Safety Standards

of the
Nuclear Safety Standards Commission (KTA)

KTA 3211.3 (2017-11)

Pressure- and activity-retaining components of systems outside the primary circuit
Part 3: Manufacture

(Druck- und aktivitätsführende Komponenten von Systemen außerhalb des Primärkreises; Teil 3: Herstellung)

Please note:
This translation includes the correction published in BAnz of April 24th, 2019.

Previous versions of this safety standard were issued 1990-06, 2003-11 and 2012-11

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

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KTA SAFETY STANDARD

November 2017	Pressure- and activity-retaining components of systems outside the primary circuit; Part 3: Manufacture	KTA 3211.3

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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.

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) No. 2.1 of the Safety Requirements for Nuclear Power Plants, among other things, sets high requirements for the quality assurance and reliability of fabrication, Furthermore, requirement no. 3.1 requires the use of qualified materials as well as the safeguarding and maintenance of quality features during fabrication. The safety requirement no. 3.4 sets further design and fabrication requirements for the pressure-retaining walls of components outside the primary circuit. Safety standard KTA 3211.3 serves the specification of detailed measures which shall be used to meet these requirements within the scope of its application. For this purpose, a large number of standards from conventional engineering, in particular DIN standards, are also used; these are specified in each particular case. For the pressure and activity retaining components of systems outside the primary circuit the requirements of the aforementioned safety criteria are further substantiated in conjunction with the following Safety Standards

KTA 3211.1 Materials and Product Forms,

KTA 3211.2 Design and Analysis,

KTA 3211.4 In-service Inspections and Operational Monitoring, and

KTA 3206 Break Preclusion Verifications for Pressure-Retaining Components in Nuclear Power Plants.

(3) KTA 3211.3 specifies the detailed requirements to be met by

a) the organizations involved in manufacture,

b) weld design, performance of welding, heat treatment and shaping of the components in consideration of the materials and the type of welded connections,

c) the demonstration and inspection procedures for attaining and maintaining the required quality of the components such as procedure qualification, production control and non-destructive tests as well as fabrication supervision and final inspection,

d) the preparation of documents concerning manufacture and the documentation of the results of tests and inspections conducted within the scope of manufacture.

1 Scope

(1) This safety standard applies to the manufacture of pressure-retaining walls of pressure and activity-retaining systems and components of light water reactors which are not part of the reactor coolant pressure retaining boundary and which are specifically significant in terms of reactor safety. This is the case, if one of the following criteria is fulfilled:

a) The plant component is needed to cope with incidents with regard to shutdown, maintenance of long-term subcriticality and direct residual heat removal. Requirements to be met by components in systems which only indirectly serve residual heat removal, i.e. the non-activity-retaining closed cooling water systems and service water systems, shall be specified in a plant-specific manner, taking into consideration the redundant design (e.g. redundancy, diversity).

b) If the plant component fails, great amounts of energy are released and the consequences of failures are not limited by structural measures, physical separation or other safety measures to an extent which is reasonable in terms of nuclear safety.

c) The failure of the plant component may lead, either directly or in a chain of assumed consequential events, to an incident as defined in Sec. 49 of the Radiological Protection Ordinance.

(2) The following components are within the scope of this safety standard:

a) pressure vessels,

b) pipes and pipe components,

c) pumps and

d) valves

including the integral areas of the component supports.

(3) This safety standard shall not apply to:

a) pipes and valves equal to or smaller than DN 50,

b) internals of the components (which are not part of the pressure-retaining wall) and accessories,

c) systems and plant components performing auxiliary functions for the systems dealt with by this safety standard,

d) subsystems whose system pressure is determined exclusively by the static head in the suction area,

e) parts used for the transmission of forces and power in pumps and valves as well as tests to demonstrate functional capability,

f) the leakage, pressure and functional tests to be conducted within the scope of commissioning of the plant as well as cleanliness inspections,

g) weld filler metals and welding consumables.

2 Definitions

Note:
The definitions of DIN EN ISO 5577 shall apply to ultrasonic testing.

(1) Deposition welding

Deposition welding is the coating (see DIN 8580) of a workpiece by means of welding, where e.g. distinction is to be made between base metals and surfacing materials (see DIN EN 14610, DIN 1910-11 and DIN 1910-100):

a) deposition welding of hard surfaces (weld hardfacing) using a surfacing material different from the base metal with a preferably higher degree of wear resistance,

b) deposition welding of claddings (weld cladding) using a surfacing material different from the base metal with a preferably higher degree of chemical resistance,

c) deposition welding of buttering layers (buttering) using a surfacing material with characteristics that make a load-resisting fusion between dissimilar materials possible,

d) deposition welding for shaping purposes (shape welding) using a surfacing material which is similar to the base metal.

(2) Sub-unit

A sub-unit is part of a component and consists of at least two parts.

(3) Part

A part is the smallest item of a sub-unit manufactured from product forms or of a prefabricated part of a pipe (spool).

(4) Allowable operating temperature

The allowable operating temperature is the maximum or minimum wall temperature of the plant component, specified for safety purposes.

(5) Maximum allowable working pressure

The maximum allowable working pressure is the highest working pressure specified for safety purposes.

(6) Echo height evaluation

Echo height evaluation means the evaluation of indications by comparing the echo amplitude (signal amplitude of the ultrasonic signal generated at the reflector) with the recording level and the evaluation limit as shown in Fig. 2-1 of KTA 3211.4. Echo height evaluation does not include the sizing of reflectors.

(7) Part groups

Part groups are parts of components with common quality characteristics. See **Table 2-1**.

