Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 1408.1 (2017-11)

Quality Assurance of Weld Filler Metals and Welding Consumables for Pressure- and Activity-Retaining Systems in Nuclear Power Plants
Part 1: Qualification Testing

(Qualitätssicherung von Schweißzusätzen und -hilfsstoffen für druck- und aktivitätsführende Komponenten in Kernkraftwerken; Teil 1: Eignungsprüfung)

Previous versions of this Safety Standard
were issued 1985-06, 2008-11 and 2015-11

If there is any doubt regarding the information contained in this translation, the German wording shall apply.

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KTA SAFETY STANDARD

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PLEASE NOTE: Only the original German version of this safety standard represents the joint resolution of the 35-member Nuclear Safety Standards Commission (Kerntechnischer Ausschuss, KTA). The German version was made public in the Federal Gazette (Bundesanzeiger) on May 17th, 2018. Copies of the German versions of the KTA safety standards may be mail-ordered through the Wolters Kluwer Deutschland GmbH (info@wolterskluwer.de). Downloads of the English translations are available at the KTA website (http://www.kta-gs.de).

All questions regarding this English translation should please be directed to the KTA office:

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Comments by the editor:

Taking into account the meaning and usage of auxiliary verbs in the German language, in this translation the following agreements are effective:

shall	indicates a mandatory requirement,
shall basically	is used in the case of mandatory requirements to which specific exceptions (and only those!) are permitted. It is a requirement of the KTA that these exceptions - other than those in the case of **shall normally** - are specified in the text of the safety standard,
shall normally	indicates a requirement to which exceptions are allowed. However, the exceptions used, shall be substantiated during the licensing procedure,
should	indicates a recommendation or an example of good practice,
may	indicates an acceptable or permissible method within the scope of this safety standard.

Translator's note:

In this translation distinction is still made between "weld filler metals" and “consumables", whereas the latest EN ISO standards (see e.g. Annex G) use only the term "welding consumables" for all types of filler metals, electrodes, wires, rods, fluxes, pastes, etc.

Fundamentals

(1) The safety standards of the Nuclear Safety Standards Commission (KTA) have the objective to specify safety-related requirements, compliance of which provides the necessary precautions in accordance with the state of the art in science and technology against damage arising from the construction and operation of the facility (Sec. 7 para. 2 subpara. 3 Atomic Energy Act - AtG) in order to achieve the fundamental safety functions specified in the Atomic Energy Act and the Radiological Protection Ordinance (StrlSchV) and further detailed in the Safety Requirements for Nuclear Power Plants as well as in the Interpretations on the Safety Requirements for Nuclear Power Plants.

(2) The “Safety Requirements for Nuclear Power Plants” require in no. 3.4 “Requirements for the reactor coolant pressure boundary and the pressure-retaining walls of components of the external systems” and no. 3.6 “Requirements for the containment system” the integrity of the pressure retaining walls as well as in requirement no. 5 (3) a documentation showing that the current condition of the safety-relevant measures and equipment fulfils the applicable requirements. Thus, to ensure proper weld connections, it follows that weld filler metals and welding consumables shall be subject to special quality assurance.

(3) When manufacturing, storing and using weld filler metals and welding consumables, it is essential that such properties are obtained and maintained which ensure that the welds meet the requirements over the entire scheduled operating time. This will be achieved by careful

a) selection of the initial materials,
b) production of the weld filler metals and welding consumables, and
c) observation of the prescribed processing conditions.

(4) Qualification tests are used to determine whether the selected weld filler metals and welding consumables meet the requirements of the intended application with respect to their composition and weldability and the properties of the welds produced.

(5) The safety standards of the KTA 1408 series are closely related to the following safety standards:

KTA 3201.3 Components of Light Water Reactors; Part 3: Manufacture,

KTA 3211.3 Pressure- and Activity-Retaining Components Outside the Primary Circuit; Part 3: Manufacture

KTA 3401.3 Steel Containment Vessels; Part 3: Manufacture.

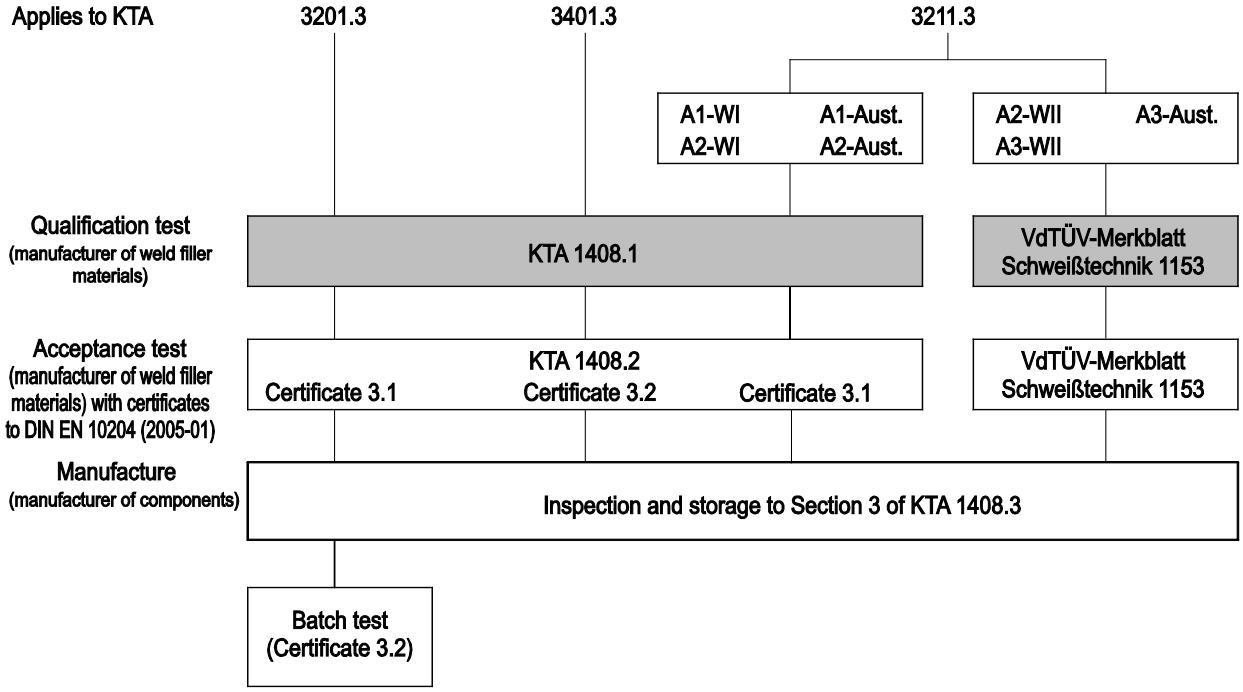
These safety standards specify the requirements for welds which are produced using the weld filler metals and welding consumables dealt with in this safety standard.

1 Scope

(1) This safety standard applies to the qualification testing of weld filler metals and welding consumables (see **Figure 1-1**) which are to be used in the fabrication of product forms, parts and sub-assemblies for pressure-retaining walls of components of stationary nuclear power plants with light water reactors. These include the:

a) components of the primary circuit (KTA 3201),
b) steel containment vessels (KTA 3401),
c) pressure- and activity-retaining components of systems outside the primary circuit (KTA 3211) - only Class 2 components -, excepted are the austenitic steels A2-WII, A3-WII and A3.

(2) In the case of weld filler metals and welding consumables which demonstrably have been used for the manufacture of components in accordance with paragraph 1 prior to the issuance of this safety standard, re-qualification testing is not required. The same applies to weld filler metals and welding consumables which, prior to the preparation of this safety standard, were investigated in special programs of a scope comparable to the following specifications.



A1, A2, A3 : Test groups

W I, W II : Materials groups

Further details on these values can be found in safety standards KTA 3211.1 and KTA 3211.3.

Figure 1-1: Requirements regarding weld filler metals and welding consumables

2 Definitions

(1) Manufacturer

The party who manufactures the consumables totally or performs the final part of production which determines the quality of the consumables.

Those purchasing the above-mentioned products as semi-finished or finished products, but undertaking the full guarantee with regard to the chemical composition, quality and properties of these products and ensuring inspection of the production and products, are also regarded as manufacturers.

(2) Manufacturer's works

The manufacturer's works is defined as the facility where weld filler metals and welding consumables are produced and packed.

(3) Supplier

The party who purchases the welding consumable from a manufacturer and supplies it under his own brand name.

(4) Authorized inspector

The authorized inspector for the tests and inspections to be conducted in accordance with this safety standard is the authorized inspector licensing or supervisory authority in accordance with Section 20 of the Atomic Energy Act. The tests/inspections required by this safety standard shall be conducted on the basis of a respective order by the competent authority.

(5) Welding consumables

Consumables are products which make possible and alleviate the welding process e.g. inert gas, flux or paste.

(6) Weld filler metal

A material added during the welding process and contributing to the formation of a welded joint.

3 Requirements regarding the manufacturer's works

3.1 Workshop equipment

(1) The workshop equipment shall permit a uniform manufacture of the products and a uniform quality of the final product. The manufacturer shall take adequate measures to ensure that mix-ups are excluded in the manufacture and storage of weld filler metals and welding consumables and that the requirements specified for manufacturing are complied with.

(2) Only subcontractors audited by the manufacturer regarding

a) technical equipment,

b) personnel,

c) quality assurance system,

d) internal and external surveillance,

e) experience

may be used as suppliers for rolled, drawn or cast initial material.

The purchase specifications for the supplies shall be submitted to the authorized inspector with respect to the chemical composition of the supplies. The authorized inspector shall be notified of any changes of the purchase specifications or of the circle of suppliers of initial materials, with respect to the written status laid down in the final documentation on the qualification test.

(3) Purchase specifications shall exist for all powdered materials for welding rods, flux cored electrodes and flux. The authorized inspector shall be notified of any changes of the materials or formulas, with respect to the written status laid down in the final documentation on the qualification test. The number or designation of the valid recipe shall be disclosed to the authorized inspector who will include it in his report on the qualification test.

(4) The manufacture of weld filler metals and welding consumables shall be performed in accordance with fabrication steps laid down in writing and shall be supervised by the manufacturer.

(5) Suitable drying facilities with adequate temperature control shall be available for the manufacture of coated welding rods, weld flux and flux cored electrodes. The drying conditions shall be laid down in manufacturing specifications, the compliance with which is to be checked by the manufacturer. The authorized inspector shall be notified of any changes of the drying conditions with respect to the status laid down in writing in the final documentation on the qualification test.

3.2 Receiving, intermediate and final inspections

(1) The manufacturer shall have at his disposal a quality assurance unit that is independent of fabrication and that performs the receiving, intermediate and final inspections in accordance with written instructions (see KTA 1408.2). These shall be in accordance with the fabrication system, shall ensure a final product of perfect quality and uniformity and shall ensure that no mix-ups occur.

(2) The quality assurance measures laid down in writing shall be submitted to the authorized inspector. The manager of the quality assurance unit shall be reported by name to the authorized inspector.

3.3 Identification marking of the products

(1) The identification marking of the products shall ensure that no mix-ups of the products occur on their way from the manufacturer's works to the point of application by the welder as a result of wrong or insufficient marking. The welding consumable shall be marked at least with its common trade name. In the case of weld filler metals and welding consumables which passed the qualification testing in accordance with sections 4 to 10 other markings than the trade name which ensure an unambiguous identification shall be included in the weld filler metals data sheet (see **Annex A**). The data sheet shall not include any additional markings.

(2) Welding rods shall be stamped; for lengths exceeding 1 m, the stamp shall be repeated several times. Unless the marking system is specified by standards, it shall be unambiguous with respect to the product range of a manufacturer and shall permit identification of the manufacturer. In the case of materials which do not permit stamping (e.g. cast rods) or where stamping is not possible for other reasons (e.g. if the diameter is 2 mm or less), some other form of unambiguous marking shall be effected (e.g. by tags glued to the material).

(3) Weld filler metals shall be marked in accordance with DIN EN ISO 544, weld flux in accordance with DIN EN ISO 14174.

(4) The imprints on the cover of welding rods shall consist only of colours that will not have detrimental effect on the welding results.

(5) If in the case of weld filler metals and welding consumables which passed the qualification testing in accordance with sections 4 to 10 additional reference to the qualification test in accordance with this safety standard is to be made, the following text shall be used:

"Qualified in accordance with KTA 1408.1".

(6) It is not permitted to use the label "Qualified in accordance with KTA 1408.1" for weld filler metals and welding consumables that were verified to be suited for such specific use by an individual material appraisal in accordance with **Annex G**.

3.4 Testing equipment

The manufacturer's works shall have sufficient testing equipment to perform the receiving, intermediate and final inspec-

tions. The welding and testing equipment required for the continuous monitoring of the mechanical properties and chemical composition shall be available. The other inspection equipment required to ensure uniform quality shall be available at the manufacturer's works.

3.5 Initial audit of the manufacturer's works

The initial audit of the manufacturer's works shall be carried out to meet the requirements of Sections 3.1 to 3.4. The authorized inspector shall establish a report on this audit.

