] Explanation of the material groups see Annex G.		

4.2.2.4 Conditions for test specimens and testing

The all-weld metal tensile test specimens of ferritic welding consumables may be exposed to a temperature not exceeding 250 ºC for a period not exceeding 16 h for hydrogen removal prior to testing, alternatively a temperature not exceeding 105 ºC for a time not to exceed 48 h may be used.

Tensile test specimens shall be of 10 mm diameter in accordance with EN 876. For all-weld metal, the test should be carried out in accordance with EN 10002-1 or EN 10002-5 and the tensile strength, lower yield strength or proof strength, elongation after fracture (A_5) and reduction of area shall be determined.

For all groups of welding consumables, tested at all temperatures, the 0,2 % proof strength shall be determined, except in the case of consumables for non alloy and fine grain steels tested at room temperature (23 ± 5) ºC when the lower yield strength shall be determined.

The requirements at room temperature and at elevated temperatures are given in Annex C, depending on the material groups according to CR ISO 15608:2000, for which the consumable is intended to be verified.

For verification of strength at elevated temperatures with welding consumables for oxy-acetylene welding the test assembly should be prepared in accordance with Annex D.

In case of welding consumables for parent metals not mentioned in Annex C the requirements shall be defined by the manufacturer based upon the applicable parent metal properties.

4.2.3 Creep rupture tests

4.2.3.1 General

Where required by the manufacturer for application at temperatures within the creep range, that is, above the temperature range defined in Table 1, short term creep rupture testing shall be carried out in accordance with EN 10291 on the all-weld metal, or when this is not practicable, on the welded joint as specified in 4.3.4.

Whereas long term creep test data may be required by application standards for high temperature design purposes, short term product check test data are only suitable for the conformity evaluation of welding consumables. This can provide general confirmation that a consumable is suitable for application within the creep range. However, the short term check test data cannot reliably be extrapolated to the longer term, and do not provide an acceptable basis for high temperature design or component life assessment.

The manufacturer shall specify a reference parent material, being that which the consumable most closely matches in chemical composition, and/or that which the consumable is principally designed to weld. This shall be a material with established reference creep rupture data. This should be as provided in Annex E or ECCC-Document (see Bibliography), or newly submitted reference data of comparable scope extending to at least 30 000 hours test duration[1)]. Conformity evaluation of welding consumables by creep rupture testing is not required when no such reference creep rupture data exist on the parent material.

A consumable is to be qualified by reference to a single specified reference parent material. Its application to weld other parent materials, dissimilar joints, etc., is the responsibility of the user.

4.2.3.2 Legacy creep rupture data

The manufacturer may, at his option, put forward legacy creep rupture test data in the public domain from previous tests on all-weld metal specimens from a consumable of matching type, as defined in 4.2.3.3, to that which is to be evaluated. When legacy data, which shall be required to meet the creep rupture testing specifications of this document, are made available, testing shall not be required on the actual consumable to be evaluated. Legacy data may alternatively be deemed to have been provided if there is documented evidence that the legacy consumable has performed satisfactorily in application at temperatures within the creep range, under pressure or dynamic loading, for at least 30 000 hours operation.

4.2.3.3 Matching consumables

When legacy data are provided, the evaluated consumable shall be required to match the legacy consumable in terms of its type designation within the appropriate classification Standard, and/or the all-weld metal chemical composition scatter band, product form (e.g. metal-arc welding with covered electrode, process 111), and flux or coating type (e.g. basic / rutile / cellulosic). The evaluated consumable shall not be required to match the legacy consumable in terms of the distribution of chemical constituents between wire, flux and/or coating, chemical additions to the consumable which do not affect the composition of the weld deposit, or the exact chemical composition limits specified for each alloying or creep strengthening element, provided that the chemical composition ranges specified are substantially overlapping. Responsibility for declaring that the evaluated consumable matches a legacy consumable shall rest with the manufacturer of the evaluated consumable.

Tungsten inert gas welding consumables may be qualified on the basis of the all-weld metal chemical analysis. The composition shall be within the range of the all-weld metal of a covered electrode or gas shielded metal arc welding consumable subjected to creep rupture testing.