Note:

*Examples of the allocation of single parts to Part Group 1 (PG 1) are shown in **Table 2-2**.*

(8) Product form

A product form is the form in its raw condition into which materials are processed, e.g. plates and sheets, forgings and castings.

(9) Fabrication isometric drawing

Fabrication isometric drawing is the isometric representation of a section of a pipe system which consists of spools or parts.

(10) Fabrication step

A fabrication step is an operating sequence related to a particular fabrication technique (e.g. forming, heat treating, welding).

(11) Mandatory hold point

A mandatory hold point is a certain point of time in the course of manufacture when fabrication is stopped so that tests may be conducted.

(12) Manufacture

Manufacture is the entirety of all fabrication, supervisory and testing steps necessary for the implementation of a design into a product. Manufacture is completed before the components are put into service.

(13) Component

A component is that part of a system defined in terms of structural or functional criteria, which still performs independent partial functions.

(14) Test coupon

A test coupon is that part of a delivery or product which is intended for taking test pieces or specimens for examinations (tests).

(15) Test groups

Parts of PG 1 are categorized into test groups according to their differing quality characteristics and quality verifications (e.g. scopes of testing) (see **Table 2-3**).

(16) Test piece

A test piece is an item manufactured for test purposes (e.g. welder’s qualification test, welding procedure qualification, production control test) which is to be tested or from which the specimens are to be taken.

(17) Room temperature

The temperature range for room temperature is (23 ± 5) °C for the mechanical tests laid down in this safety standard.

(18) Noise

Depending on the test conditions, randomly distributed additional signals due to noise of the test system, reflections from the structure of the material of the test object or its surface condition.

(19) Noise level

Noise level means the 95 % value of the cumulative frequency of the heights of the noise signals in the examined volume free from defects.

(20) Pipe system

A pipe system is the entirety of legs as a single functional unit (same identification code in accordance with the "KKS" nuclear power plant identification system, alternatively also plant identification system “AKZ”).

(21) Authorized inspector

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

(22) Welding process

A welding process is a particular method of welding involving the application of certain metallurgical, electrical, physical, chemical or mechanical principles.

(23) Welding procedure

A welding procedure is a specified course of action to be followed in making the weld, including the welding process(es), reference to materials, welding consumables, preparation, preheating (if necessary), method and control of welding and post-weld heat treatment (if relevant), and necessary equipment to be used.

(24) Leg

A leg is that part of a pipe system which is plotted on one or several fabrication isometric drawings. The leg is characterized by a allowable operating temperature, maximum allowable working pressure, fluid, class, test group, material and pipe connection dimensions.

(25) System section

A system section is that section of a pipe system which is classified as a unit for pressure test purposes.

(26) Partial final inspection

A partial final inspection is the performance of parts of the final inspection, with the items to be inspected in a suitable condition.

(27) Prefabricated pipe part (spool)

A prefabricated pipe part is that part of a pipe which is manufactured by means of weld-joining of parts at the manufacturer’s works or on site. Components (e.g. valves) may also be built into a prefabricated pipe part.

Part Groups	Criteria for classification
PG 1 (pressure-retaining wall)	a) parts subject to a pressure differential between the atmosphere and the system medium b) elements connecting PG 1 parts to each other or between PG 1 and PG 2 parts c) welds and attachment welds on PG 1 d) integral supports e) heat exchanger tubes
PG 1 - small items (in accordance with Section 10)	PG 1 parts whose failure leads to an outward leak of an equivalent cross section ≤ DN 50
PG 2 [1)]	a) pressure barriers in the interior of the system; there is no outward release of media if these pressure barriers fail b) welds on PG 2 and attachment welds on PG 2 (and on PG 1 outside the die-out length [2)]) c) parts welded onto PG 1 d) parts transmitting mechanical power, forces or moments
PG 3 [1) 3)]	fluid-wetted parts, insofar as they do not belong to PG 1 or PG 2
PG 4 [1)]	a) standard items from the definition area of PG 2 to PG 3 b) other non fluid-wetted parts

1) The classification criteria for PG 2 to PG 4 only serve the delimitation with respect to PG 1. They are not part of the scope of this safety standard.
2) The die-out length has been laid down in KTA 3211.2.
3) Excepted are parts which are exchanged, as scheduled, in the course of specified normal operation, e.g. membranes, seals. Such parts are not categorized.

Table 2-1: Criteria for the classification into Part Groups

Pressure Vessels	**Valves**	**Pumps**	**Pipes**
- shells - heads (ends) - flanges - bellows expansion joints - cross-sectional transition pieces - closure heads - nozzles - reinforcements of openings - tubesheets [1)] - pipe connections - support rings [1)] - elements connecting PG 1 with PG 1: • bolts • nuts • extension sleeves - heat exchanger tubes - welded attachments for integral supports - welds and attachment welds on PG 1	- casings - casing covers - casing and cover flange - nozzles - connecting elements PG 1 with PG 1: • bolts • nuts • extension sleeves • segment rings • clamps - discharge outlets [3)], e.g. for safety valves - isolating elements [2)]: • globe valve disks • gate valve disks • check valve disks - welds and attachment welds on PG 1 - welded attachments for integral supports	**Centrifugal Pumps** - casings - casing covers - safe ends - nozzles - flanges - multistage casings (in the case of ring section pumps) - barrel-type casings - seal casings - relief water pipes - elements connecting PG 1 with PG 1: • bolts • nuts • extension sleeves - welded attachments for integral supports - welds and attachment welds on PG 1 **Reciprocating pumps** - pump bodies - valve covers flanges - elements connecting PG 1 with PG 1: • bolts • nuts • extension sleeves - welded attachments for integral supports - welds and attachment welds on PG 1	- pipes - pipe elbows - fittings - reducers - branches - end caps - flanges - nozzles - elements connecting PG 1 with PG 1: • bolts • nuts • extension sleeves - welded attachments for integral supports - welds and attachment welds on PG 1

1) As essential parts of the pressure-retaining wall.
2) If they take outward isolating functions during load cases of loading levels A and B.
3) PG 1 of the connected system.