The manufacturer shall make available reference values of chemical composition and mechanical properties for initial materials as well as for finished products.

Note:
The requirements to be met by the manufacturer's works shall be deemed to have been fulfilled if Section 4 of VdTÜV-Merkblatt Schweißtechnik 1153 in conjunction with DIN EN 12074 is complied with.

4 Assessment of the suitability of weld filler metals and welding consumables

4.1 General

(1) The requirements regarding specific characteristics of weld filler metals and welding consumables shall be based on the requirements of the respective applicable classifying standard. Weld filler metals and welding consumables not corresponding to a classification shall be assigned to the classifying standards with respect to their properties (see e.g. **Annex C**). Additional requirements for the chemical composition of all-weld metal of coated rod electrodes, flux cored wire electrodes and wire flux combinations as well as the chemical composition of massive products are specified in **Annex F**.

(2) The authorized inspector shall assess the suitability of weld filler metals and welding consumables on the basis of the specifications and tests required below. The qualification test shall only be carried out on welding consumables of manufacturers whose manufacturing equipment has been checked before by the authorized inspector.

(3) The qualification test shall be carried out at the manufacturer's works for weld filler metals and welding consumables.

4.2 Manufacturer's specification

4.2.1 General

Prior to the beginning of the tests, the authorized inspector shall be informed of the characteristic data, properties and chemical composition specified for the product by the manufacturer, as well as of the intended applicability of qualification testing to the weld filler metals and welding consumables to be tested.

4.2.2 Characteristic data

The characteristic data are:

a) type designation in accordance with either the pertinent standards or the type of weld filler metals and welding consumables,
b) nature of coating or flux type,
c) alloy type of the weld metal,
d) code number designating the mechanical properties,
e) welding processes and their combinations in accordance with DIN EN ISO 4063,
f) welding positions in accordance with DIN EN ISO 6947,
g) type of current and polarity,
h) marking,
i) dimensions,
k) welding consumables (e.g. inert gases),
l) recommended welding parameters (e.g. range of current and welding rates).

4.2.3 Statement of reference values and properties

(1) The allowable limits shall be specified for:

a) the analysis of the strip-type and wire electrodes, the core or welding rods, and the metal coating of flux cored electrodes,
b) the typical analysis of the weld metal,
c) quantitative information on the characteristic chemical compounds or elements of coatings or fillings (e.g. TiO_2, SiO_2) of fluxes and pastes which can be verified by chemical analysis,
d) the properties of the weld metal in the heat treatment conditions concerned.

(2) Properties for conditions of special applications shall be specified, e.g.:

a) suitability for high or low temperatures,
b) corrosion resistance.

4.2.4 Scope of application

The scope of application of the qualification test shall be specified by the manufacturer such that there is adequate compatibility between the weld metal properties and the service properties of the base metal within the scope. When specifying the scope of application, the KTA safety standards applying to nuclear facilities shall be taken into account. The scope of application shall be described by means of the following information:

a) materials,
b) heat treatments,
c) wall thickness limitations,
d) highest and lowest operating temperatures of the parts to be welded together,
e) type of current and polarity,
f) root weldability,
g) welding positions as a function of the dimensions of the weld filler metals,
h) design strength values, if any,
i) special fields of application.

4.3 Extent of the qualification test

(1) Investigations shall basically be carried our regarding:

a) the weld filler metals and welding consumables (see Section 4.4),
b) the all-weld metal (see Section 4.5),
c) weld connections and weld claddings (see Sections 4.6 and 4.7), and
d) susceptibility to cracking (see clause 4.6.4.11).

(2) The above-mentioned investigations relate to the examination of the

a) outer appearance and condition,
b) chemical composition,
c) mechanical properties,
d) satisfactory weldability of the weld filler metals and welding consumables.

(3) Depending on the application of the welding consumable, supplementary tests shall be performed, for example:

a) corrosion resistance,

b) determination of the delta ferrite content,
c) low temperature fracture toughness,
d) high temperature strength,
e) long-term behaviour,
f) cold formability,
g) hot formability,
h) determination of hydrogen content.

(4) If weld filler metals and welding consumables are used in such small quantities (with a maximum amount of 500 kg on each occasion) that a qualification test is unsuited due to the disproportionately high expenditure required, an individual material appraisal may be prepared to satisfy the specific application concerned. The procedure to be followed in this case is laid down in **Annex G**. An application-specific qualification test is allowed only if the case of application and the later operating conditions are known. Here it is presumed that the weld filler metal to VdTÜV-Merkblatt Schweißtechnik 1153 in conjunction with DIN EN 14532-1 and DIN EN 14532-2 has been qualification tested.

4.4 Investigation of the weld filler metals and welding consumables

4.4.1 Specimen-taking and examination of the outer appearance and condition

(1) Within qualification testing, the weld filler metals and welding consumables used for the qualification test shall be taken from the manufacturer's stock in the presence of the authorized inspector.

(2) For all weld filler metals and welding consumables, the dimensions which are to be included in the scope of application of the test shall be verified, i.e.

a) in the case of rod electrodes, these are the core wire, thickness of the coating and length,
b) in the case of welding rods, these are the rod diameter and length,
c) in the case of wire electrodes, this is the diameter,
d) in the case of strip-type electrodes, this is the width and thickness,
e) in the case of flux cored electrode, these are the diameter and degree of filling.

(3) In the case of fluxes for submerged arc welding or electro-slag welding, the granulation specified in DIN EN ISO 14174 shall be verified. The particle size of other fluxes (e.g. for plasma deposition welding) shall also be checked to verify that the manufacturer’s specifications have been satisfied

(4) In addition, all other external features of the weld filler metals and welding consumables should also be documented, for example

a) the colour of the coating or of the flux,
b) the bonding strength of the coating, if any, the surface condition and identification marking.

4.4.2 Chemical composition

(1) On the basis of the data on the chemical composition, the authorized inspector shall verify whether the limit values specified by the manufacturer for the analyses are adhered to with respect to

a) core wire,
b) welding rod,
c) strip-type and wire electrodes,
d) inert gas,
e) coat of flux cored wire,
f) coating of the rod electrode,
g) flux for submerged arc and electro-slag welding,
h) flux of the flux cored electrode,
i) flux for plasma arc weld surfacing.

(2) When carrying out the chemical analysis of the core wires, strip-type electrodes and wire electrodes, the alloy constituents and also the impurities (e.g. phosphorus, sulphur, nitrogen and chromium in the case of low-alloy weld filler metals) shall be determined. Special attention shall be paid to metallic coatings such as copper. The proportion of the coating shall be determined when carrying out the analysis of the weld filler metal.

(3) When carrying out the chemical analysis of the coatings or fluxes, random samples should be taken and verified of the constituents governing the properties of the coating or flux, provided a comprehensive reference analysis performed by the manufacturer is available. If the manufacturer provides insufficient reference values, a comprehensive analysis shall be required.

(4) In order to be able to determine the properties of a coating at least the proportions of SiO_2, Mn and CaF_2 shall be determined. Where certain constituents, such as chromium, nickel or molybdenum are added from the alloy of the coating, they shall be determined as well.

4.5 Investigations of the all-weld metal

4.5.1 General

The properties of the all-weld metal shall be tested. In the case of weld filler metals and welding consumables which are used exclusively for weld cladding and hard surfacing (e.g. austenitic steels, hard surfacing alloys), no tests of the all-weld metal - with the exception of the chemical analysis - need be carried out.

4.5.2 Test coupon forms

(1) Weld metal test coupons shall be prepared in accordance with DIN EN ISO 15792-1. When testing rod, wire and flux cored electrodes as well as welding rods, test coupon forms 1.2 or 1.3 shall be used; when testing wire flux combinations for submerged arc welding, test coupon forms 1.3 or 1.4 shall be used. For the tests of weld filler metals and welding consumables for deposition welding, test coupons shall be prepared in accordance with the corresponding standards.

(2) If the manufacturer specifies a test of the weld filler metal for welding with direct and alternating current or, in the case of direct current, at both poles, the test shall be carried out for all currents or polarities. For this purpose, the full extent of the test shall be carried out for the current having the most unfavourable effects on the welding process - this is, as a rule, the alternating current - or for the less commonly used polarity. For the remaining type of current or polarity, the test coupons shall not only be tested for their chemical compositions but also for their mechanical and technological properties in the unannealed condition or following the specified shortest heat treatment for the largest diameter of the weld filler metal under the scope of application. If the test of the all-weld metal leads to substantial differences in the results for the different types of current or polarities, then, instead of random sampling, the entire test program shall be carried out.

(3) Prior to the beginning of the test, the welding procedure sheet and the test and inspection sequence plan to be prepared by the manufacturer shall be submitted to the authorized inspector. In the procedure sheets, the basic structure of the welds shall be represented by outline drawings. If welding consumables are used they shall be certified by an acceptance test certificate to DIN EN 10204 (see Sec. 8 of KTA 1408.2).

4.5.3 Welding conditions

(1) The following welding conditions shall be complied with:

a) rod electrodes: see **Table 4.5.3-1**,

b) wire flux combinations: see **Table 4.5.3-2,**

c) metal inert gas arc welding with solid wire **Table 4.5.3-3**,

d) metal inert gas arc welding with flux cored electrodes: see **Table 4.5.3-4**,

e) tungsten inert gas arc welding: see **Table 4.5.3-5**.

Deviations from the above-mentioned welding conditions shall be specified in the data sheet.

(2) **Tables 4.5.3-1 to 4.5.3-5** apply to ferritic weld filler metals and, where applicable, shall also apply to austenitic, nickel alloy and other weld filler metals. The data shall be laid down by the manufacturer and be examined by the authorized inspector.

(3) The preheat and interpass temperatures shown in **Tables 4.5.3-1** to **4.5.3-5** and **4.6.2-1** to **4.6.2-3** refer to fine-grain steels. For other materials the preheat and interpass temperature shall be fixed and be checked by the authorized inspector. The interpass temperature shall be recorded. The definitions of preheat and interpass temperature shall be taken from DIN EN ISO 13916.

Core rod diameter · length mm	Welding current A	Approximate electrode run-out length mm	Energy per unit length [1)] kJ/cm	Test coupon form to DIN EN ISO 15792-1	Preheat and interpass temperatures °C
2.5 · 250	For the individual dimensions of the rod electrodes, the upper current specified by the manufacturer on the label, reduced by 10%, shall be used as a mean value.	150	5 to 7	1.2	125 to 175
2.5 · 300		170			
2.5 · 350		200			
3.25 · 350		240	7 to 9	1.2	
4 · 350		260	11 to 13	1.3	
4 · 450		340			
5 · 450		400	14 to 16		
6 · 450		470	18 to 22		
[1)] The specified energy per unit length is attained with the specified run-out lengths (50 mm stub length).					

Table 4.5.3-1: Welding data reference values for the production of all-weld metal test coupons - Rod electrodes -

Wire electrode diameter mm	Welding current A	Welding voltage V	Welding speed cm/min	Energy per unit length kJ/cm	Test coupon form to DIN EN ISO 15792-1	Preheat and interpass temperatures °C
4	approx. 550	flux-specific	approx. 45	21 to 24	1.3 or 1.4	125 to 175

Table 4.5.3-2: Welding data reference values for the production of all-weld metal test coupons - Wire-flux combination -

Wire electrode diameter mm	Welding current A	Welding voltage V	Welding speed cm/min	Energy per unit length kJ/cm	Test coupon form to DIN EN ISO 15792-1	Preheat and interpass temperatures °C
1.2	280 ± 10	gas-dependent	50	8 to 10	1.3	125 to 175
			30	14 to 17		
For other electrode diameters and welding conditions outside the verified range of energy per unit length - in particular in the range of the short arc - the welding data shall be laid down by the manufacturer and be checked by the authorized inspector.						

Table 4.5.3-3: Welding data reference values for the production of all-weld metal test coupons - Solid wire electrode -

Wire electrode diameter mm	Welding current A	Welding voltage V	Welding speed cm/min	Energy per unit length kJ/cm	Test coupon form to DIN EN ISO 15792-1	Preheat and interpass temperatures °C
1.2	250 ± 10	25 to 28	50	7.5 to 8.5	1.3	125 to 175
	280 ± 10	26 to 31	30	14 to 17		
1.6	300 ± 10	26 to 29		15.5 to 17.5		
For other electrode diameters and welding conditions outside the verified range of energy per unit length - in particular in the range of the short arc - the welding data shall be laid down by the manufacturer and be checked by the authorized inspector						

Table 4.5.3-4: Welding data reference values for the production of all-weld metal test coupons - Flux cored electrode -

Welding rod diameter mm	Welding current A	Welding current V	Welding speed cm/min	Energy per unit length kJ/cm	Test coupon form to DIN EN ISO 15792-1	Preheat and interpass temperatures °C
3.0	200 ± 10	approx. 15	approx. 15	approx. 12	1.2	125 to 175

Table 4.5.3-5:Welding data reference values for the production of all-weld metal test coupons - Tungsten inert gas welding -

4.5.4 Heat treatment conditions

(1) If the size of the furnace does not permit the heat treatment of the entire test coupon, the test coupon may be subdivided. The heat treatment of the all-weld metal may not be performed on machined-out test specimens.