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1) Other recognised public domain sources of parent material mean creep rupture data may alternatively be used as reference data subject to technical review. The source of reference data should be given on the test certificate.

4.2.3.4 Testing conditions

Creep rupture testing shall normally[2)] be carried out using a test assembly as specified in EN 1597-1. The minimum gauge diameter shall be 8 mm, except for legacy test data.

NOTE Gauge diameters of at least 10 mm are recommended to limit data scatter.

The test specimen axis shall be aligned with the direction of welding.

Constant load creep rupture testing shall be carried out at a selected fixed temperature within the range (T to T+100) °C, where T is the maximum application temperature for which qualification is required. At least four tests to rupture shall be obtained. At least one of these shall record a rupture life in excess of 1 000 hours, and at least one shall record a rupture life between 50 hours and 250 hours. Data points recording a rupture life below 50 hours shall be discarded. At least one of the tests to failure shall be carried out at an applied stress lower than the 10 000 hour mean data creep strength of the reference parent material at the specified maximum application temperature, as given in Annex E or other suitable parent material reference data source[3)].

4.2.3.5 Requirements

The test data shall be analysed using a best-fit linear regression between the logarithm of the test life and the logarithm of the applied stress. The 1 000 hour creep rupture strength of the all-weld metal at the test temperature shall thereby be calculated, expressed as a percentage of the mean data 1 000 hour creep rupture strength of the reference parent material given by Annex E or other suitable parent material reference data source, and recorded on the test certificate. Its value shall be assessed by comparison with the scatter band of the parent material, defined as a range from 80 % to 120 % of the mean parent material rupture strength. If the value falls outside the scatter band of the parent material, a cautionary note shall be recorded on the test certificate. The individual creep rupture values shall also be shown as a table in the test certificate.

The extrapolated 10 000 hour creep rupture strength of the all-weld metal at the test temperature shall similarly be calculated and expressed as a percentage of the mean data 10 000 hour creep rupture strength of the reference parent material. If this value falls below 80 %, it shall be recorded on the test certificate, with a cautionary note that the results may indicate a potentially adverse long term trend. In this case, a repeat creep rupture test series may be undertaken, including alternative test conditions and / or longer test durations. If the repeat tests are successful, the cautionary note may be deleted.

4.2.4 Embrittlement tests

If the intended service temperature for stainless steel welding consumables is > 450 °C and the ferrite content > 10 FN (see EN 14532-1), or for nickel based welding consumables if the intended service temperature is > 550 °C, embrittlement tests shall be carried out.

This shall be checked on the basis of an impact energy / time curve at different post weld ageing temperatures. Temperatures shall be fixed in accordance with the range of application for the parent metal to be welded. Test specimens in accordance with EN 14532-1 shall be used.

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2) The manufacturer may alternatively opt to use a notched bar test specimen geometry when the reference parent material creep rupture data, and legacy all-weld metal creep rupture data when provided, have been obtained using a similar notched bar test specimen geometry.

3) The test temperature should be selected by the manufacturer to enable the realistic test stress condition to be achieved. Annex E may be used for guidance. Typically, a test temperature exceeding the maximum application temperature by 30 °C to 50°C may be required.

To establish the effect of embrittlement for nickel based welding consumables, impact test specimens made of all-weld metal shall be tested at ambient temperature. Apart from the initial values in the as-welded condition, impact test specimens shall be tested after post weld ageing for 10 000 h at the application temperature and at least at two temperatures in between. For stainless steel welding consumables ageing at 750 °C for 10 h shall apply.

NOTE 1 For all other welding consumables susceptible to embrittlement the ageing temperatures should be fixed in accordance with the parent metals to be welded.

The minimum average value required after 10 000 h is 34 J at room temperature. Only one individual value may be less than 24 J.

NOTE 2 Consumables that do not fulfil the above requirements may be used. The test report should point out that special precautions may be required in application.