Table 2-2: Examples of the classification of single items into PG 1

<table>
<tr><td rowspan="3">Test group</td><td colspan="2">Classification Criteria</td><td colspan="4">Allocation of Materials</td></tr>
<tr><td rowspan="2">Design stress intensity</td><td rowspan="2">Size limitation</td><td colspan="2">Ferritic Materials</td><td colspan="2">Austenitic Materials</td></tr>
<tr><td colspan="2">Materials in accordance with KTA 3211.1</td><td>Materials under the scope of AD 2000-Merkblatt W 0</td><td>Materials in accordance with KTA 3211.1</td><td>Materials 1.4550, 1.4580, 1.4541, 1.4571 under the scope of AD 2000-Merkblatt W 0</td></tr>
<tr><td>A 1</td><td>S_m</td><td>—</td><td>W I</td><td rowspan="4">(1) W II for:
- PG 1-small items
- integral supports

(2) Materials for special application upon specific agreement</td><td rowspan="4">Materials where $R_{p0.2RT} \leq 370$ N/mm² for PG 1-small items</td><td rowspan="4">Permitted for all dimensions</td><td rowspan="4">for:
a) PG 1-small items,
b) integral supports</td></tr>
<tr><td rowspan="2">A 2</td><td rowspan="2">S</td><td>—</td><td>W I
$R_{p0.2RT} \leq 370$ N/mm²</td></tr>
<tr><td>for vessels:
$s \leq 16$ mm
for pipes, pumps, valves:
$\leq$ DN 150 [1)]</td><td rowspan="2">W II</td></tr>
<tr><td>A 3</td><td>S
in addition:
$P_{mNB} \leq 50$ N/mm²</td><td>—</td></tr>
<tr><td colspan="7">(1) These test groups are based on the same basic safety in accordance with the varying hazard potential (stress, dimensions), observing the materials used.
(2) Components within a system and subunits within a component may be allocated to different test groups.
1) In the case of pumps: nominal diameter of the largest pressure nozzle
In the case of valves: nominal diameter of the inlet nozzle.</td></tr>
</table>

Table 2-3: Test Groups: Classification criteria and allocation of materials

3 Requirements to be met by the manufacturer

3.1 General requirements

The manufacturer of components shall ensure the due and proper execution of all necessary work in compliance with the specifications laid down in KTA 1401 and in this safety standard.

3.2 Prerequisites

(1) The manufacturer shall have equipment and personnel at his disposal which enables him to properly process, test and inspect, and transport product forms, parts, subunits and components. Equipment and personnel from other organizations meeting these requirements may also be employed. The test facilities shall permit the implementation of the tests in accordance with the valid rules and codes. The measuring and testing equipment to be used shall be monitored. The type and intervals of monitoring shall be specified by the equipment manufacturer with a view to the accuracy of the equipment. The tests of such measuring and testing equipment shall be certified.

(2) The manufacturer shall ensure that the required quality of the parts to be manufactured is attained. The persons or organizations conducting quality auditing activities shall be independent of the persons or organizations responsible for fabrication.

(3) The manufacturer shall employ responsible and competent supervisory personnel for all manufacturing steps to be conducted under his control. The tasks set for welding supervisory personnel, test supervisory personnel and test personnel shall be specified in writing.

(4) The organizational and personnel requirements for the maintenance and transfer of identification markings shall be available.

3.3 Welding and test personnel

3.3.1 Welding supervisory personnel

(1) The welding supervisory personnel shall only be composed of persons who, after having been familiarized with the work, are regarded as suitable for this job on the basis of their training, experience and ability. They shall have, above all, practical experience in those areas of welding, and welding processes and their combinations in particular, which are applied in the course of the fabrication of components in accordance with this safety standard.

(2) Distinction shall be made between the following groups of persons:

a) As responsible welding supervisors at the manufacturer's works:

Welding engineers with comprehensive technical knowledge in accordance with DIN EN ISO 14731, para 6.2 a) may be employed as responsible welding supervisors without restriction of their duties.

The responsible welding supervisory personnel shall be employees of the manufacturer’s works. They shall ensure that the relevant rules and codes of engineering are adhered to. They are also responsible for the employment of qualified welders/operating personnel as well as the faultless operating condition of the welding and auxiliary equipment.

If, at a plant, several people are nominated as responsible welding supervisory personnel, their individual areas of responsibility shall be clearly defined.

b) As additional personnel for welding supervisory purposes (e.g. as delegates or deputies):

ba) Welding technicians with specific technical knowledge in accordance with DIN EN ISO 14731, para 6.2 b) may be employed as welding supervisors with restriction to certain materials.

bb) Welding experts with basic technical knowledge in accordance with DIN EN ISO 14731, para 6.2 c) may be employed as welding supervisors only for components made of simple materials to be processed without heat treatment.

bc) Other persons suited for employment as welding supervisors who do not have certificates of qualification, may be employed for the special fields of work for which they have gained the necessary experience like the persons mentioned in ba) and bb) above.

The additional personnel for welding supervisory purposes shall normally be employees of the manufacturer's works.

(3) The authorized inspector shall be notified of the names of the responsible welding supervisory personnel. In terms of competence, they shall have the qualifications required for the possible area of responsibility.