(2) If other heat treatments are required than those specified in **Tables 4.5.4-1 to 4.5.4-3**, the requirements of (3) to (8) hereafter apply:

(3) Stress relieving

a) Welding rods for welding of carbon and low-alloy steels as well as weld metal with similar chemical composition

The holding time shall be 15 hours at the highest stress-relieving temperature for the materials within the intended range of application of the weld filler metal. Cooling shall be effected down to approx. 300 °C in the annealing furnace and then in air.

b) Filler metals for low-alloy and medium-alloy steels

The holding time shall be 50 hours for all wall thicknesses and 15 hours in the case of a wall thickness limitation to ≤ 80 mm at the highest stress relieving temperature for the materials within the intended range of application of the weld filler metal. Cooling shall be effected down to approx. 300 °C in the annealing furnace and then in air.

(4) Normalizing

The holding time shall be half an hour at the highest normalizing temperature permitted for the materials within the intended range of application of the weld filler metal. Cooling shall be effected in the annealing furnace not to exceed 3 hours down to 300 °C and then in air.

(5) Tempering

The holding time shall be 15 hours at the highest tempering temperature permitted for the materials within the intended range of application of the weld filler metal. Cooling shall be effected down to approx. 300 °C in the annealing furnace and then in air.

(6) Quenching and tempering

Accelerated cooling as specified for the material with subsequent tempering as per (5) shall be effected.

(7) Stabilizing

The heat treatment shall be effected to satisfy AD 2000-Merkblatt HP 7/3. The holding time shall be 15 hours.

(8) Solution annealing

The holding time shall be half an hour at the lowest solution annealing temperature permitted for the materials within the intended range of application of the weld filler metal, e.g. to DIN EN 10088-2, Tables A.1 to A.5. Cooling shall be effected in water. Depending on the range of application of the weld filler metal a shorter or longer holding time as well as other cooling conditions are possible. These conditions shall be taken over into the data sheet for weld filler metals.

4.5.5 Test conditions, form and number of test specimens

4.5.5.1 General

The requirements of DIN EN ISO 15792-1 shall apply to all-weld metal test specimen coupons, the orientation and the form of test specimens. The extent of the test shall be as specified in **Tables 4.5.4-1** to **4.5.4-3.**

4.5.5.2 Tensile tests at room temperature

(1) The tensile test shall be carried out to DIN EN ISO 6892-1. The following values shall be determined:

a) in the case of ferritic welding consumables:
the lower yield strength or, if this does not develop, the 0.2 %-proof stress, as well as tensile strength, elongation at fracture, reduction of area,

b) in the case of austenitic and nickel alloy welding consumables:
the 0.2 %- and 1.0 %-proof stresses, as well as tensile strength, elongation at fracture, reduction of area.

The proportional specimen to DIN 50125 with a diameter d_0 of 10 mm shall be used.

(2) Three specimens shall be tested for each heat treatment condition and test diameter.

4.5.5.3 Hot tensile tests

(1) The tensile test shall be carried out to DIN EN ISO 6892-2. The following values shall be determined:

a) in the case of ferritic welding consumables:
the 0.2 %-proof stress, tensile strength, elongation at fracture, reduction of area,

b) in the case of austenitic and nickel alloy welding consumables:
the 0.2 %- and 1.0 %-proof stresses, as well as tensile strength, elongation at fracture, reduction of area.

The proportional specimen to DIN 50125 with a diameter d_0 of 10 mm shall be used.

One specimen shall be tested for each temperature and tested diameter of the weld filler metal.

(2) For one dimension of the respective weld filler metal, hot tensile tests at several temperatures (e.g. between room temperature and the upper test temperature at intervals of about 100 °C) shall be carried out within the range of application of the test such that the characteristic curve is determined. For all other dimensions, it shall be sufficient to choose as test temperature the highest temperature to be guaranteed.

4.5.5.4 Notched bar impact tests

For each test temperature, one set of impact test specimens (3 V-notch test specimens) shall be tested in accordance with DIN EN ISO 9016, where a 2 mm radius striker shall be used. The absorbed energy (KV_2) shall be determined; in the case of ferritic materials, the lateral expansion and the ductile fracture portion to DIN EN ISO 148-1 shall be determined additionally.

a) The complete KV_2-T curve shall be determined for ferritic materials, as follows:

The temperatures to be used shall be 33 °C and 80 °C. At least three further temperatures shall be specified such that both upper shelf and lower shelf are covered (90 % and 10 % ductile fracture portion). The extent of testing shall be as specified in **Tables 4.5.4-1** and **4.5.4-2.**

In the case of weld filler metals and welding consumables which are intended for the containment vessel, one of the test temperatures shall be 5 °C.

b) The partial KV_2-T curve shall be determined for ferritic materials as follows:

In addition to the 33 °C temperature, at least three other temperatures shall be specified in such a way that the upper shelf and transition temperature range are covered.

c) In the case of austenitic weld filler metals the requirements of **Tables 4.5.4-3** shall apply.

			Notched bar impact test KV_2-T curve			Drop weight test for the determination of the NDT temperature	Tensile test			Bend test		Chemical composition of weld metal	Hardness test and examination of microstructure		Determination of hydrogen
							flat tensile specimen	round tensile specimen		cover pass	root		Weld metal	Weld connection	
			complete	limited	ageing			room temp.	design temp.	on the tensile side					
Rod electrode, flux cored wire electrode	Weld metal	Smallest core rod diameter (minimum 2.5 mm), flux cored wire diameter 1.2 mm, with 7.5 to 8.5 kJ/cm	U, S_{SV}					U, S_{SV}	U, S_{SV}			X	U, S_{SV}		
		Core rod diameter 4 mm, flux cored wire diameter 1.2 mm	U, S_3, S_{SV}	S_2				U, S_3, S_{SV}	U, S_3, S_{SV}			X	U, S_3, S_{SV}		X [2]
		Greatest core rod diameter; flux cored wire diameter 1.6 mm	U, S_3, S_{SV}	S_2	U, S_1			U, S_{SV}	U [3]			X	U, S_{SV}		
	Weld connection	Position PA	U, S_{SV}			U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}	
		Position PF	U, S_{SV}	S_2		U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}	
		Position PE		U						U	U			U	
Wire flux combination	Weld metal	Medium energy per unit length	U, S_3, S_{SV}		U, S_1			U, S_3, S_{SV}	U, S_3, S_{SV}			X	U, S_3, S_{SV}		X [2]
	Weld connection	High energy per unit length	U, S_3, S_{SV} [4]	S_2		U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}	
		Low energy per unit length [1]	U, S_3, S_{SV}	S_2		U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}	

Heat treatment
U : If allowable, without heat treatment - otherwise S_1
S_1 : 1 h at T_{min}
S_2 : 5 h at $0.5 \cdot (T_{min} + T_{max})$
S_3 : 15 h at T_{max}
S_{SV} : Specification by the authorized inspector

[1] Where required, use of a second wire diameter from the same batch.

[2] Two production units; different core rod diameters may be tested.

[3] The high-temperature strength history in the temperature range that is applied for above 20 °C shall be determined at intervals of 100 °C each.

[4] An additional set of notched bar impact test specimens from the dendritic area in the bead centre shall be tested at a temperature to be agreed upon with the authorized inspector.

Table 4.5.4-1: Extent of testing for low-alloy weld filler metals (rod electrodes, flux cored electrodes and wire/flux combination)

			Notched bar impact test KV_2-T curve			Drop weight test for the determination of the NDT temperature	Tensile test			Bend test		Chemical composition of weld metal	Hardness test and examination of microstructure	
							flat tensile specimen	round tensile specimen		cover pass	root			
			complete	limited	ageing			room temp.	design temp.	on the tensile side			Weld metal	Weld connection
Gas shielded wire electrode	Weld metal	Low energy per unit length	U, S_{SV}					U, S_{SV}	U, S_{SV}			X	U, S_{SV}	
		High energy per unit length	U, S_3, S_{SV}	S_2	U, S_{S1}			U, S_{SV}	U [2)]			X	U, S_{SV}	
	Weld connection	Position PA	U, S_{SV}			U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}
		Position PF	U, S_3, S_{SV}	S_2		U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}
		Position PE		U						U	U			U
TIG welding rods	Weld metal	Medium energy per unit length	U, S_3, S_{SV}		U, S_{S1}			U, S_3, S_{SV}	U, S_3, S_{SV}			X	U, S_3, S_{SV}	
	weld connection [1)]	Position PA	U, S_{SV}			U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}
		Position PF	U, S_3, S_{SV}	S_2		U, S_{SV}	U, S_3			U, S_3	U, S_3			U, S_{SV}
		Position PE		U						U	U			U

Heat treatment
U : If allowable, without heat treatment - otherwise S_1
S_1 : 1 h at T_{min}
S_2 : 5 h at $0.5 \cdot (T_{min} + T_{max})$
S_3 : 15 h at T_{max}
S_{SV} : Specification by the authorized inspector

1) Upon agreement with the authorized inspector, TIG welding rods may be included in the tests of weld connections of other types of weld filler metals.

2) The high-temperature strength history in the temperature range that is applied for above 20 °C shall be determined at intervals of 100 °C each.

Table 4.5.4-2: Extent of testing for low-alloy weld filler metals (wire electrodes for gas-shielded arc welding and TIG welding rods)

			Notched bar impact test KV_2 at room temperature		Tensile test			Bend test		Chemical composition of weld metal and calculation of delta ferrite content [4]	Examination of microstructure and determination of delta ferrite content [4]	Resistance to intergranular corrosion [7]	Test for susceptibility to hot cracking [8]
			without cold working [6]	after 15% cold working [5], [6]	flat tensile specimen	round tensile specimen		cover pass	root				
						room temp.	design temp.	on the tensile side					
Rod electrode (SE), flux cored wire electrode (FDE)	Weld metal	SE: smallest core rod diameter FDE: smallest diameter								U	U		U [1]
		SE: 4 mm core rod diameter FDE: 1.2 mm diameter	U			U	U			U	U		U [1]
		SE: greatest core rod diameter FDE: greatest diameter	U	U		U	U [3]			U	U		U [1]
	Weld connection	Position PA	U		U			U	U		U	U	
		Position PF	U		U			U	U	U	U	U	
		Position PE			U			U	U				
Wire flux combination (DPK) and TIG welding rods	Weld metal	Medium energy per unit length	U	U		U	U [3]			U	U		U [2]
	Weld connection	DPK: High energy per unit length WIG-SS: Medium energy per unit length	U		U			U	U	U	U	U	

U: As a rule, without post-weld heat treatment. If the manufacturer requests post-weld heat treatment (solution annealing, stabilizing, tempering) of the weld metal, the extent of testing shall be agreed on the basis of this table.

1) See **Annex E**.

2) The authorized inspector shall select one batch of three production units submitted. The testing method shall be laid down by the manufacturer and be checked by the authorized inspector.

3) The high-temperature strength history in the temperature range that is applied for above 20 °C shall be determined at intervals of 100 °C each.

4) The determination of the delta ferrite content does not apply in the case of nickel alloy weld filler metals.

5) As a result of the small number of such weld connections, these tests may be carried out within the scope of individual appraisals or procedure qualifications.

6) If the weld filler metal is to be used for low temperatures as well, its absorbed impact energy shall also be demonstrated at the lowest temperature applied for.

7) To be carried out for nickel alloys only within the respective qualified range.

8) In the case of a delta ferrite content of 3 % or less, further specimens shall be taken from the weld connections upon agreement with the authorized inspector, which shall provide information on the hot cracking susceptibility of the weld metal.

Table 4.5.4-3: Extent of testing for austenitic and nickel alloy weld filler metals

4.5.5.5 Notched bar impact tests on aged test specimens

(1) Notched bar impact tests on aged test specimens shall be performed only if significant ageing is to be expected on the weld filler metal to be examined or due to the intended application.

(2) Prior to being machined to the finished size, the notched bar impact test specimens shall be subjected to a 10 % upset deformation in the area of the test cross section followed by annealing for half an hour at 250 °C.

(3) Cold upset deformation shall be performed in accordance with **Figure 4.5.5-1**.

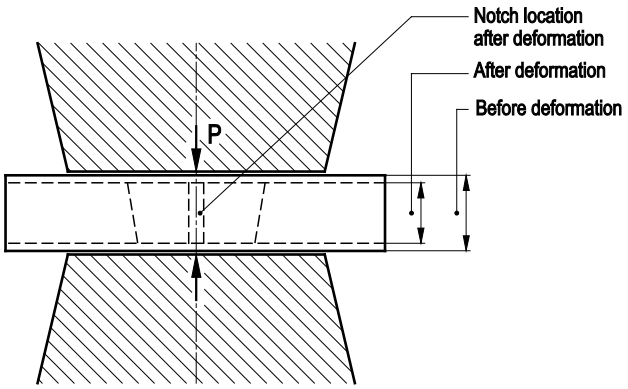


Figure 4.5.5-1: Upsetting of notched bar impact test specimens to be aged

(4) A KV_2-T curve shall be determined

a) on artificially aged test specimens. This test can be waived if heat treatment is required.

b) on artificially aged test specimens followed by heat treatment at T_{min} for one hour.