Requirements may alternatively be deemed to have been satisfied if there is documented evidence that the consumable has performed satisfactorily in application at the required temperature and time. In that case no further testing is required.

4.3 Welded joint

4.3.1 General

Welded joints shall be tested only when the welding consumable cannot practicably be used to produce an all-weld metal test specimen. This applies to the following welding processes:

— electro gas welding;

— electroslag welding;

— single and two run welding, where qualification is not required for multi-run welding;

— oxyacetylene welding, when qualification is required for material thicknesses not exceeding 8 mm.

4.3.2 Post weld heat treatment

Post weld heat treatment of the welded joint shall be applied in accordance with 4.2.1.

4.3.3 Tensile testing

Tensile testing shall be carried out in accordance with 4.2.2. The test specimen gauge portion shall consist wholly of material from the fused weld metal and its axis shall be aligned with the direction of welding.

4.3.4 Creep rupture tests

Creep rupture testing shall be carried out in accordance with 4.2.3. The test specimen gauge portion shall consist wholly of material from the fused weld metal and its axis shall be aligned with the direction of welding.

4.4 Overlay welding

Where welding consumables are to be qualified for overlay welding see prEN 14700, the scope of testing shall be as specified in the classification standard.

NOTE For special applications additional tests such as side bend tests, surface cracking tests, tests for under bead cracking, ultrasonic tests and/or micrographic and, if applicable, special corrosion tests should be performed.

4.5 Moisture resistant system

If special steps for the packaging are taken to avoid the absorption of moisture by welding consumables, the properties of this special packaging can be tested additionally to the properties of the welding consumables (absorption behaviour).

A report should give a detailed account of the performance of testing, the storage conditions and the processing after the packaging was opened. After opening the moisture resistant packaging the consumable can be used without redrying within the time to be indicated by the manufacturer.

NOTE See Annex F.

5 Retests, certification, extension, modification and prolongation of type qualification

The Clauses 7 to 12 of EN 14532-1:2004 and Annex O of EN 14532-1:2004 are also valid for this document.

Annex A
(informative)

Supplementary tests – Overview

Table A.1 — Supplementary tests – Overview

Test No.	Test description	Clause reference	Test purpose
1	All-weld metal or welded joint Post weld heat treatment	4.2.1 and 4.3.2	Part of qualification when required by directive, rules or application standards.
2	All-weld metal Testing at elevated temperatures	4.2.2	Part of qualification when required by application standards.
3	All-weld metal or welded joint Creep rupture testing	4.2.3 and 4.3.4	Part of qualification when required by application standards.
4	All-weld metal Embrittlement tests	4.2.4	Part of qualification when required by application standards; Depending on all-weld metal chemical composition and application temperature.
5	Overlay welding	4.4	Part of qualification when required by application standards.
6	Moisture resistant packaging	4.5	Part of qualification when required by application standards.

Annex B
(normative)

Post weld heat treatment temperature

Table B.1 — Post weld heat treatment temperature

Material group according to CR ISO 15608:2000 *)	Post weld heat treatment conditions –Temperature [e]				
	Stress relief °C	Normalising °C	Quenching °C	Tempering °C	Solution heat treatment °C
1.1/1.2	620	950	–	–	–
1.3	580	950	–	–	–
1.4	620	950	–	650	–
2.1	600 [b f]	–	–	–	–
4.1	[d]	–	[c]	620	–
4.2	[d]	–	[c]	720	–
5.1	670	–	[c]	720	–
5.2	720	–	[c]	740	–
5.3	–	–	[d]	[d]	–
5.4	750	–	[d]	[d]	–
6.1	720	–	[c]	720	–
6.2	720	–	[c]	730 ± 10 [a]	–
6.3	–	–	[c]	[d]	–
6.4	770	–	[c]	770 [a]	–
7.1	[d]	[c]	[c]	–	–
7.2	–	[d]	[c]	[c]	1100 [a]
7.3	660 [a]	–	–	–	1050
8.1/8.2	–	–	–	–	1020/1100
8.3	–	–	–	–	[d]
9.1	580	940	[c]	660	–
9.2	580	880	[c]	660	–
9.3	[d]	[c]	[c]	600	–
10	–	–	–	–	1100
11	[c]	[c]	[c]	[c]	[c]

[a] Certain members of the group may require a lower temperature.