(4) An organizational specification of the tasks for welding monitoring and supervision in accordance with KTA 3201.3 is permitted.

3.3.2 Welders (except hard surfacing welders)

Note:
See Section 3.3.3 for hard surfacing welders.

3.3.2.1 General

Only welders who have a valid test certificate shall be employed for the welding of parts and components.

3.3.2.2 Training

(1) The welders shall be trained at training facilities which deal systematically with the training of welders and fulfil all requirements for welding instruction needed by the welders to meet the qualification requirements.

(2) Training facilities may also be training facilities belonging to manufacturers approved in accordance with Section 3.

3.3.2.3 Implementation of the initial welder's qualification test

(1) In case of steel, the welder's qualification test for manual and partly mechanized welding shall be performed in accordance with DIN EN ISO 9606-1 including the examination of the welder's technical knowledge, and shall comply with the essential variables of Section 5 of DIN EN ISO 9606-1 in conjunction with AD 2000 Merkblatt HP 3. In addition, Table 2 of DIN EN 287-1:2011-11 shall apply to the range of qualification for parent metal. Deviating from the requirements in Section 5.5 of DIN EN ISO 9606-1 the following shall be observed for base metals in material group 4.2 to DIN CEN ISO/TR 15608: For welding work on high-temperature fine-grained heat treatable steels 20 MnMoNi 5 5, 15 NiCuMoNb 5 S and 22 NiMoCr 3 7 it is required to perform the qualification test on each of these materials or on another high-temperature material of this material group.

Where welders have been qualified on one of the aforementioned steels, this qualification also applies to the other steels of material group 4.2 to DIN CEN ISO/TR 15608. For welding on those steel types in addition to the requirements of DIN EN ISO 9606-1 the tensile strength shall be determined on transverse specimens (the requirements for the base metal apply) and for information the hardness traverse (HV 10) on a transverse section.

In deviation from the requirements of DIN EN ISO 9606-1 Section 6.4 Table 13 and DIN EN ISO 9606-4 Section 7.4 Table 5

a) in the case of qualification tests for welding processes 131, 135 or 138 (metal powder filled wire electrode) radiographic tests and tensile tests are required,

b) where austenitic filler metals with a delta ferrite content of less than 3 % or nickel alloys are used, microsections (one microsection per weld position) shall be made and be examined.

(2) The test may be conducted by the following test agencies:

a) the authorized inspector,

b) by competent independent agencies to AD 2000-Merkblatt HP 3 by agreement with the authorized inspector.

(3) The test results shall be recorded in writing and held at the disposal of the authorized inspector.

3.3.2.4 Operating personnel of fully mechanized and automatic welding units

(1) Before the start of fabrication it shall be demonstrated by a test in conformance with DIN EN ISO 14732 to the authorized inspector that the operating personnel of fully mechanized and automatic welding units are sufficiently competent to operate the units. The qualification test shall be performed

a) by the personnel during welding procedure qualification or pre-manufacturing production control tests in conformance with DIN EN ISO 14732 subclause 4.1 a),

or

b) as test prior to the beginning of fabrication in conformance with DIN EN ISO 14732 subclause 4.1 b).

For tests as per b), the extent of testing laid down in DIN EN ISO 9606-1 Section 6.4 and the evaluation criteria of DIN EN ISO 9606-1 Section 7 apply to steel, and the extent of testing laid down in DIN EN ISO 9604-4 Section 7.4 and evaluation criteria of DIN EN ISO 9604-4 Section 8 apply to nickel alloys.

(2) The proof of technical knowledge shall be rendered by the examination to DIN EN ISO 14732, Annexes A and B.

(3) The scope of weld operator testing shall be taken from the welding procedure specification used for specimen welding.

3.3.2.5 Implementation of the requalification test

(1) In deviation from the requirements of of DIN EN ISO 9606-1, the welder's qualification test shall be repeated at two year intervals or if a welder has not performed welding activities for more than six months. The welder's qualification shall be renewed in accordance with DIN EN ISO 9606-1, clause 9.3 a) or clause 9.3 b). For the renewal of the welder's qualification in the welding processes 131, 135 or 138, results from fracture tests shall be submitted additionally.

(2) Welding procedure qualification and production control tests shall be recognized as requalification tests for the welders in question within the scope of the welder qualification test.

(3) In deviation from the requirements of DIN EN ISO 14732, the qualification or requalification for the operating personnel of fully mechanized and automatic welding units shall be repeated at two-year intervals or before operating personnel starts welding work again as operator after an interruption of more than six months.

(4) Every two years, proof of technical knowledge shall be rendered by an examination of technical knowledge to DIN EN ISO 14732, Annexes A and B.

(5) The scope of weld operator testing shall be taken from the welding procedure specification used for specimen welding.

3.3.2.6 Test certificate

The necessary test certificates or a list signed by the authorized inspector and the welding supervisory personnel shall be available at the welder's site of employment.

3.3.3 Hard surfacing welders and operating personnel of fully mechanized welding units

3.3.3.1 General

Only welders with a valid test certificate shall be employed for the welding of hard surfaces.

3.3.3.2 Training

(1) Welders for manual and semi-mechanized welding shall be trained at training facilities which deal systematically with the training of welder's and fulfil all the requirements for welding instruction needed by the welders to meet the qualification requirements.

(2) Training facilities may also be training facilities belonging to manufacturers approved in accordance with Section 3.

3.3.3.3 Implementation of the initial welder's qualification test

(1) The welders shall demonstrate that they have the required manual skill and the necessary competence to conduct their work in a proper and correct manner. In general, this shall be demonstrated by means of a practical test in which the welder executes a single-layer hardsurface with a hard alloy on a ferritic base metal belonging to material group 4.2 to DIN CEN ISO/TR 15608. This welding test shall apply to all welding filler metals for hard surfacings and butterings as well as to all base metals.