An absorbed impact energy of at least 35 Joule shall be obtained at the lowest test temperature to be certified in accordance with the data sheet for the aged condition.

4.5.5.6 Metallographic examination and hardness test

(1) To review the bead sequence, macrosections shall be taken to the weld in accordance with **Tables 4.5.4-1 to 4.5.4-3**, and shall be documented by photos. In the middle of the weld metal the microstructure shall be shown with a suitable enlargement (usual scale 200:1).

(2) In the middle of the weld metal the hardness HV 10 shall be determined in accordance with DIN EN ISO 6507-1. The measuring results of at least three indentations shall be used to form a mean value.

4.5.5.7 Chemical composition

(1) The chips and specimens required for the analysis of the weld metal shall be taken from the middle of the weld metal; remainders of specimens may be used for this purpose. For other methods of analysis, a transverse microsection consisting of all-weld metal may also be used.

The chemical composition of the weld metal shall be determined. Normally, the elements to be determined are those specified in **Table 4.5.5-1**.

(2) In the case of ferritic and fully austenitic weld filler metals the following trace elements shall, also, be determined: Sn, As, Sb and Pb.

4.5.5.8 Determination of the delta ferrite content

(1) The proportion of ferrite in an austenitic weld metal shall be determined mathematically on the basis of all the weld metal analyses in accordance with **Table 4.5.4-3** and with the aid of the DeLong diagram in accordance with **Figure 4.5.5-2**. A supplementary metallographic determination of the delta ferrite content shall be carried out for one dimension of the corresponding weld filler metal.

(2) Ferritic lattice structure is not permitted in austenitic weld filler metals.

4.6 Investigations of weld connections

4.6.1 Number and dimensions of test coupons

(1) For the number and dimensions of the specimens the requirements of DIN EN 14532-1, sec. 6.2 as well as the requirements of (2) to (4) hereafter apply.

(2) The number of the test coupons to be produced depends on the scope of qualification applied for with respect to the weld filler metal concerned. The thickness of the test coupons should be at least 20 mm. Basically, welding of the test specimens shall be performed using base metals of the lower and upper strength grades in accordance with the scope of qualification.

(3) For the base metals used, the chemical composition and the strength, strain and toughness values shall be available as determined on the test coupons. If these values have been certified in an acceptance test certificate 3.1 to DIN EN 10204 these tests may be waived. If welding consumables are used, they shall also be certified by an acceptance test certificate 3.1 to DIN EN 10204 (see Sec. 8 of KTA 1408.2).

(3) The weld length and, possibly, the number of test coupons shall be chosen in such a way that the prescribed number of specimens and possible substitute specimens can be taken without difficulty in consideration of the welding process concerned.

4.6.2 Welding conditions

4.6.2.1 General

When carrying out test weldings, the welding conditions specified in Sections 4.6.2.2 to 4.6.2.6 shall be adhered to.

4.6.2.2 Preheating

Preheating shall only be done if this is required in the corresponding KTA safety standards for the base metal to be welded.

4.6.2.3 Interpass temperature and energy per unit length

The specifications for interpass temperature and energy per unit length for the corresponding base metals, e.g. in standards, VdTÜV material sheets or KTA safety standards shall be adhered to. Deviations from these values shall be specifically mentioned in the test report and in the qualification test data sheet and shall be substantiated in the test report.

4.6.2.4 Welding position

When welding the test specimens, all welding positions (in general, they correspond to the code number of the standardized designation of the weld filler metal) shall be used at least once. In the case of rod electrodes and tungsten inert gas arc welding rods, the test coupon welded in welding position PA, in general, will also cover the test coupon produced in welding position PC.

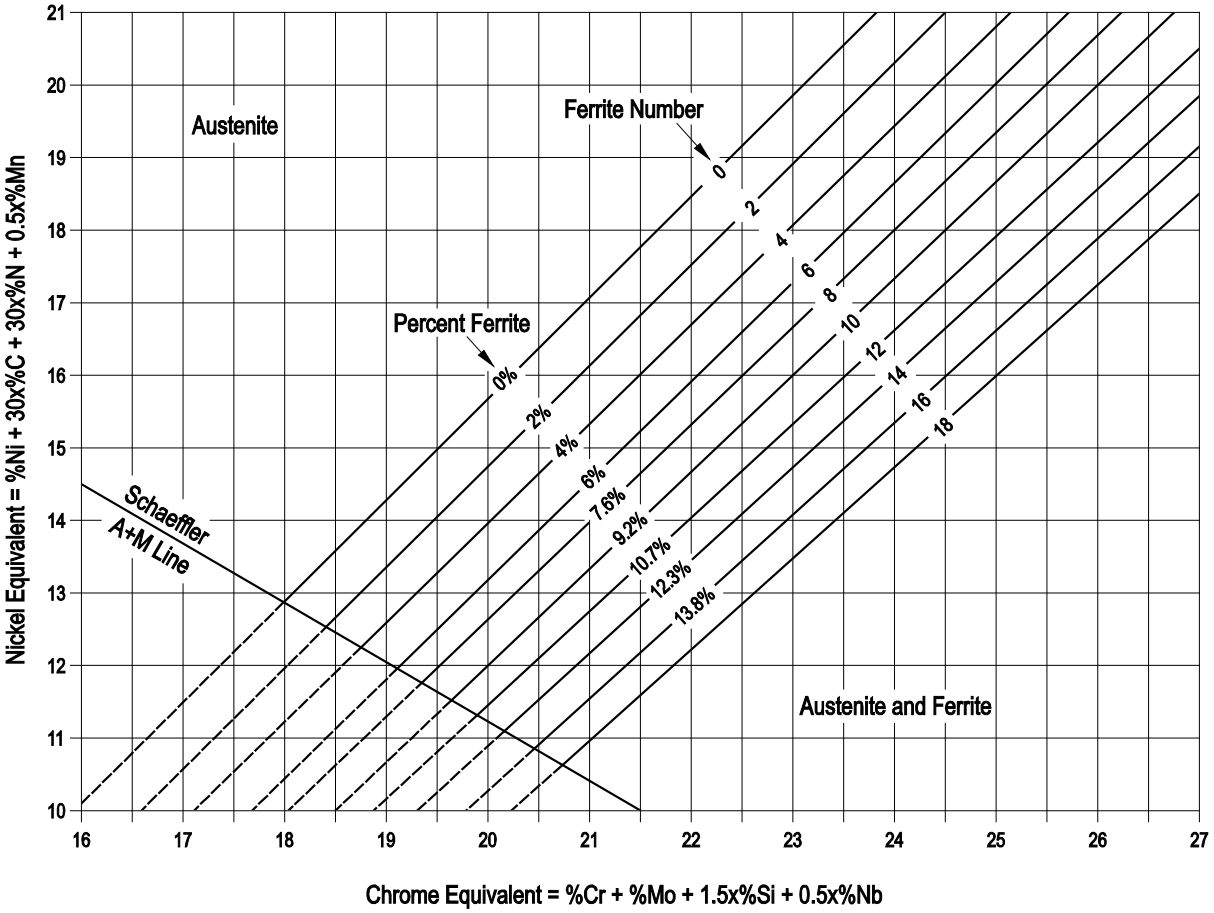
4.6.2.5 Type of current and polarity

If welding of a weld filler metal is possible with both direct and alternating current, both types of current shall be used at least once when welding the specimens. The same applies to the selection of the plus and minus poles when welding with direct current.

	C	Mn	Si	P	S	Cr	Mo	Ni	N_2	Fe	Ti	Co	Nb	Cu	Al	V
Ferritic-perlitic weld filler metals	x	x	x	x	x	x	x	x	x				x	x	x	x
Austenitic weld filler metals	x	x	x	x	x	x	x	x	x			x	x[1)]	x		
Nickel alloy weld filler metals	x	x	x	x	x	x	x	x	x	x	x	x	x	x		

[1)] Nb need only be verified if DIN EN ISO 3581 or DIN EN ISO 14343 contain a requirement for verification of this element.

Table 4.5.5-1: All-weld metal elements to be determined



Si %	x 1.5								
Cr	x 1.0								
Mo	x 1.0								
Nb	x 0.5								
Cr-Equivalent									
C %	x 30								
Mn	x 0.5								
Ni	x 1.0								
N	x 30								
Ni-Equivalent									
% Ferrite									

Nickel and chromium equivalents shall be calculated on the basis of the analysis of the weld metal. If the nitrogen content is unknown, 0.06 % shall be used for TIG weld metals and weld metals of coated electrodes, and 0.08 % for MIG/MAG weld metals. If an exact chemical analysis is performed the diagram of the Welding Research Council shows the ferrite numbers within a tolerance of ± 3 in approximately 90 % of all cases for alloy groups 308, 309, 316 and 317.

Figure 4.5.5-2: Phase diagram for weld metal of stainless steel (Delong diagram, Rev. Jan. 1973) and table for evaluation purposes

4.6.2.6 Welding parameters and weld build-up sequence

(1) The welding parameters and weld build-up shall be selected in accordance with the manufacturer specifications. However, weld connections should be carried out with the most unfavourable values specified. With respect to the weld build-up, all core rod and wire diameters included in the certification by the manufacturer of the weld filler metal shall be taken into account. In this context, the weld build-up shall be performed as in practice, i.e. with increasing diameters from root to surface layer, however, with respect to welding position PA, the surface layer shall be welded with the greatest diameter to be tested in the range of application applied for.

(2) The conditions for submerged arc welding and metal inert gas welding are specified in **Tables 4.6.2-1** to **4.6.2-3** for ferritic weld filler metals. For other materials, weld parameters to correspond the material concerned shall be agreed upon with the manufacturer.

(3) In the case of submerged arc welding, care shall be taken to ensure that only fluxes of one batch are used for the production of the all-weld metal and the weld connection.

(4) If the weld filler metal is also intended to be used for single-side welding, the test coupon to be produced in welding position PA shall not be re-welded on the root side. The root shall be welded without backing and shall be evaluated in accordance with evaluation category B of DIN EN ISO 5817. Where preparatory work deviating from the pertinent standards is done to carry out single-sided welding, this shall be stated in both the test report and the data sheet.

4.6.3 Heat treatment

(1) Heat treatment shall only be carried out if it is required for weld connections of base metals within the range of application. The stress relief annealing temperatures and holding times specified in **Tables 4.5.4-1** to **4.5.4-3** shall be adhered to. For other applications, different heat treatments (e.g. normalizing, quenching and tempering) shall be determined by the manufacturer and be checked by the authorized inspector as regards the suitability of the weld filler metals and welding consumables for this purpose. These parameters may be specified e.g., to correspond to Section 4.5.4 and the pertinent VdTÜV Material Sheets.

(2) The test coupons shall be annealed in the furnace, if possible, in one passage or section by section. Heat treatment of individual test specimens is not permitted. The heat treatment shall be documented by monitoring diagrams.

(3) In the case of stress relief annealing and tempering, the rate of heating and cooling shall not exceed 100 K/h above a temperature of 300 °C up to the heat treatment temperature.

Wire electrode diameter mm	Welding current A	Welding voltage V	Welding speed cm/min	Energy per unit length kJ/cm	Preheat and interpass temperatures °C
4	approx. 620	flux-specific	approx. 40	28 to 32	175 to 225
	approx. 500		approx. 55	14 to 16	125 to 175

Table 4.6.2-1: Welding data reference values for the production of weld joint test coupons - Submerged arc welding -

Wire electrode diameter mm	Welding position	Welding current A	Welding voltage [1] V	Welding speed cm/min	Energy per unit length kJ/cm	Preheat and interpass temperatures °C	Contact tip distance mm
1.2	PA	280 ± 10	26 to 31 [1]	40 to 45	9 to 13	125 to 175	20
	PF	140 ± 10	19 to 21	as in practice	–		12 to 15
For other electrode diameters and welding conditions outside the verified range of energy per unit length - in particular in the range of the short arc – the welding data shall be laid down by the manufacturer and be checked by the authorized inspector.							
[1] Depending on chemical composition of the shielding gas.							

Table 4.6.2-2: Welding data reference values for the production of weld joint test coupons
- Metal inert gas arc welding with solid wire -

Wire electrode diameter mm	Welding position	Welding current A	Welding voltage [1] V	Welding speed cm/min	Energy per unit length kJ/cm	Preheat and interpass temperatures °C	Contact tip distance mm
1.2	PA	250	23 to 28 [1]	35 to 45	9 to 12	125 to 175	20
	PF	120	21 to 25 [1]	as in practice	–		10 to 15
1.4	PA	280 ± 10	26 to 31 [1]	35 to 45	9 to 14		20
	PF	140 ± 10	19 to 21	as in practice	–		15 to 20
1.6	PA	300	25 to 30 [1]	35 to 45	10 to 15		25
2.0		350		40 to 50	11 to 16		
2.4		400		45 to 50			
[1] Depending on chemical composition of the shielding gas.							