[b] Not for thermo mechanically treated steels and precipitation-hardened steels.

[c] A special temperature is needed for each member of the group.

[d] Information from material manufacturer to be applied.

[e] Temperature tolerances are given in 4.2.1.

[f] Special cast types may require a higher temperature.

*) Explanation of the material groups see Annex G.

Annex C
(normative)

All-weld metal of consumables for steel – Requirements

Table C.1 — All-weld metal of consumables for steel – Requirements

Material group according to CR ISO 15608 :2000 *)	Test temperature °C[a]	R_{eL} min. N/mm^2	$R_{p0,2}$ min. N/mm^2	$R_{p1,0}$ min. N/mm^2	R_m min. N/mm^2	A_5 min. %
1.1	RT	285	–	–	480	22
	350	–	185	–	–	–
	500	–	165	–	–	–
1.2	RT	360	–	–	520	22
	350	–	226	–	–	–
	450	–	155	–	–	–
2	RT	380[c]	–	–	530 [c]	18
	350 [b]	–	265	–	–	–
	400 [b]	–	235	–	–	–
3	RT	500[c]	–	–	610 [c]	18
	350 [b]	–	284	–	–	–
	400 [b]	–	255	–	–	–
5.1	RT	355	–	–	540	20
	350 [b]	–	294	–	–	–
	500 [b]	–	185	–	–	–
8.1 [d]	RT	–	215	250	580	30
	400 [b]	–	135	164	–	–
	500	–	128	–	–	–
8.2	RT	–	300	340	650	30
	400	–	170	200	–	–
	500	–	148	–	–	–
8.3 [e]	RT	–	320	–	600	25

[a] RT = Room temperature (23 ± 5) °C.

[b] Where applicable, see also 8.8 in EN 14532-1:2004.

[c] If the consumable is intended for steels with higher yield and tensile strength the minimum requirements of the parent metal apply, see also 8.1 in EN 14532-1:2004.

[d] For all nitrogen alloyed based materials of group 8.1 the requirements of group 8.2 apply.

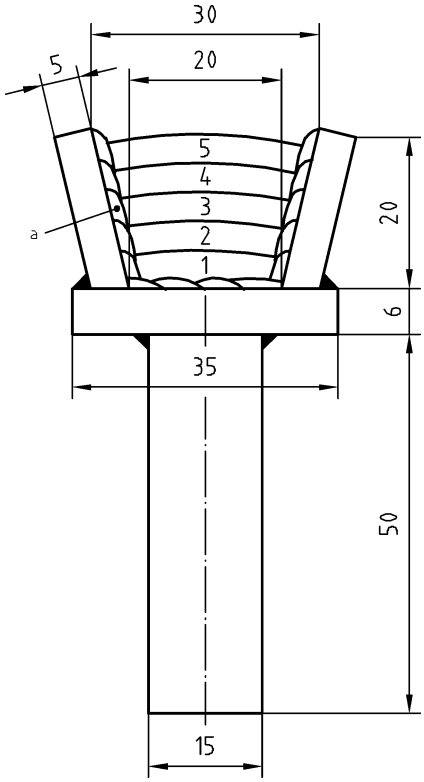
[e] At 400 °C and higher temperatures, requirements for $R_{p0,2}$ of the parent material apply.

*) Explanation of the material groups see Annex G.

Annex D
(informative)

Test assembly for oxyacetylene welding

Dimensions in millimetres



Oxyacetylene backhand welding process:

– Rod diameter: 4 mm;
– Torch: tip-size 6 to 9;
– Oxygen pressure: 3,5 bar;
– Acetylene pressure: 0,3 bar;
– Parent material: S 235 JRG according to EN 10025.