Note:

Materials with carbide-forming elements in a metallic matrix (e.g. Co or Ni alloy) and of a Rockwell C hardness greater than 35 constitute hard alloys.

(2) If welders are to be tested who only apply austenitic or nickel alloy buttered hardsurfaces or who only apply hardsurfaces to austenitic base metals, a base metal belonging to material group 8 to DIN CEN ISO/TR 15608 may also be selected.

(3) The dimensions of the test piece and the hardsurface are specified in **Figure 3-1**. The build-up weld shall be executed by means of the stringer bead technique.

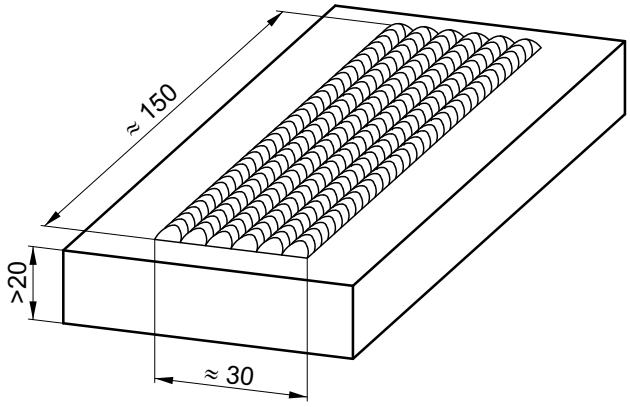


Figure 3-1: Test piece for the welding of hardsurfaces

(4) The following tests shall be conducted on the test piece:

a) Visual assessment of the uniformity of the bead formation.
b) Surface inspection (magnetic particle or penetrant testing) of the undressed hardsurface. The significance of indications arising from the unevenness of the surface shall normally be clarified by means of selective grinding and further testing. Cracks and pores which occur systematically are not permitted.
c) Macrosection transverse to the welding progress direction for the assessment of penetration depth and overlapping.
d) Ultrasonic testing of coalescence with the base metal by means of straight beam scanning from the back of the test piece.

The manufacturer's specifications shall lay down the requirements. Alternatively, a macrosection longitudinal to the welding progress direction may be taken for the purpose of assessing coalescence.

(5) The practical demonstration of manual skill may also be made by welding work conducted in welding procedure qualification and pre-manufacturing production control tests.

(6) The welder's technical knowledge shall be examined to or in conformance with DIN EN ISO 9606-1, Annex B.

(7) The training facility shall issue an informal certificate concerning the demonstration of manual skill and competence. This shall be kept at the authorized inspector's disposal.

3.3.3.4 Operating personnel of fully mechanized and automatic welding units

(1) It shall be demonstrated to the authorized inspector that the operating personnel of fully mechanized and automatic welding units are sufficiently competent to operate the units. This may be demonstrated by the personnel during welding procedure qualification or pre-manufacturing production control tests.

(2) If none of the above-mentioned conditions apply, a test weld in correspondence with Section 3.3.3.3 shall be effected.

3.3.3.5 Implementation of the requalification test

The specifications in accordance with Section 3.3.2.5 shall apply to the requalification test.

3.3.3.6 Test certificate

The necessary test certificates or a list signed by the authorized inspector and the welding supervisory personnel shall be available at the welder's site of employment.

3.3.4 Test supervisory personnel and operators for non-destructive tests

(1) Test supervisors shall

a) have the technical knowledge required to perform their tasks and know the possibilities of application as well as limits of test procedures,
b) have basic knowledge of fabrication processes and of the characteristic appearance of fabrication irregularities.

The test supervisory personnel shall normally be independent from the fabrication department and the authorized inspector shall be notified of their names. The test supervisory personnel is responsible for the application of the test procedure and for the details of the implementation of the test in accordance with the relevant specifications. They are responsible for the employment of qualified and certified operators. This applies also to the employment of personnel not belonging to the works. The test supervisory personnel shall sign the test report.

(2) The test supervisory personnel shall have been qualified and certified for the testing procedures in the relevant product or industrial sectors at least with level 2 to DIN EN ISO 9712. For radiographic and ultrasonic testing level 3 qualification and certification is required.

(3) The NDT operators shall be capable of conducting the tests described in Sections 9.3.9 and 11. They shall have been qualified and certified to DIN EN ISO 9712 for the applicable testing procedures in the relevant product or industrial

sectors. For the procedures RT, UT, ET and LT in the case of helium leak testing at least level 2 qualification and certification is required.

3.4 Review of the prerequisites in accordance with Sections 3.2 and 3.3

(1) Prior to the first-time start of manufacture, it shall be demonstrated to the authorized inspector within the scope of the manufacturer's audit that the above-mentioned requirements are met. The authorized inspector shall issue a corresponding statement.

(2) In the course of manufacture, the authorized inspector shall satisfy himself that the requirements have been met.

(3) In the case of significant changes as compared to the state noted at the time of the manufacturer's audit, the manufacturer shall apply for a supplementary audit.

(4) Where the fulfilment of the fabrication prerequisits is checked, available documentation on reviews, e.g. reviews to AD 2000-Merkblatt HP 0, may be taken into account [see also clause 2 (21)]. A review of the prerequisites as regards manufacture to KTA 3201.3 includes reviews to this safety standard.

3.5 Validity of the manufacturer's audit

The validity of a manufacturer's audit is 24 months after receipt of the authorized inspector's statement. If fabrication and testing have taken place in the period of validity, the validity may be extended for another 24 months upon request of the manufacturer, provided that there are no essential changes as compared to the state noted at the time of the manufacturer's audit.