Table 4.6.2-3: Welding data reference values for the production of weld joint test coupons
- Metal inert gas arc welding with flux cored electrodes -

4.6.4 Test conditions and test specimen forms

4.6.4.1 Non-destructive examination

(1) Following a possibly required heat treatment and prior to the machining the test specimens, all test coupons shall be subjected to a radiographic examination and, where required, to a surface examination in accordance with AD 2000-Merkblatt HP 5/3.

(2) The NDT operators shall have been qualified and certified to DIN EN ISO 9712 in the product sector “welded products” for the applicable examination procedure. For radiographic examinations at least level 2 qualification and certification is required.

4.6.4.2 Type of test specimens

The test specimens to be removed from the test coupons are specified in **Tables 4.5.4-1** to **4.5.4-3**.

4.6.4.3 Chemical composition

The chemical composition of the weld metal shall be determined. Apart from the determination of the alloying constituents, the companion and trace elements shall be specified in accordance with Section 4.5.5.7. The test specimens shall be taken from the middle of the weld metal.

4.6.4.4 Tensile test at room temperature

For flat tensile test specimens, the test specimen cross section shall be as large as possible. They shall be taken transversely to the weld and shall have a thickness of at least 10 mm; they shall be tested at room temperature in accordance with DIN EN ISO 4136. Deviating from the requirements of this standard a test length L_c = weld width + 80 mm shall be used in order to adequately cover the base metal, junction and weld metal. The tensile strength, fracture location and, as far as possible, yield strength shall be determined. In addition, the progress of elongation shall be documented (e.g. by photos) over the test length at intervals of 5 mm. Two test specimens shall be tested for each test coupon and heat treatment lot.

4.6.4.5 Bend test

Bend test specimens shall be taken transversely to the weld and shall be subjected to a face and a root bend test. The test shall be carried out in accordance with DIN EN ISO 5173. The bending strain shall be determined at symmetric intervals of 5 mm and shall be documented (e.g. by photos). The bend test shall cover the entire thickness of the welded test coupon. In the event of thicknesses exceeding 30 mm, several test specimens may be arranged one above the other. A total of four test specimens shall be tested for each test coupon.

4.6.4.6 Notched bar impact test

(1) For each test temperature, one set of impact test specimens (3 V-notch specimens) shall be taken in the VWT position from the middle of the weld metal in accordance with DIN EN ISO 9016 where a 2 mm radius striker shall be used. The absorbed energy (KV_2) shall be determined; in the case of ferritic materials, the lateral expansion and the ductile fracture portion to DIN EN ISO 148-1 shall additionally be determined.

(2) The following shall apply to the determination of the KV_2-T curves:

a) The complete KV_2-T curve for ferritic-perlitic materials

   The temperatures to be used shall be 33 °C and 80 °C. At least three further temperatures shall be specified such that both the upper shelf and lower shelf are covered (90 % and 10 % ductile fracture portion). The extent of the notched bar impact test shall be as specified in **Tables 4.5.4-1** and **4.5.4-2**.

   In the case of weld filler metals and welding consumables which are intended for the containment vessel, one of the test temperatures shall be 5 °C.

b) Partial KV_2-T curve

   In addition to the 33 °C temperature, at least three other temperatures shall be specified such that the upper shelf and transition temperature range are covered.

c) In the case of austenitic weld filler metals the specifications of **Table 4.5.4-3** apply.

4.6.4.7 Pellini drop weight test

For the determination of the NDT temperature of ferritic materials, drop weight tests in accordance with SEP 1325 shall be carried out on six P2 test specimens transversely to the weld. The notch shall be located on the cover pass side in the middle of the weld metal.

4.6.4.8 Metallographic examination

The metallographic examination shall be carried out on macrosections and microsections transverse to the weld. Both the weld metal and the area of dilution in the weld metal shall be investigated and documented by photomicrographs (as a rule, 200 fold enlargement). In the case of ferritic materials, both recrystallized and non-recrystallized coarse grain regions shall be documented.

4.6.4.9 Hardness test

A hardness test shall be carried out in accordance with DIN EN ISO 9015-1 on structural microsections transverse to the weld (in general, HV 10). The test shall cover the base metal, transition zone and weld metal from the upper and lower edges of the weld and from the middle of the weld.

4.6.4.10 Determination of diffusible hydrogen

(1) The content of diffusible hydrogen shall be determined in accordance with DIN EN ISO 3690 for the all-weld metal of ferritic weld filler metals, manufactured with wire-flux combinations for submerged arc welding, as well as for rod and flux cored electrodes from two production units each.

(2) In order to demonstrate that weld filler metals and welding consumables are capable of being stored, the manufacturer shall carry out rebaking tests which should furnish the rebaking recommendations for further processing.

4.6.4.11 Test for susceptibility to cracking

(1) The tests for susceptibility to cracking shall be carried out in accordance with DIN EN ISO 17641-2 and shall cover the most unfavourable composition of the spectrum of base metals within the range of application. In the case of coated rod electrodes of types B and RB, which are used for the welding of unalloyed steels as well as the materials 16Mo3 and the fine-grain steels with yield strengths of 235 MPa to 355 MPa, the test for susceptibility to cracking may be waived. When testing weld filler metals to DIN EN ISO 3580 or DIN EN ISO 21952, the test coupon shall be as depicted in Figure 1 type A of DIN EN ISO 17641-2. Within the range of application, at least the material that is most susceptible to hot cracking shall be tested.

(2) For austenitic weld filler metals, where the delta ferrite content of the weld metal is 3 % or less (determination to Section 4.5.5.8), and for weld filler metals of nickel alloys, the ring segment specimen shall be used (see **Annex E**).

4.7 Investigations of weld claddings and hardfacings

4.7.1 Austenitic and nickel alloy weld claddings on ferritic base metals

(1) With respect to weld claddings, the same welding principles shall be observed as in the production of butt welds.

(2) Weld claddings shall be tested to the extent shown in **Table 4.7.1-1**. Hardness testing shall be made to DIN 32525-4.

(3) If the strength properties of weld claddings are to be made part of the calculations, the necessary characteristic data shall be determined in a welding procedure qualification test adapted to the part in question with respect to welding data and heat treatment.

(4) The requirements of DIN EN 14532-1, Section 4.6.1, shall apply to the dimensions of the test coupons. If the weld filler metal for weld claddings is to be used for wall thicknesses greater than 50 mm, the annealing time shall be 50 h at 550 °C and additionally about 50 h at the highest scheduled annealing temperature T_{max} of the substrate. In the case of special conditions of application the annealing conditions to be used shall be individually specified.

Note:
In the case of substrates which are quenched and tempered and subsequently stress-relieved, T_{max} is the hardness temperature.

4.7.2 Weld filler metals for hardfacing

One test coupon shall be manufactured in accordance with **Figure 4.7.2-1**. The number of passes shall be the same like for the intended application. The base metals intended for the range of application shall be used. The hardfacing shall be subjected to a surface examination by means of liquid-penetrant examination and to a hardness test to DIN 32525-4.

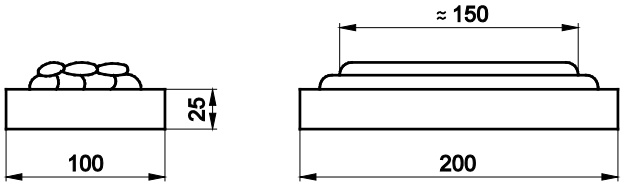


Figure 4.7.2-1: Test coupon for hardfacings

	Chemical composition [1]	Delta ferrite content in the middle of the pass	Resistance to IGC in 2 mm depth	Macrostructure	Microstructure	Transverse bend test specimen to Fig. 1 and Fig. 2 of DIN EN ISO 5173 [5]	Side-bend test specimen to Fig. 3 of DIN EN ISO 5173 [5]	Liquid penetrant examination	Hardness test
1st pass [3] [4]	Layer analysis	u, b [2]	—	yes	u, b [2]			—	Hardness test HV 1 u, b [2]
Cover pass			u, b [2]					u, b [2]	

u : untreated
b : annealing: 20 h at T_{max}; however, for s greater than 50 mm: 50 h at 550 °C + 50 h at T_{max}

1) Additional analyses and delta ferrite calculations are needed for all-weld metals (DIN EN ISO 6847).
2) If the qualification test is applied for with respect to one annealing condition only, the test shall be carried out for this condition only.
3) For manual arc welding, the lap boundaries shall be examined, and the overlapping range shall be determined by the manufacturer and be checked by the authorized inspector.
4) For manual arc welding, the 3.25 mm and maximum electrode diameters shall be examined.
5) Unmachined surface.

Table 4.7.1-1: Testing scope for weld claddings

4.8 Special tests

4.8.1 Test for resistance to intergranular corrosion

In the case of austenitic weld filler metals, the test for resistance to intergranular corrosion shall be carried out in accordance with DIN EN ISO 3651-2 on test specimens with intersecting butt welds, taking the heat treatment conditions specified in the range of application into consideration. Other testing methods (e.g. Huey test in accordance with DIN EN ISO 3651-1, hydrochloric acid test, modified Streicher test in accordance with SEP 1877) may be used in the case of special corrosion conditions, special materials and the related weld filler metals.

4.8.2 Liquid metal embrittlement

If the weld filler metal contains copper as an alloying constituent, or if a copper content of more than 0.3 % is found in the weld metal, special tests (e.g. metallographic examinations) shall be agreed upon.

4.9 Requirements regarding mechanical properties of all-weld metal and the weld metal of welded joints

(1) Basically, all-weld metal shall meet the requirements of the pertinent classifying standard.

(2) The minimum requirements to be met by the base metals shall basically also be met by the weld metals of welded joints.

(3) Notwithstanding this requirement, the following shall apply to all-weld metal and the weld metal of welded joints:

a) The elongation at fracture in austenitic weld metal shall be at least 30 %.
b) The impact energy in notched-bar impact testing of austenitic weld metal at room temperature shall be at least 70 J (individual values at least 60 J) in the unannealed or solution annealed condition and be at least 55 J (individual values at least 40 J) in the stress relief annealed condition.
c) For W II materials the average value of impact energy in notched-bar impact testing shall not be less than 41 J at 0 °C. Only one individual value may be less than required, but shall not be less than 29 J.

5 Workability of weld filler metals

The workability of the weld filler metals shall be assessed during production of the weld connections in accordance with Section 4.6. In particular, the properties shall be described in accordance with Section D 3. Corrective changes and grinding during welding shall be documented in the welding record.

6 Limitation of the range of application

6.1 General

Following the tests of the weld filler metal, the range of application shall be specified in accordance with the following Sections. The range of application shall be summarised in the weld filler metals data sheet (see **Annex A**).

6.2 Physical dimensions

The physical dimensions of the core rod, rod, wire and flux cored wire diameters produced or of the strip-type electrodes shall be specified by the manufacturer. When defining the limits, the indications in clause 4.6.2.6 shall be observed, and all dimensions to be verified shall have been welded as a single weld connection or weld cladding.

6.3 Shielding gases and backings

(1) The shielding gases and backings used shall be indicated.

(2) With respect to the range of application for inert gases, the classification into groups to DIN EN ISO 14175 shall be observed.

6.4 Base metals

The range of application regarding the base metals to be welded shall be specified such that the mechanical, physical and chemical properties of the base metals are compatible with the results of the tests performed on the weld metal and weld connection.

6.5 Heat treatment

The allowable heat treatment conditions shall be fixed on the basis of the values determined during testing of the weld metal for the materials used in the range of application.

6.6 Wall thickness, thickness of weld claddings and hardfacings

(1) The largest test coupon thickness used in qualification testing will govern the range of application in dependence of the welding process and the type of consumable as per **Table 6.6-1**.

(2) The thickness of weld claddings and hardfacings shall generally be specified, on the basis of the number of passes used in the test coupons.

6.7 Type of current and polarity

The type of current and polarity shall be specified in accordance with the results of the suitability test.

Welding process to DIN EN ISO 4063	Rod electrode type/flux	Maximum wall thickness to be certified
111	R, RR, RA	1.5 · thickness of welded test coupon ≤ 30 mm
	B, RB	no limitation
141		1.5 · thickness of welded test coupon
		for non-ferrous metals, maximum thickness of welded test coupon unlimited for root welding
131, 135, 136, 138		1.5 · thickness of welded test coupon
121 to 125	FB, AB	no limitation
	other fluxes	1.5 · thickness of welded test coupon

AB : aluminate basic FB : fluoride-basic
B : basic-coated R : rutile-coated
RA : rutile acid-coated RB : rutile-basic-coated
RR : thick rutile-coated

Table 6.6-1: Maximum wall thickness to be certified in dependence of the welding process and consumable used

6.8 Welding positions

6.8.1 General

The welding positions shall be specified in accordance with the results of the qualification test. In this respect, Section 4.6.2.4 shall be considered.

6.8.2 Coated rod electrodes

In the case of coated rod electrodes, the welding positions shall be specified in accordance with the nature of the coating and in compliance with the applicable product standard.

6.8.3 Flux cored and wire electrodes

The welding positions shall be specified as a function of the corresponding welding process.

6.9 Root weldability

The possibility of one-sided root welding shall be indicated.