Key

a MAG-buttering

Figure D.1 — All-weld metal test assembly for oxyacetylene welding consumables

Annex E
(informative)

Reference mean data creep properties

Table E.1 — Reference mean data creep properties

Steel according to EN 10027-1	Constants for the equation of the master curve [a]					Constants for the parametric equation		
	A	B	C	D	E	*r*	*Ta*	log *ta*
C7 to C24	-1,258 375 287	2,614 840 508	-2,058 339 119	0,717 218 577 9	-0,093 936 935 07	1	500	10,678 713 799
P195, P235, P265	12 083,437 50	11 945,410 16	-5 041,642 090	277,016 174 3	–	-1	0	-20,580 183 029
P355	-0,665 640 115 7	1,416 657 686	-1,151 554 346	0,413 083 046 7	-0,055 795 278 40	1	500	10,658 872 604
16Mo3	–	–	–	–	–	-1	0	-23,46
17Mo5	-15,918 817 5	1 638,478 02	-587,796 264	–	–	-1	650	-1,314 738 2
13NiMoV4-2	–	–	–	–	–	–	–	–
15MnCrMoV5-3	–	–	–	–	–	–	–	–
12MoCrV6-2-2	-1,730 246 782	3,300 741 434	-2,387 772 322	0,766 823 709 0	-0,092 737 816 27	1	520	13,783 925 056
13CrMo4-5+N	7 297,777 344	-7 238,721 680	3 306,159 668	-568,921 875 0	–	-1	600	-2,609 928 607 9
13CrMo4-5+NT	0,066 684 093 7	-0,143 434 107 3	0,073 764 830 83	-0,013 083 911 50	–	1	280	20,328 840 256
13CrMo5-5+NT	0,066 684 093 7	-0,143 434 107 3	0,073 764 830 83	-0,013 083 911 50	–	1	280	20,328 840 256
40CrMo5-6+NT	-58 488,132 13	107 347,230 1	-71 847,650 41	21 171,743 94	-2 332,020 504	-1	650	-1,116 471 322 4
40CrMoV5-6+NT	-29,549 158 10	49,968 894 96	-31,702 205 66	8,939 930 916	-0,946 190 416 8	1	650	8,976 790 428 2