4 Design approval and documentation

4.1 Design approval

4.1.1 Design approval documents ("VPU")

4.1.1.1 Preparation

(1) The design approval documents shall be divided into two groups:

a) VPU 1: documents which shall be available in a reviewed form before the beginning of manufacture and

b) VPU 2: documents which will be prepared and reviewed at a later date.

(2) The exact times for the submission and release of the documents shall be taken from **Annex C**.

(3) The design approval documents shall enable a safety-related assessment with a view to

a) structural design,

b) selection of materials,

c) dimensioning,

d) manufacturing process,

e) capability of being tested,

f) feasibility of periodic tests and inspections,

g) accessibility for maintenance and repair,

h) equipment required for the operation of the components,

i) installation and assembly,

k) function.

For this purpose, the documents in accordance with **Table 4-1** shall be submitted to the authorized inspector for design approval purposes.

(4) A stage-by-stage design approval may be laid down by agreement with the authorized inspector, and the documents to be submitted for design approval shall be adapted to the respective stage of manufacture in which case the requirements of clause 4.1.2 (2) shall be taken into account. In such a case, the manufacturer shall establish a list to make possible an evaluation of the importance of the documents submitted for the respective stage of manufacture with respect to the entire fabrication of the component or system.

4.1.1.2 Form, contents and abbreviations

(1) The design approval documents shall be drawn up in conformity with the standards and in German language. Foreign languages may only be used additionally.

(2) Uniform abbreviations shall be used in the design approval documents. If additional abbreviations or abbreviations other than those specified in **Table 4-2** or in the individual sections are used, these shall be explained in the design approval documents.

(3) For some design approval documents, certain information contents are mandatory. Some of them shall be designed as documentation carriers. These requirements are contained in the sample forms in **Annex A**; the layout of the forms is to be regarded as recommendation.

(4) The documentation of the test results shall be identified by the specification of the type of documentation in the test and inspection sequence plan (E, ST or Z) in accordance with Section 4.2.1.1.

(5) An example of the relationship between design approval and documentation is represented in **Figure 4-1**.

4.1.1.3 Type of design approval documents

4.1.1.3.1 Title page

(1) A title page (**Forms A-1**) shall individually list the design approval documents with abbreviations and page numbers in addition to the exact designations of the product forms, parts, subunits and components.

(2) It shall also contain a status table and a list of all KTA safety standards and specifications valid for manufacture as well as any possible testing and work instructions.

4.1.1.3.2 Design data sheet, pipe loading specifications

The required specifications are compiled in **Table 4-3**.

4.1.1.3.3 Drawing

(1) The components and parts to be subjected to a design approval shall be represented in an assembly drawing. Required detail drawings shall be clearly allocated.

(2) The assembly drawing shall contain all specifications required for the design approval, unless they are contained in other documents. Examples of specifications required in the assembly drawing are cited in **Table 4-4**.

(3) The exact positions of all single items, regardless of whether they are subject to a design approval or not, as well as the exact positions of the welds, shall be included in the assembly drawing. This information may be contained in detail drawings if the assembly drawing does not contain complete information.

(4) The dimensions to be recorded as actual dimensions within the scope of the final inspection shall be specified in the drawing or in a dimensional check form.

4.1.1.3.4 Materials list

At the time of the design approval, the materials list (**Form A-2**) shall normally contain at least the following specifications:

a) position number of the part in the assembly drawing,
b) material number or abbreviation in accordance with DIN,
c) requirements to be met by the product form in accordance with KTA 3211.1 (where required with reference to the design approval documents of the product form),
d) dimensions.

4.1.1.3.5 Dimensioning and calculation documents

The relevant design approval documents for dimensioning (VPU 1) and for calculation (VPU 2) shall be drawn up in accordance with the specifications laid down in KTA 3211.2.

4.1.1.3.6 Test and inspection sequence plan

Note:

The review of the manufacturing preconditions and in-process inspections and interim tests effected in the course of fabrication are conducted by the manufacturer and the authorized inspector on the basis of inspection plans. These inspection plans are drawn up in relation to the manufacturers and the components. Compliance with the inspection plans shall be confirmed in the test and inspection sequence plan.

The test and inspection sequence plan (**Form A-3**) shall contain the tests required in accordance with this safety standard as specified in the Inspection Sheet for final inspection. The times of testing and supervisory steps shall be apparent with respect to the manufacturing state. Separate test and inspection sequence plans shall be drawn up for shop production and site fabrication.

4.1.1.3.7 Welding procedure sheets (welding procedure specifications)

(1) A welding procedure specification (**Form A-4**) shall be drawn up for all welds. The specifications concerning the weld preparation shall be contained in either the drawing or the welding procedure specification. The welding procedure specification may be drawn up as a standard specification.

(2) For the design approval, each welding procedure specification shall be accompanied by the manufacturer's report on the welding procedure qualification with the certificate of the authorized inspector in accordance with Section 8.1.1.7 (3).

(3) If no valid welding procedure qualification is available at the time of the design approval,

a) the welding procedure specification reviewed by the authorized inspector and the heat treatment plan for the welding procedure qualification to be conducted shall be submitted and
b) the manufacturer's report as well as the certificate of the authorized inspector on this welding procedure qualification shall be submitted subsequently without delay.

4.1.1.3.8 Heat treatment plan

(1) A heat treatment plan (**Form A-5**) shall be drawn up for heat treatment. This plan may be waived if the welding procedure specification or drawing contains all the required specifications concerning heat treatment.