6.10 Maximum operating temperature

(1) The temperature range shall normally be in compliance with that specified for the base metal.

(2) In addition, the following data shall be observed in the case of austenitic weld filler metals:

a) 0,04 % ≤ C ≤ 0,07 % in the weld metal, unstabilized: max. 300 °C

b) interpass in the case of claddings: same as base metal or cladding cover pass

c) ferritic/austenitic compounds, austenitic weld filler metal: max. 300 °C

6.11 Minimum operating temperature

(1) The temperature range shall normally be in compliance with that specified for the base metal.

(2) The temperature to be specified as minimum operating temperature shall be that for which the verification resulted in adequate toughness values in both the weld metal and weld connection.

6.12 Design strength value

If the weld metal has a lower yield strength or proof stress than the base metals specified in the range of application, the corresponding design strength value shall be specified.

6.13 Corrosion resistance

The standards or examination guidelines on which the examinations for corrosion resistance are based as well as the heat treatments performed, if any, shall be indicated.

6.14 Special tests

Special tests, e.g. for resistance to ageing, shall be specified in the weld filler metal data sheet (**Annex A**) in the column entitled “Remarks”.

7 Supplementary tests

7.1 Extending the range of application

If the range of application of qualification testing is to be extended, supplementary tests shall be specified in due consideration of Sections 4.4 to 4.8.

7.2 Modification of the weld filler metal

If the weld filler metal tested is modified with respect to the limits specified by the manufacturer in the data sheet, it shall be laid down in due consideration of Sections 4.4 to 4.8 to what extent supplementary tests will be required.

8 Certificates

8.1 Preliminary certificate

Upon the successful completion of the tests required for a preliminary certificate, the authorized inspector shall issue a preliminary data sheet with respect to the qualification test of weld filler metals and welding consumables (see sample in **Annex A**) which is to be handed over to the manufacturer as preliminary certification of the test.

8.2 Test report

(1) A test report shall be prepared on the tests performed on weld filler metals and welding consumables. The results obtained in the various tests shall be specified and evaluated on the basis of the requirements valid with respect to the intended range of application.

(2) The test report shall provide information on the validity of the qualification test as well as the number of plant-internal tests which are necessary for the extension of validity. The manufacturer shall be notified of the obligation that his statements concerning a qualification test must be in agreement with the results of the test report.

8.3 Final certificate

(1) Upon completion of the qualification test, including statistical and possibly long-term tests, and upon submission of the test report to the manufacturer, the preliminary data sheet becomes invalid to be replaced by a final one.

(2) The qualification test remains valid for a maximum period of one year. Any validity beyond this period shall be as indicated in the list of qualification-tested weld filler metals and welding consumables (Editor: VdTÜV, Berlin) which is published quarterly.

9 Transfer of qualification test

(1) The principles for the transfer of qualification tests of weld filler metals and welding consumables shall be in accordance with Section 9 of VdTÜV-Merkblatt Schweißtechnik 1153.

(2) If a company intends to distribute under its own trade name a weld filler metal or welding consumable that has already been subjected to a qualification test elsewhere, it shall file a written application to this effect with the authorized inspector who carried out the qualification test.

(3) Both the manufacturer and the supplier shall confirm to the above-mentioned authorized inspector in writing that the identity conditions of the weld filler metal or welding consumable as qualification-tested and supplied are unambiguous and that the authorized inspector issuing the certificate will be immediately notified upon termination of the agreement between the two contracting parties. A binding example for this declaration of identity is shown in **Annex B**.

(4) The supplier shall receive a certificate on the qualification test of the weld filler metal or welding consumable. The supplier shall not combine products originating from several manufacturers under a single trade name.

10 Extension of the validity of the qualification test

10.1 General

The principles for the continuous surveillance of manufacturers and suppliers shall be in compliance with Section 10 of VdTÜV-Merkblatt Schweißtechnik 1153.

10.2 Conditions

The authorized inspector shall extend the validity of the qualification test for weld filler metals or welding consumables by one year at a time provided the following tests and examinations are documented by the manufacturer’s fabrication-independent quality assurance unit:

a) Receiving inspection by verification of the certificates accompanying the consignment and by tests in accordance with Sec. 4.1 of KTA 1408.2 as well as documentation of these measures.

   The authorized inspector shall satisfy himself of the proper performance of the receiving inspection.

b) Surface examination, check of drying, identification marking and physical dimensions as well as performance of weldability tests, if any, together with the documentation of the results (including negative results) and the intervals of tests and examinations.

   The above-mentioned tests and examinations shall be carried out as in-process inspections.

c) Test and examinations of the finished products in accordance with **Annex C**, in which case

ca) the chemical composition shall satisfy the respective classifying standard and the additionally restricted limit values of **Annex F**,

cb) the tolerances as per Annex F referred to the typical analysis given by the manufacturer shall be adhered to.

d) The fabrication-independent quality assurance unit shall regularly take random samples (at least once a day) in order to ensure that the material is properly packaged. These inspections (including negative results) shall be documented.

e) Review of the suppliers

The suppliers shall be checked yearly for

ea) clear assignment of trade names of the delivered products to the product manufacturers, the manufacturers' trade names and their qualification tests to KTA 1408.1 (data sheet no.),

eb) proof of the yearly check at the manufacturer's works,

ec) documentation, purchase specification, orders, receiving inspections, certificates issued, if any, for delivered products,

ed) orderly and proper storage of welding consumables under controlled conditions with recording of temperature and humidity,

ee) condition of stored products (packaging, identification marking and freedom from damage).

Annex A

Data sheets for weld filler metals

Data sheet for weld filler metals	1	Manufacturer/Supplier	2	Data sheet number

3	Weld filler metal			Manufacturer's specifications
4	Trade name			
5	Type			
6	Diameter range mm	7	Consumables	

The continued validity of this data sheet is certified by the latest edition of the CD ROM "Welding consumables quality-tested by TÜV".

8	Test requirements			
9	Materials and heat treatment			
10	Root weldability demonstrated / not demonstrated			1)
11	Wall thickness max. mm	12	Current type and polarity G^+ / G^- / W	1)
13	Welding position to DIN EN ISO 6947			
14	Highest short-time operating temperature / as for base metal, but not exceeding °C Highest long-time operating temperature max. °C			1)
15	Lowest operating temperature / as for base metal, but not lower than °C			1)
16	Design strength value / as for base metal / max. If used in the long-time range:			1)
17	Resistance to intergranular corrosion demonstrated to			
18	Remarks			

Explanations	U : unannealed S : stress relief annealed N : normalized	L : solution annealed and quenched A : tempered V : quenched and tempered	St: stabilized W: soft annealed	G^+ : DC positive pole G^- : DC negative pole W : AC

1) Delete if not applicable

Compiled from information as provided by:

Editor: VdTÜV, Berlin

Page 2 Data sheet for weld filler metals no.

The qualification test was carried out on the basis of the following requirements:

1. Chemical composition of the weld metal (content by mass percentage)

	C	Si	Mn	P	S					
Min.										
Max.										

2. Tensile test of the weld metal

Heat treatment	Test temperature °C	Yield strength R_{eL} MPa	0.2 % proof stress $R_{p0.2}$ MPa	1.0 % proof stress $R_{p1.0}$ MPa	Tensile strength R_m MPa	Elongation at fracture A %	Reduction of area Z %

3. Notched bar impact test of the weld metal

Heat treatment	Test temperature °C	Test specimen form	Absorbed impact energy KV_2 Joule

4. Remarks

Data sheet for weld filler metals	1 Manufacturer/Supplier	2 Data sheet number

3	Weld filler metal **WIRE FLUX/ STRIP FLUX COMBINATION**			Manufacturer's specifications
4	Wire / strip trade name:	5	Flux trade name:	
6	Wire / strip type:	7	Flux type:	
8	Flux manufacturing method:	9	Flux grain size:	

As a result of the qualification test carried out, this wire-flux or strip-flux combination which has the welding parameters specified in 12 below is deemed to have been tested within the following limits of application.

The continued validity of this data sheet is certified by the latest edition of the CD ROM "Welding consumables quality-tested by TÜV".

Unless specified otherwise in 20 below, the suitability test refers to the welding position PA.

10 Test requirements

11 Materials and heat treatment

12 The range of application specified in 11 above was specified in compliance with the following welding parameters used for the all-weld metal in the case of wire flux combinations and for the cladding in the case of strip flux combinations.

Wire diameter mm	**Current** A	**Voltage** V	**Equipment feed** cm/min	**Working temperature** °C

13 Weld build-up: suitable for single-pass / multi-pass / fillet welds [1)]

14 Wall thickness max. mm

15 Current type and polarity G^+ / G^- / W [1)]

16 Highest short-time operating temperature / as for base metal, but not exceeding °C [1)]

Highest long-time operating temperature max. °C

17 Lowest operating temperature / as for base metal, but not lower than °C [1)]

18 Design strength values / as for base metal / max. [1)]

If used in the long-time range:

19 Resistance to intergranular corrosion demonstrated to

20 Remarks

Explanations				
	U : unannealed S : stress relief annealed N : normalized	L : solution annealed and quenched A : tempered V : quenched and tempered	St: stabilized W: soft annealed	G^+ : DC positive pole G^- : DC negative pole W : AC

[1)] Delete if not applicable

Compiled from information as provided by:

Editor: VdTÜV, Berlin

Page 2 Data sheet for weld filler metals no.

The qualification test was carried out on the basis of the following requirements:

1. Chemical composition of the weld metal (content by mass percentage)

	C	Si	Mn	P	S					
Min.										
Max.										

2. Tensile test of the weld metal

Heat treatment	Test temperature °C	Yield strength R_{eL} MPa	0.2 % proof stress $R_{p0.2}$ MPa	1.0 % proof stress $R_{p1.0}$ MPa	Tensile strength R_m MPa	Elongation at fracture A %	Reduction of area Z %

3. Notched bar impact test of the weld metal

Heat treatment	Test temperature °C	Test specimen form	Absorbed impact energy KV_2 Joule

4. Remarks

Annex B

Declaration of identity

Transfer of the qualification test of our weld filler metal .....
.....
to the trade name.....
of the company .....

This is to confirm that we are supplying our qualification-tested weld filler metal.....
.....
Data sheet no. .....
to the company .....
.....

The company .....
will supply our above-mentioned weld filler metal under its own trade name .....
.....
The identity statement issued by the company .....
is enclosed.

We commit ourselves to inform you on any termination of our contractual relationship.

Enclosure: 1

Letter from the manufacturer to the competent authorized inspector

Qualification test of our weld filler metal.....
.....

We herewith apply for the transfer of the qualification test of our above-mentioned weld filler metal and inform you that we are purchasing this weld filler metal only from the company.....
.....
The material in question is the trade name .....
.
of the company.....
for which a qualification test has already been carried out as specified in the weld filler metal data sheet no.: .....

We kindly ask for transfer and commit ourselves to inform you immediately on any termination of our contractual relationship.

Letter from the supplier to the authorized inspector responsible for the manufacturer

Annex C

Extent of the tests to be carried out within the scope of the plant internal quality assurance for the validity extension of the qualification tests of weld filler metals and welding consumables

Weld filler metals		Test of the product			Test of the weld metal [1]					Resistance to hot cracking	Resistance to intergranular corrosion
		Chemical composition	Sieve analysis	Verification of the welding behaviour to Annex D	Chemical composition	Tensile test specimens [1]		Sets of notched bar impact test specimens [2]			
						RT	> RT	RT	< RT [4]		
Rod electrodes, flux cored wire electrodes	DIN EN ISO 2560, DIN EN ISO 17632	—	—	for each production unit	10	4	—	4	8	—	—
	DIN EN ISO 3581, DIN EN ISO 17633					—	—	—	—		5
	DIN EN ISO 3580 [5], DIN EN ISO 17634					4	4 [6]	—	4	—	—
	DIN EN ISO 14172					10	—		—	4	
	DIN EN ISO 18275, DIN EN ISO 18276					10	5 [6]		10	—	
	Others [7]					4	—		4		
Arc flux		6	10			4 [8]	—		4 [8]		
Submerged arc wire electrodes, submerged arc strip electrodes, gas shielded wire electrodes, TIG welding rods		Analysis of the chemical composition of the product for each production unit									

1) If less than 20 production units are manufactured, the chemical composition of every 2nd production unit and fifty percent of the tensile and notched bar impact test specimens shall be tested.

2) A set of specimens consists of 3 test specimens.

3) The specimens shall be taken from all-weld metal (rod electrodes: 4 mm diameter / flux cored wire electrodes: 1.2 mm diameter and the maximum diameter as a percentage of production). The test coupon form shall be as specified in DIN EN ISO 15792-1. In as far as this is allowable for the weld metal, the test shall be carried out in the as-welded condition. If heat treatment is basically required, the test shall be carried out in the softest condition (e.g. tempered).

4) Lowest certified temperature. Only if qualification tested for the range of application relating to low temperature toughness. The tests at room temperature are not required.

5) Rod electrodes EMo 1R and EMo 1B are tested as rod electrodes to DIN EN ISO 2560.

6) In as far as temperatures above 350 °C have been certified within the scope of application.