Table E.1 — Reference mean data creep properties *(continued)*

Steel according to EN 10027-1	Constants for the equation of the master curve [a]					Constants for the parametric equation		
	A	B	C	D	E	*r*	*Ta*	log *ta*
20CrMoVTiB4-10	-231,758 454 0	402,805 188 5	-262,331 096 1	75,874 123 22	-8,224 261 141	1	750	6,463 699 290 5
11CrMo9-10+I	–	–	–	–	–	1	400	15,41
11CrMo9-10+NT1	-1,386 920 571	2,832 926 035	-2,196 207 523	0,756 533 384 3	-0,098 411 701 62	1	610	10,395 759 583
11CrMo9-10+NT2	-0,524 605 751 0	1,046 909 690	-0,819 874 346 3	0,289 080 709 2	-0,039 396 610 11	1	610	10,360 854 149
X11CrMo5+I	–	–	–	–	–	1	400	14,57
X11CrMo5+NT1, +NT2	–	–	–	–	–	1	650	8,985
X11CrMo9-1+I1	-0,806 423 008 4	1,757 547 379	-1,457 643 270	0,532 602 310 2	-0,073 432 676 49	1	600	11,695 010 185
X11CrMo9-1+NT	0,111 461 408 4	-0,221 906 140 4	0,114 587 746 6	-0,016 373 638 06	-0,001 907 426 864	1	560	14,172 191 620
X10CrMoVNb9-1	-0,493 827 790 0	0,974 988 639 4	-0,767 101 705 1	0,266 840 726 1	-0,035 136 841 24	1	370	24,755 538 940
X20CrMoNiV11-1 (R_m 690 N/mm^2 to 840 N/mm^2)	-0,428 634 136 9	0,940 327 704 0	-0,803 901 672 4	0,301 457 077 3	-0,042 622 927 58	1	610	12,751 610 756
X6CrNi18-10	0,202 073 290 9	-0,440 956 682 0	0,328 647 106 9	-0,108 594 514 4	0,013 175 404 63	1	0	25,241 230 011
X4CrNiN18-10	-0,075 662 143 53	0,060 607 813 30	-0,011 381 036 60	-0,001 937 349 210	–	1	500	10,873 614 311
X5CrNiMo17-12-2	-0,033 490 326 26	0,056 882 970 04	-0,065 327 875 32	0,029 111 728 07	-0,004 703 271 668	1	0	25,763 597 489
X5CrNiMoB17-13-3	0,536 308 169 4	-1,045 994 639	0,731 662 154 2	-0,225 830 242 0	0,025 575 074 60	1	0	26,223 617 554
X3CrNiMoN17-12-3	379 488,562 5	-683 745,187 5	464 988,687 5	-139 595,562 5	15 554,232 42	-1	550	-6,041 174 411 8
X7CrNiTi18-10 (Heat treatment 950 °C to 1 070°C)	0,005 118 919 536	-0,039 542 630 31	0,025 762 947 28	-0,007 168 778 218	0,000 546 021 910 8	1	0	21,785 516 739
X7CrNiTi18-10 (Heat treatment 1 070 °C to 1 140°C)	20 463,962 89	-13 077,156 25	-2 728,328 125	4433,528 320	-974,259 460 4	-1	510	-3,966 900 825 5
X6CrNiNb18-10 (Heat treatment 950 °C to 1 070°C}	0,025 520 339 61	-0,131 714 105 6	0,134 208 768 6	-0,054 848 995 06	0,007 650 834 508	1	340	14,446 140 289
X6CrNiNb18-10 (Heat treatment 1 070 °C to 1 125 °C)	-108 856,898 4	252 363,562 5	-182 577,312 5	57694,468 75	-6 863,740 723	-1	0	-14,445 973 396
X5CrNiNbN18-10	-2,290 895 700	4,143 799 305	-2,824 598 551	0,854 297 697 5	-0,097 026 146 95	1	400	14,914 063 454

Table E.1 — Reference mean data creep properties *(concluded)*

Steel according to EN 10027-1	Constants for the equation of the master curve [a]					Constants for the parametric equation		
	A	B	C	D	E	*r*	*Ta*	log *ta*
X10CrNiMoMnNbVB15-10-1	-336 414,531 3	799 872,062 5	-654 687,062 5	234 517,421 9	-31 193,529 30	-1	0	-18,431 352 615
X10CrNiMnNbV15-10-6-1	–	–	–	–	–	1	700	8,715
X5NiCrAlTi31-20	–	–	–	–	–	-1	250	12,548 5
X15CrNi25-21	2 380,403 320	4 522,662 109	-7 219,988 281	3 388,112 793	-539,233 886 7	-1	710	-1,475 691 199 3
40CrMo5-6+NT (Notched properties)	-36 536,664 06	70 050,703 13	-47 128,351 56	13 944,214 84	-1 546,441 406	-1	550	-2,878 401 517 9
40CrMoV5-6+NT (Notched properties)	–	–	–	–	–	-1	0	20
20CrMoVTiB4-10 (Notched properties)	–	–	–	–	–	1	600	8,320 4

[a] The master curve for each steel represents the average creep rupture strength values as a function of a time-temperature creep rupture parameter P, such that: $P = A + B (\log \sigma) + C (\log \sigma)^2 + D (\log \sigma)^3 + E (\log \sigma)^4 = (\log t - \log ta) / (T - Ta)^r$, where T is temperature (K), t time to rupture (h), σ stress (N/mm^2), A to E are constants in the stress function, and *ta*, *Ta* and r are constants in the time-temperature parameter.

NOTE The source of the values in this table is: PD 6525 (see Bibliography).

Annex F
(normative)

Moisture resistant system – Assessment

F.1 General

The assessment of a moisture resistant system shall be in two steps: one long-time investigation of the packaging itself and additionally investigations after opening of the packaging with the appropriate welding consumables to be verified. The first test shall be carried out on product of the same product form, flux or coating type, and H5[4)] designation.