The following minimum information is required:

a) type of heat treatment,
b) type of heat treatment facility,
c) type, number and position of temperature measuring points,
d) temperature-time sequences (e.g. heating speed, holding time, cooling speed),
e) heat input area and width of the heat insulation in the case of local heat treatment,
f) type of cooling, cooling agent.

(2) In the case of components requiring individual temperature measurements, a heat treatment plan specifying the temperature measuring points shall be drawn up.

4.1.1.3.9 Materials testing and specimen-taking plans

(1) As far as required by individual clauses of this safety standard (e.g. forming, heat treatment, production test) the required tests and inspections shall be laid down in a materials testing and specimen-taking plan (see example in **Form A-7**).

(2) Regarding the non-destructive tests the number, type, direction, and location of specimens in the test pieces as well as the location of test pieces in the product form and the test temperature shall be given. In the case of large extent of testing the location of specimens and test pieces shall be shown on a location sketch (as annex to the materials testing and specimen-taking plan) (**Form A-7**).

(3) All specimens shall be clearly identified.

(4) In addition, the following information shall be given on the:

a) rules, specifications, working and testing instructions applying to the individual inspection hold points,
b) production steps relevant to inspection (e.g. welding, heat treatment as well as such information on fabrication as is required for the determination and assignment of tests and inspections,
c) parties involved in inspection and/or testing with description of activities (e.g. performance, participation),
d) type of documentation (final file, stamping, interim file).

4.1.1.3.10 Pressure test plans

Pressure test plans shall be established for pressure tests to be performed upon assembly of components and piping in the plant. They shall contain at least:

a) indication of the area to be subjected to pressure testing,
b) the test pressure, MPa (bar),
c) the test temperature, °C,
d) the test fluid,
e) the chronological sequence of pressure build-up, holding times and pressure decrease as well as point and times of measurements,
f) information on the valves installed at the pressure test boundaries, on valve positions and on temporary pressure test isolation fittings,
g) information on type of pressure application.

4.1.1.3.11 Repair plan

Repair plans shall be drawn up for repairs carried out on parts, subunits and components. These are test and inspection sequence plans or standard test and inspection sequence plans. Insofar as the repair is effected in accordance with the conditions to be met by initial fabrication, the plans for initial fabrication may be used.

4.1.1.3.12 Test instructions for non-destructive tests

The specifications in accordance with Section 11.2.1 shall apply.

4.1.1.3.13 Nameplates for vessels and pumps

The nameplate containing the required data may be represented on the assembly drawing or on a separate drawing. **Table 4-5** contains a compilation of the minimum data.

4.1.1.3.14 Isometric item list

The isometric item list (**Form A-10**) shall normally contain all the product forms, parts and components needed for manufacture which are represented in the accompanying fabrication isometric drawings.

4.1.1.3.15 Fabrication isometric drawing

(1) The fabrication isometric drawing (**Form A-11**) shall normally contain the following information:

a) piping arrangement with all dimensions required for assembly,
b) position number,
c) weld number,
d) dissimilar welds (change of material) shall be identified with a specification of the material,
e) leg designation (unless part of the isometric number),
f) position and designation of the pipe hangers,
g) fabrication isometric drawing number,
h) compartment number,
i) welding procedure specification number, revision,
k) test and inspection sequence plan number, revision,
l) accompanying isometric item list,
m) classification (class "K2"),
n) Test Group in accordance with **Table 2-3**.

(2) In addition to the data mentioned in subclause (1) the fabrication isometric drawing or the isometric item list shall contain the tightening parameters of fasteners to be met including the lubrication areas. By way of substitution, separate documents may be used which are clearly assignable to the fabrication isometric drawing which they shall accompany.

4.1.1.3.16 Stress isometry

The stress isometry shall normally contain the following information:

a) classification (class "K2"),
b) Test Group in accordance with **Table 2-3**,
c) maximum allowable working pressure, allowable operating temperature, fluid,
d) all dimensions of pipes, fittings, hangers and supports required for calculation,
e) materials,
f) marking of parts (e.g. Ident. No.) and components (code according to "KKS" or “AKZ” identification system),
g) reference to the centre line,
h) specifications on the pipe hangers (limited degrees of freedom, designation).

4.1.1.3.17 Laying provisions

Overall demonstrations for pipe sections (e.g. laying instructions) may also be made instead of individual demonstrations.

4.1.2 Implementation of design approval

(1) The authorized inspector shall effect the safety assessment on the basis of the design approval documents submitted to him.

(4) Where a stage-by-stage design approval has been fixed as per clause 4.1.1.1 (4), the documents submitted for each individual approval stage must permit the assessment of the effects of the fabrication step on the finished component. Partial final inspections shall be adapted to the approval and fabrication stages.

4.1.3 Mark of approval

(1) If the design approval conducted by the authorized inspector has had a positive result, the authorized inspector shall sign the design approval documents and affix a mark of approval, thereby confirming the completion of the design approval.

Note:
The mark of approval is a stamp impression which shows the organization conducting the design approval, the authorized inspector and the date of approval.

(2) Any changes and additional entries made to the design approval documents which become necessary in the course of the design approval shall be incorporated into these documents and marked by the authorized inspector.

(3) If several product forms, parts, subunits and components of identical design are to be manufactured for a plant, and in the case of identical manufacture, the documents previously subjected to a design approval shall remain valid. With respect to other plants, the validity of documents previously subjected to a design approval shall be specified by agreement with the authorized inspector.

4.1.4 Validity

(1) Basically, the documents subjected to a design approval shall remain valid until completion of the component. Insofar as occasioned by changes in valid rules and codes, the authorized inspector shall review the design-approved documents if

a) manufacture has not started within 24 months after the date of the mark of approval marking,
b) manufacture has been interrupted for more than 24 months.