7) If necessary, further tests shall be specified within the scope of the first-time verification.

8) The test specimens shall be removed from 4 all-weld metals which shall be manufactured using a wire associated with the flux with a diameter of 4 mm or the biggest allowable diameter within the scope of application of the qualification test. The test coupon form shall be as specified in DIN EN ISO 15792-1.

Annex D

Verification of the welding behaviour of rod electrodes

D 1 Purpose

The verification of the welding behaviour of rod electrodes is a final inspection within the scope of quality assurance. In general, it is carried out once or several times with respect to each production unit. The verification of the welding behaviour is based on the values from absolutely perfect electrodes, i.e. so called formula specimens which are to be documented for each type of electrode and diameter. The verification of welding behaviour will reveal defects which may have been caused during mass production or during pressing and drying of the electrodes.

D 2 Personnel

The verification of welding behaviour shall be carried out by skilled welders (welder approval to DIN EN ISO 9606-1 or welding instructors). Revalidation of welder qualification shall be performed in accordance with section 9.3 a) or section 9.3 b) of DIN EN ISO 9606-1. Semi-skilled welders may be employed provided they have been trained for a sufficiently long time and are supervised by a skilled welder.

D 3 Performance

(1) If only one verification is carried out per production unit, at least four electrodes shall be subjected to the welding verification. If several verifications are carried out per production unit, at least two electrodes shall be burned off per location of removal. Each electrode shall be burned off down to a stub length of 50 mm. The following properties shall be observed and compared with those of the formula specimens:

a) ignition properties,

b) arc stability,

c) molten weld pool behaviour,

d) slag flow,

e) wetting properties,

f) formation of spatter,

g) slag tailings,

h) outer appearance of slag,

i) outer appearance of weld,

k) degree of penetration.

(2) The verification of welding behaviour is carried out in accordance with burn-off instructions which shall be prepared for each type of electrode. The instructions contain special information on the performance of the verification of welding behaviour, for example

a) base metal and dimensions of the test coupon,

b) form of weld and welding position,

c) type of current and amperage,

d) information on the properties to be obtained such as

da) diameter of coating,

db) outer condition,

dc) arc voltage and

dd) particularly characteristic welding properties.

D 4 Documentation and release

(1) A welding record shall be established of each verification of welding behaviour; this record shall contain the welding data and results obtained as well as any defects or discrepancies which may have been found.

(2) Subsequently, the record shall be evaluated by the head of the quality control unit or by an employee designated by him who will decide whether the production unit is to be approved or rejected or whether supplementary investigations are required.

Annex E

Testing for susceptibility to hot cracking (ring segment specimen)

E 1 General

(1) This testing method applies to weld filler metals made of stainless austenitic chromium-nickel steel with a delta ferrite content of 3 % or less as well as to weld filler metals made of nickel alloys.

(2) The test applies to metal arc welding with rod electrodes as well as to metal and tungsten inert gas welding.

E 2 Test coupon

E 2.1 Test coupon form

The test specimen shall consist of four square segments of equal size into which, on one-side, an annular groove is machined after tack welding is completed on both sides (**Figure E-1**).

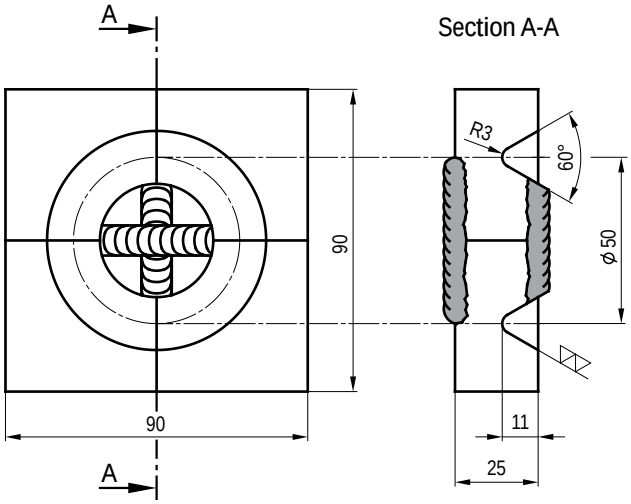


Figure E-1: Test coupon form

E 2.2 Base metals

(1) For the test coupon the base metal X6 CrNiTi 18-10 (material no. 1.4541), X6CrNiNb18-10 (material no. 1.4550) or X6CrNiMoTi17-12-2 (material no. 1.4571) to DIN EN 10088-2 shall be used unless another material is specified in the purchase specification.

(2) Weld filler metals are considered to be “not susceptible to hot cracking” if the test demonstrates that the welds are free from cracks.

E 2.3 Preparation

(1) Four square parts each with a thickness of 25 mm and an edge length of 45 mm shall be prepared such that they can be used to produce the test coupon (**Figure E-1**) by means of tack welding. Rolling scale needs not be removed. The contact surfaces shall be face-ground prior to tack welding.

(2) In the case of combination of different base metals, segments A and C as well as segments B and D shall consist of the same base metal.

E 2.4 Work sequence (Figure E-2)

a) Grind surfaces 1-0 of parts A and B as well as surfaces 3-0 of parts C and D.
b) Clamp parts A and B as well as C and D together.
c) Join parts A and B as well as C and D by tack welds on both sides (25 mm long).
d) Grind surfaces 4-0-2 of tack-welded parts A-B and C-D.
e) Clamp tack-welded parts A-B and C-D together.
f) Join tack-welded parts A-B and C-D by tack welds on both sides (50 mm long).

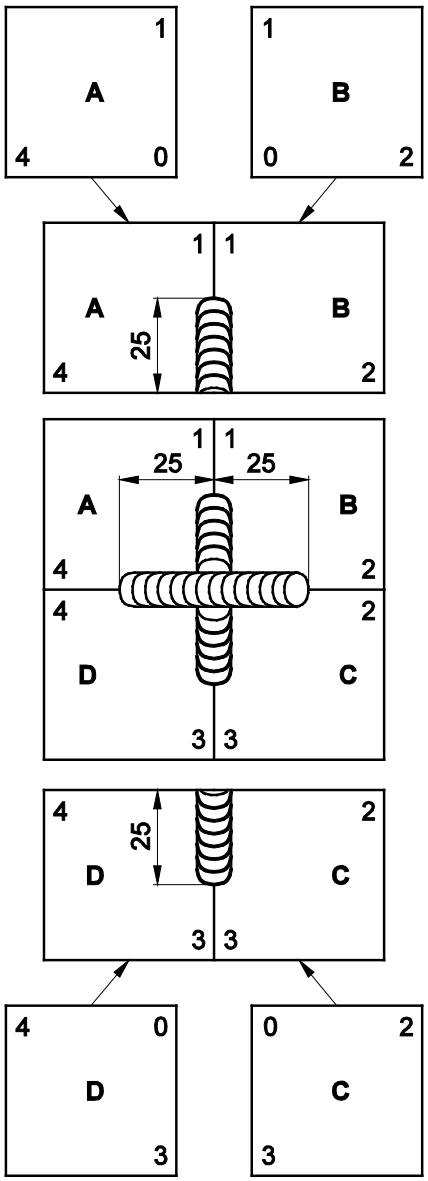


Figure E-2: Preparation of test coupon

E 2.5 Annular groove

After tack welding, an annular groove shall be machined into one side of the test specimen; the dimensions of the groove shall be as indicated in **Figure E-1**. The use of cooling liquids during mechanical processing is not permitted.

E 3 Production of test specimens

E 3.1 Welding conditions

Type of current, polarity and type of inert gas shall be in compliance with the welding conditions under which the weld filler metals to be tested are required to be non-susceptible to hot cracking.

E 3.2 Diameter of the weld filler metal

For the production of the test specimens, the diameters of the weld filler metals to be supplied in accordance with the purchase specification shall be used.

E 3.3 Welding position

The test specimen shall be welded in flat position (PA).

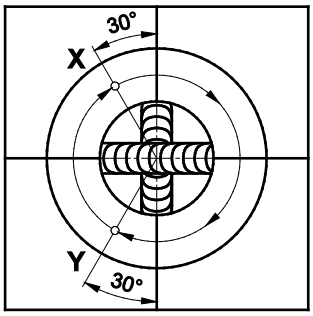


Figure E-3: Welding of test coupon

E 3.4 Welding

Welding shall be carried out clockwise from Point X (**Figure E-3**) to Point Y, without weaving and in an uninterrupted process. After the specimen has cooled down to approximately room temperature and the weld surface and groove have been cleaned, welding shall be restarted clockwise from Point Y to Point X, again without weaving and in an uninterrupted process. The welding speeds for distances X-Y and Y-X shall be specified by the manufacturer depending on the weld filler metal and the welding method.

E 4 Evaluation

(1) After the test specimen has cooled to room temperature, the cleaned annular weld shall be examined for surface cracks by penetrant testing using sensitivity class 4 to section 4.2.2 of DIN EN ISO 3452-2.

(2) After the surface inspection, the specimen shall be broken at the four separation points in order to be able to verify fusion at the root.

E 5 Test report

The test report shall contain the following information:

a) weld filler metals (trade name and DIN designation, production unit),

b) welding consumables (e.g. inert gas),

c) base metal or combinations of base metals,

d) welding process,

e) amount of inert gas,

f) current source, amperage, current type, polarity,

g) average weld thickness, measured from base of groove at three points and rounded to 0.1 mm,

h) test results

ha) If no crack was found - “not susceptible to hot cracking”;

hb) If cracks were found, information on position, direction, number and length of the cracks as well as details of the evaluation;

i) deviations, if any, from the specifications of this Annex;

k) identification of tester and date of testing.

Annex F

Additional requirements (values in mass percentage) regarding the chemical composition of all-weld metal of coated rod electrodes, flux cored wire electrodes and wire flux combinations as well as the chemical composition of massive products

Chemical element		Limit values and tolerance range of the chemical composition [1]			
		Weld filler metals to DIN EN ISO 636, DIN EN ISO 14171, DIN EN ISO 2560, DIN EN 12536, DIN EN ISO 14341, DIN EN ISO 17632 for non alloy and fine grain steels	Weld filler metals to DIN EN ISO 18275, DIN EN ISO 26304, DIN EN ISO 16834, DIN EN ISO 18276 for high-tensile steels	Weld filler metals to DIN EN ISO 3580, DIN EN 12536, DIN EN ISO 17634, DIN EN ISO 21952, DIN EN ISO 24598 for creep-resisting steels	Weld filler metals to DIN EN ISO 3581, DIN EN ISO 14343, DIN EN ISO 17633 for stainless and heat resisting steels
C		≤ 0.10	≤ 0.10	in accordance with standard	
Si		± 0.20	± 0.30	± 0.25	± 0.25
Mn	Mn ≤ 2.5	± 0.25			
	Mn > 2.5	—	—	—	± 0.25
P [3]	Mn ≤ 5.0	≤ 0.030 [2]	≤ 0.025	≤ 0.025	≤ 0.018
	Mn > 5.0 or Cr > 20	—	—	—	≤ 0.025
S		≤ 0.030 [2]	≤ 0.020	≤ 0.025	≤ 0.015
Cr	Cr ≤ 0.8	—	± 0.20	± 0.15	—
	Cr > 0.8 ≤ 3.0			± 0.25	—
	Cr > 3.0 ≤ 7.0		—	± 0.40	—
	Cr > 7.0 ≤ 20			± 0.80	± 0.65
	Cr > 20			—	± 0.80
Cu [3]		≤ 0.30			
Ni [3]	Ni ≤ 2.0	—	± 0.25	± 0.30	± 0.25
	Ni > 2.0 ≤ 6.0			—	± 0.35
	Ni > 6		—		± 0.50 [4]
Mo	Mo ≤ 0.7	—	± 0.15	± 0.15	± 0.15
	Mo > 0.7 ≤ 3.0		—	± 0.20	± 0.25
	Mo > 3.0			—	± 0.40
Nb [3] [5]		—	—	± 0.15	≥ 10 x %C ≤ 1.10
V		—	± 0.10	± 0.10	—
W		—	—		

The requirements of DIN EN ISO 14172 or DIN EN ISO 18274 shall apply for the chemical composition of weld filler metals made of nickel alloys.

[1] The limit values and tolerances of this table shall be adhered to if they present restrictions compared to the classifying standard. Where the table does not show limit values or tolerances, the values specified in the respective classifying standard shall be observed.

[2] The sum of P and S shall not exceed 0.050 %.

[3] For special cases, e.g. the belt-line area, further restrictions may be agreed upon when ordering.

[4] In the case of a manganese content exceeding 5 % the tolerance for nickel shall be ± 1.0 %.

[5] Where used for medium-wetted surfaces of the primary circuit in pressurized-water reactor plants or of the water-steam circuit in boiling-water reactor plants it is not permitted to substitute Nb by Ta.

Annex G

Suitability assessment of weld filler metals and welding consumables in the case of small quantities (application-specific individual material appraisal)

G 1 General

(1) Weld filler metals and welding consumables successfully tested under the conditions laid down in this Annex and certified by an application-specific individual material appraisal shall be regarded as qualification tested as set out in KTA 3201.3, KTA 3211.3 and KTA 3401.3.