F.2 Long-time investigation of the packaging

F.2.1 Each packaging type for moisture resistant shall be investigated over a period of at least 10 000 h in the climatic test cabinet under the conditions specified by the manufacturer. If not specified it is recommended to apply 27 °C and 80 % relative humidity, air circulation 1 m/s plus or minus 0,5 m/s.

F.2.2 The manufacturer shall demonstrate that possible moisture pick-up is limited, so that the welding consumable complies with the original hydrogen classification. Determination of diffusible hydrogen shall be in accordance with EN ISO 3690.

F.3 Diffusible hydrogen investigations after opening of the packaging

For each welding consumable to be qualified the following investigations shall be performed:

— Maximum exposure time in the climatic test cabinet (27 °C, 80 % relative humidity, and air circulation 1 m/s plus or minus 0,5 m/s). The manufacturer shall specify the maximum exposure time.

— The appropriate welding consumable shall be taken without re-drying for determination of diffusible hydrogen in accordance with EN ISO 3690. The manufacturer shall demonstrate that possible moisture pick-up is limited, so that the welding consumable complies with the original hydrogen classification.

— Other testing conditions may be agreed with the manufacturer.

F.4 Report

A report on the assessment shall be prepared. A note of the assessment may be given on the packaging.

4) See classification standards.

Annex G
(informative)

List of material groups according to CR ISO 15608:2000

Table G.1 — Grouping system for steel according to CR ISO 15608:2000

Group	Sub-group	Type of steel
1		Steels with a specified minimum yield strength $R_{eH} \leq 460$ N/mm² [a] and with analysis in % : C ≤ 0,25 Si ≤ 0,60 Mn ≤ 1,70 Mo ≤ 0,70 [b] S ≤ 0,045 P ≤ 0,045 Cu ≤ 0,40 [b] Ni ≤ 0,5 [b] Cr ≤ 0,3 (0,4 for castings) [b] Nb ≤ 0,05 V ≤ 0,12 [b] Ti ≤ 0,05
	1.1	Steels with a specified minimum yield strength $R_{eH} \leq 275$ N/mm²
	1.2	Steels with a specified minimum yield strength 275 N/mm² < $R_{eH} \leq 360$ N/mm²
	1.3	Normalized fine grain steels with a specified minimum yield strength $R_{eH} > 360$ N/mm²
	1.4	Steels with improved atmospheric corrosion resistance whose analysis may exceed the requirements for the single elements as indicated under 1
2		Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength $R_{eH} > 360$ N/mm²
	2.1	Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength 360 N/mm² < $R_{eH} \leq 460$ N/mm²
	2.2	Thermomechanically treated fine grain steels and cast steels with a specified minimum yield strength $R_{eH} > 460$ N/mm²
3		Quenched and tempered steels and precipitation hardened steels except stainless steels with a specified minimum yield strength $R_{eH} > 360$ N/mm²
	3.1	Quenched and tempered steels with a specified minimum yield strength 360 N/mm² < $R_{eH} \leq 690$ N/mm²
	3.2	Quenched and tempered steels with a specified minimum yield strength $R_{eH} > 690$ N/mm²
	3.3	Precipitation hardened steels except stainless steels
4		Low vanadium alloyed Cr-Mo-(Ni) steels with Mo ≤ 0,7 % and V ≤ 0,1 %
	4.1	Steels with Cr ≤ 0,3 % and Ni ≤ 0,7 %
	4.2	Steels with Cr ≤ 0,7 % and Ni ≤ 1,5 %

(to be continued)

Table G.1 — Grouping system for steel according to CR ISO 15608:2000 *(continued)*