(2) Basically, an application-specific individual material appraisal for the suitability assessment of weld filler metals and welding consumables shall follow the requirements of section 4, however, the deviations laid down in this Annex shall apply.

(3) Deviating from the requirements under para. 4.1 (3) the tests may be carried out at the processor's plant in the course of welding procedure qualifications or production control tests.

G 2 Range of application

The application-specific individual material appraisal shall apply

a) within the scope of application covered by the welding procedure qualification or production control test and

b) to the production lot of weld filler metal or welding consumable in question (does not apply to shielding gas).

G 3 Scope of tests and investigations to be carried out

(1) The extent of tests shall be specified depending on the application required and on the later operating conditions. At least

a) investigations of weld connections, weld claddings and hardfacings according to sections 4.6 and 4.7, however, limited to the given case of application (e.g. with regard to the base metals to be welded, to the welding conditions)

and

b) tests for susceptibility to cracking according to section 4.6.4.11.

must be carried out. In addition, the requirements laid down in section 4 shall apply.

(2) The results of mechanical testing obtained in the course of welding procedure qualifications or production control tests may be used for the suitability assessment of weld filler metals and welding consumables.

G 4 Certificates

(1) Upon completion of the suitability assessment the authorized inspector shall establish an individual material appraisal adapted to the designated application.

(2) It is not permitted to establish a data sheet according to **Annex A**.

G 5 Validity

Individual material appraisals according to this Annex will remain valid within their scope of application for an unlimited period of time.

Annex H

Regulations referred to in this Safety Standard

(The references exclusively refer to the version given in this annex. Quotations of regulations referred to therein refer to the version available when the individual reference below was established or issued.)

Atomic Energy Act (AtG)		Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards (Atomic Energy Act) of December 23, 1959 (BGbl. I, p. 814) as Amended and Promulgated on July 15, 1985 (BGBl. I, p. 1565), last amended by article 2 (2) of the law dated 20th July 2017 (BGBl. I 2017, no. 52, p. 2808)
StrlSchV		Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation (Radiation Protection Ordinance) dated 20th July 2001 (BGBl. I p. 1714; 2002 I p. 1459), last amended in accordance with article 10 by article 6 of the law dated 27th January 2017 (BGBl. I p. 114, 1222)
SiAnf	(2015-03)	Safety Requirements for Nuclear Power Plants (SiAnf) as Amended and Promulgated on March 3rd 2015 (BAnz. AT 30.03.2015 B2)
Interpretations on the SiAnf	(2015-03)	Interpretations on the Safety Requirements for Nuclear Power Plants of November 22nd 2012, as Amended on March 3rd 2015 (BAnz. AT 30.03.2015 B3)
KTA 1408.2	(2017-11)	Quality Assurance of Weld Filler Metals and Welding Consumables for Pressure- and Activity-Retaining Systems in Nuclear Power Plants; Part 2: Manufacture
KTA 1408.3	(2017-11)	Quality Assurance of Weld Filler Metals and Welding Consumables for Pressure- and Activity-Retaining Systems in Nuclear Power Plants; Part 3: Processing
KTA 3201.3	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 3: Manufacture
KTA 3211.1	(2017-11)	Pressure- and activity-retaining components of systems outside the primary circuit; Part 1: Materials
KTA 3211.3	(2017-11)	Pressure- and activity-retaining components of systems outside the primary circuit; Part 3: Manufacture
KTA 3401.3	(1986-11)	Steel Reactor Safety Containment; Part 3: Manufacture
DIN EN ISO 544	(2011-06)	Welding consumables - Technical delivery conditions for filler materials and fluxes - Type of product, dimensions, tolerances and markings (ISO 544:2011); German version EN ISO 544:2011
DIN EN ISO 636	(2016-05)	Welding consumables - Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels - Classification (ISO 636:2004); German version EN ISO 636:2015
DIN EN ISO 2560	(2010-03)	Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels. Classification (ISO 2560:2009); German version EN ISO 2560:2009
DIN EN ISO 3580	(2017-08)	Welding consumables - Covered electrodes for manual metal arc welding of creep-resisting steels - Classification (ISO 3580:2017); German version EN ISO 3580:2017
DIN EN ISO 3581	(2016-12)	Welding consumables - Covered electrodes for manual metal arc welding of stainless and heat-resisting steels - Classification (ISO 3581:2016); German version EN ISO 3581:2016
DIN EN ISO 3651-1	(1998-08)	Determination of resistance to intergranular corrosion of stainless steels - Part 1: Austenitic and ferritic-austenitic (duplex) stainless steels - Corrosion test in nitric acid medium by measurement of loss in mass (Huey test) (ISO 3651-1:1998); German version EN ISO 3651-1:1998
DIN EN ISO 3651-2	(1998-08)	Determination of resistance to intergranular corrosion of stainless steels. Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels. Corrosion test in media containing sulfuric acid; German version EN ISO 3651-2:1998
DIN EN ISO 3690	(2012-07)	Welding and allied processes. Determination of hydrogen content in steel arc weld metal (ISO 3690:2012); German version EN ISO 3690:2012

DIN EN ISO 4063	(2011-03)	Welding and allied processes - Nomenclature of processes and reference numbers (ISO 4063:2009, Corrected version 2010-03-01); German version EN ISO 4063:2010
DIN EN ISO 4136	(2013-02)	Destructive tests on welds in metallic materials - Transverse tensile test (ISO 4136:2012); German version EN ISO 4136:2012
DIN EN ISO 5173	(2012-02)	Destructive tests on welds in metallic materials - Bend tests (ISO 5173:2009 + Amd 1:2011); German version EN ISO 5173:2010 + A1:2011
DIN EN ISO 5817	(2014-06)	Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817:2014); German version EN ISO 5817:2014
DIN EN ISO 6507-1	(2006-03)	Metallic materials - Vickers hardness test - Part 1: Test method (ISO 6507-1:2005); German version EN ISO 6507-1:2005
DIN EN ISO 6847	(2013-11)	Welding consumables - Deposition of a weld metal pad for chemical analysis (ISO 6847:2013); German version EN ISO 6847:2013
DIN EN ISO 6892-1	(2017-02)	Metallic materials - Tensile testing - Part 1: Method of test at room temperature (ISO 6892-1:2016); German version EN ISO 6892-1:2016
DIN EN ISO 6892-2	(2011-05)	Metallic materials - Tensile testing - Part 2: Method of test at elevated temperature (ISO 6892-2:2011); German version EN ISO 6892-2:2011
DIN EN ISO 6947	(2011-08)	Welding and allied processes - Welding positions (ISO 6947:2011); German version EN ISO 6947:2011
DIN EN ISO 9015-1	(2011-05)	Destructive tests on welds in metallic materials - Hardness testing - Part 1: Hardness test on arc welded joints (ISO 9015-1:2001); German version EN ISO 9015-1:2011
DIN EN ISO 9016	(2013-02)	Destructive tests on welds in metallic materials - Impact tests - Test specimen location, notch orientation and examination (ISO 9016:2012); German version EN ISO 9016:2012
DIN EN ISO 9606-1	(2013-12)	Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1:2012, including Cor 1:2012); German version EN ISO 9606-1:2013
DIN EN ISO 9712	(2012-12)	Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712:2012); German version EN ISO 9712:2012
DIN EN 10088-2	(2014-12)	Stainless steels. Part 2: Technical delivery conditions for sheet/plate and strip for general purposes; German version EN 10088-2:2014
DIN EN 10204	(2005-01)	Metallic products; Types of inspection documents; German version EN 10204:2004
DIN EN 12074	(2000-07)	Welding consumables - Quality requirements for manufacture, supply and distribution of consumables for welding and allied processes; German version EN 12074:2000
DIN EN 12536	(2000-08)	Welding consumables - Rods for gas welding of non alloy and creep-resisting steels - Classification; German version EN 12536:2000
DIN EN ISO 13916	(1996-11)	Welding - Guidance on the measurement of preheating temperature, interpass temperature and preheat maintenance temperature (ISO 13916:1996); German version EN ISO 13916:1996
DIN EN ISO 14171	(2016-12)	Welding consumables - Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non alloy and fine grain steels - Classification (ISO 14171:2016); German version EN ISO 14171:2016
DIN EN ISO 14172	(2016-02)	Welding consumables - Covered electrodes for manual metal arc welding of nickel and nickel alloys - Classification (ISO 14172:2015); German version EN ISO 14172:2015
DIN EN ISO 14174	(2012-05)	Welding consumables - Fluxes for submerged arc welding and electroslag welding - Classification (ISO 14174:2012); German version EN ISO 14174:2012
DIN EN ISO 14175	(2008-06)	Welding consumables - Gases and gas mixtures for fusion welding and allied processes (ISO 14175:2008); German version EN ISO 14175:2008
DIN EN ISO 14341	(2011-04)	Welding consumables - Wire electrodes and deposits for gas shielded metal arc welding of non alloy and fine grain steels - Classification (ISO 14341:2010); German version EN ISO 14341:2011
DIN EN ISO 14343	(2017-08)	Welding consumables - Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels - Classification (ISO 14343:2017); German version EN ISO 14343:2017
DIN EN 14532-1	(2005-02)	Welding consumables - Test methods and quality requirements - Part 1: Primary methods and conformity assessment of consumables for steel, nickel and nickel alloys; German version EN 14532-1:2004

DIN EN 14532-2	(2005-02)	Welding consumables - Test methods and quality requirements - Part 2: Supplementary methods and conformity assessment of consumables for steel, nickel and nickel alloys; German version EN 14532-2:2004
DIN EN 14610	(2005-02)	Welding and allied processes - Definitions of metal welding processes; Trilingual version EN 14610:2004
DIN EN ISO 15792-1	(2012-01)	Welding consumables - Test methods - Part 1: Test methods for all-weld metal test specimens in steel, nickel and nickel alloys (ISO 15792-1:2000 + Amd 1:2011); German version EN ISO 15792-1:2008 + A1:2011
DIN EN ISO 16834	(2012-08)	Welding consumables - Wire electrodes, wires, rods and deposits for gas-shielded arc welding of high strength steels - Classification (ISO 16834:2012); German version EN ISO 16834:2012
DIN EN ISO 17632	(2016-05)	Welding consumables - Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels - Classification (ISO 17632:2015); German version EN ISO 17632:2015
DIN EN ISO 17633	(2011-03)	Welding consumables - Tubular cored electrodes and rods for gas shielded and non-gas shielded metal arc welding of stainless and heat-resisting steels - Classification (ISO 17633:2010); German version EN ISO 17633:2010
DIN EN ISO 17634	(2015-12)	Welding consumables - Tubular cored electrodes for gas shielded metal arc welding of creep-resisting steels - Classification (ISO 17634:2015); German version EN ISO 17634:2015
DIN EN ISO 17641-2	(2016-03)	Destructive tests on welds in metallic materials - Hot cracking tests for weldments - Arc welding processes - Part 2: Self-restraint tests (ISO 17641-2:2015); German version EN ISO 17641-2:2015
DIN EN ISO 18274	(2011-04)	Welding consumables - Solid wire electrodes, solid strip electrodes, solid wires and solid rods for fusion welding of nickel and nickel alloys - Classification (ISO 18274:2010); German version EN ISO 18274:2010
DIN EN ISO 18275	(2012-07)	Welding consumables - Covered electrodes for manual metal arc welding of high-strength steels - Classification (ISO 18275:2011); German version EN ISO 18275:2012
DIN EN ISO 18276	(2017-07)	Welding consumables - Tubular cored electrodes for gas-shielded and non-gas-shielded metal arc welding of high strength steels - Classification (ISO 18276:2017); German version EN ISO 18276:2017
DIN EN ISO 21952	(2012-08)	Welding consumables - Wires electrodes, wires, rods and deposits for gas-shielded arc welding of creep-resisting steels - Classification (ISO 21952:2012); German version EN ISO 21952:2012
DIN EN ISO 24598	(2012-08)	Welding consumables - Solid wire electrodes, tubular cored electrodes and electrode-flux combinations for submerged arc welding of creep-resisting steels - Classification (ISO 24598:2012); German version EN ISO 24598:2012
DIN EN ISO 26304	(2011-11)	Welding consumables - Solid wire electrodes, tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels - Classification (ISO 26304:2011); German version EN ISO 26304:2011
DIN 32525-4	(2010-05)	Welding consumables - Testing of welding consumablesby means of weld metal specimens- Part 4: test piece for determining the hardness for surfacing
DIN 50125	(2016-12)	Testing of metallic materials - Tensile test pieces
AD 2000-Mbl. HP 5/3	(2015-04)	Manufacture and testing of joints - Non-destructive testing of welded joints
AD 2000-Mbl. HP 7/3	(2015-04)	Heat treatment - Austenitic steels
SEP 1325	(1982-12)	Drop-weight test to W.S. Pellini
SEP 1877	(1994-07)	Test of the resistance of high-alloy, corrosion-proof materials against intercrystalline corrosion
VdTÜV Merkblatt Schweißtechnik 1153	(2012-10)	Guidelines for the suitability testing of welding filler materials; Welding Technology 1153