Group	Sub-group	Type of steel
5		Cr-Mo steels free of vanadium with C ≤ 0,35 % [c]
	5.1	Steels with 0,75 % ≤ Cr ≤ 1,5 % and Mo ≤ 0,7 %
	5.2	Steels with 1,5 % < Cr ≤ 3,5 % and 0,7 % < Mo ≤ 1,2 %
	5.3	Steels with 3,5 % < Cr ≤ 7,0 % and 0,4 % < Mo ≤ 0,7 %
	5.4	Steels with 7,0 % < Cr ≤ 10,0 % and 0,7 % < Mo ≤ 1,2 %
6		High vanadium alloyed Cr-Mo-(Ni) steels
	6.1	Steels with 0,3 % ≤ Cr ≤ 0,75 %, Mo ≤ 0,7 % and V ≤ 0,35 %
	6.2	Steels with 0,75 % < Cr ≤ 3,5 %, 0,7 % < Mo ≤ 1,2 % and V ≤ 0,35 %
	6.3	Steels with 3,5 % < Cr ≤ 7,0 %, Mo ≤ 0,7 % and 0,45 % ≤ V ≤ 0,55 %
	6.4	Steels with 7,0 % < Cr ≤ 12,5 %, 0,7 % < Mo ≤ 1,2 % and V ≤ 0,35 %
7		Ferritic, martensitic or precipitation hardened stainless steels with C ≤ 0,35 % and 10,5 % ≤ Cr ≤ 30 %
	7.1	Ferritic stainless steels
	7.2	Martensitic stainless steels
	7.3	Precipitation hardened stainless steels
8		Austenitic steels
	8.1	Austenitic stainless steels with Cr ≤ 19 %
	8.2	Austenitic stainless steels with Cr > 19 %
	8.3	Manganese austenitic stainless steels with 4 % < Mn ≤ 12 %
9		Nickel alloyed steels with Ni ≤ 10,0 %
	9.1	Nickel alloyed steels with Ni ≤ 3,0 %
	9.2	Nickel alloyed steels with 3,0 % < Ni ≤ 8,0 %
	9.3	Nickel alloyed steels with 8,0 % < Ni ≤ 10,0 %
10		Austenitic ferritic stainless steels (duplex)
	10.1	Austenitic ferritic stainless steels with Cr ≤ 24 %
	10.2	Austenitic ferritic stainless steels with Cr > 24 %
11		Steels covered by group 1 [d] except 0,25 % < C ≤ 0,5 %
	11.1	Steels as indicated under 11 with 0,25 % < C ≤ 0,35 %
	11.2	Steels as indicated under 11 with 0,35 % < C ≤ 0,5 %

[a] In accordance with the specification of the steel product standards, R_{eH} may be replaced by $R_{p0,2}$ or $R_{t0,5}$.
[b] A higher value is accepted provided that Cr + Mo + Ni + Cu + V ≤ 0,75 %.
[c] "Free of vanadium" means not deliberately added to the material.
[d] A higher value is accepted provided that Cr + Mo + Ni + Cu + V ≤ 1 %.

Table G.2 — Grouping system for nickel and nickel alloys according to CR ISO 15608:2000

Group	Type of nickel and nickel alloys
41	Pure nickel
42	Nickel-copper alloys (Ni/Cu) Ni ≥ 45 %, Cu ≥ 10 %
43	Nickel-chromium alloys(Ni/Cr/Fe/Mo) Ni ≥ 40 %
44	Nickel-molybdenum alloys (Ni/Mo) Ni ≥ 45 %, Mo ≤ 32 %
45	Nickel-iron-chromium alloys (Ni/Fe/Cr) Ni ≥ 30 %
46	Nickel-chromium-cobalt alloys (Ni/Cr/Co) Ni ≥ 45 %, Co ≥ 10 %
47	Nickel-iron-chromium-copper alloys (Ni/Fe/Cr/Cu) Ni ≥ 45 %
48	Nickel-iron-cobalt alloys (Ni/Fe/Co/Cr/Mo/Cu) 25 % ≤ Ni ≤ 45 % and Fe ≥ 20 %

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[2] EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

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[4] ECCC-Document: Reference compilation of parent material stress rupture properties for conformity assessment of welding consumables", ed. S. R. Holdsworth, European Creep Collaborative Committee. Submitted for publication in "OMMI: Power Plant Operation, Maintenance and Materials Issues", Vol.2, Issue 3, December 2003, internet journal available online at www.ommi.co.uk, ISSN 1740-5181.

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