(2) If an extension of the validity of the design-approved documents is required for the manufacture of individual parts (e.g. spare parts), the validity shall be specified in the document.

4.1.5 Changes in design-approved documents

(1) If documents are to be changed upon completion the design approval, these altered documents shall be subjected to another design approval. Any additional entries which the authorized inspector may have previously made shall be taken into consideration in the altered documents or the documents to be drawn up anew.

(2) The altered documents shall be numbered consecutively in accordance with the latest status of revision and included in the title page.

4.2 Documentation

4.2.1 Manufacturer's documentation

4.2.1.1 Drawing up and compilation of documents

(1) The manufacturer of a part, subunit or component shall ensure that all the documents required for documentation are drawn up and compiled in the course of manufacture at either his own works or those of his subcontractors.

(2) The documentation of the test results shall be identified with E, ST or Z:

E : final file at the licensee's plant

This documentation shall contain all documents subjected to a design approval and certificates of tests describing the quality of the condition of a part (product form, part, subunit, component, system) before it is put into operation.

ST : stamp in the documentation section of the design approval documents

This applies to:

a) tests with yes/no statements,

b) tests, the implementation and permissible results of which are specified in such a way that a list of the actual values is not necessary in order to assess the quality.

If deviations from required values are found, the documents required to deal with the respective deviation and its handling (e.g. non-conformance report) shall be included in the final file.

Z : interim file at the manufacturer's works

This shall contain certificates of tests which are not needed to describe the quality of the part's condition before it is put into operation, such as

a) records of tests required for meeting certain deadlines,

b) tests which will be repeated when the parts have reached their final state,

c) project-related records of system oriented quality assurance.

If deviations from required values are found, the documents required to deal with the respective deviations and its handling (e.g. non-conformance report) shall be included in the final file.

(3) If a summary certificate is intended as proof of a test, this shall be specified in the design approval documents. It shall also be specified whether the summary certificate shall be allocated to the final or to the interim file.

(4) It is the manufacturer's duty to ensure that

a) the documentation system specified in this safety standard is adhered to at both his works and those of his subcontractors,

b) the prepared documents are filled in completely in accordance with the requirements of this safety standard and have their required marks of approval,

c) in the course of manufacture, the documentation reflects the state of fabrication and testing of a part, including any deviations from the scheduled manufacturing sequence,

d) all documents required for the final file and the interim file are available for final inspection after manufacture has been completed.

(5) The listing and filing of certificates shall be effected in accordance with the numbering of the associated materials list or that of the test and inspection sequence plan.

4.2.1.2 Handling of changes and additional entries

(1) Altered and approved documents shall be documented in the revision index on which manufacture was based.

(2) If changes or additional entries are made to the certificates, they shall be made in the original and by the same body which prepared the original. If this is not possible, the alterations or additional entries shall be made on a separate sheet to be attached to the original. The alterations and additional entries shall be approved by all bodies involved and shall be dated and signed.

4.2.1.3 Documentation of repairs

Documents concerning repairs which have been conducted (see Section 4.1.1.3.11) shall be documented in the same way as the manufacturing documents.

4.2.1.4 Documentation of production control tests

(1) A production control test allocated to the welding of parts shall be documented once together with the component.

(2) In the case of part welds covered by other production control tests (see 8.2.1.1 (4)), the production control test performed shall be specified in the test and inspection sequence plan and confirmed by a stamp.

4.2.1.5 Documents for the interim file

(1) These documents shall be kept in good order at the manufacturer's works in a way permitting their allocation.

Note:
Details about the manner in which and the period for which the documents are to be kept are specified in KTA 1404.

(2) The following documents are an integral part of the interim file:

a) all manufacturer's inspection plans,

b) all certificates prescribed in the design approval documents to be included in the interim file.

4.2.1.6 System of the final file

(1) A standard filing system for the documents intended for the final file shall be arranged with the licensee. The final file shall normally make it possible to review everything from the design to the manufacture of the components and systems to their installation, including any deviations or tolerances.

(2) In keeping with this filing system, the manufacturer of a component shall compile all the documents concerning this component which are intended for the final file at the plant of the licensee.

4.2.1.7 Documents for the final file

The following documents are an integral part of the final file:

a) all design approval documents as specified in **Table 4-1**,

b) all certificates marked "E" in the design approval documents,

c) all results of the tests conducted on product forms, welding filler metals and welding consumables, insofar as this is required in the materials list.

4.2.1.8 Compilation of the documentation of identical parts or components

(1) If there are several parts or components of identical design (e.g. identical type, identical nominal diameter) which are subject to the same design approval, the documentation may be combined. This combination may be effected as follows:

a) a joint documentation is drawn up for all parts or components,

b) the documentation is combined in sections for all parts or components,

ba) a joint documentation section covering a plurality of components,

bb) a part-related or component-related documentation section.

(2) The allocation of certificates to individual components and their parts shall be ensured. Additional measures required as a result of special events which have occurred in the course of manufacture shall be documented such as to ensure allocation to the parts under consideration.

4.2.1.9 Documentation review and assembly release

(1) The documentation shall be reviewed in the course of manufacture.

(2) Basically, upon completion of a component, the manufacturer shall submit the original version of the documentation, which he has found to be correct and complete, to the authorized inspector for final review. Copies may be used in the documentation instead of original versions (e.g. for material certificates) if the manufacturer confirms that the copy is a true copy of the original.

(3) The assembly of components on the site may only be effected on the basis of a release granted by the authorized inspector. This release may only be granted if the review of the documentation of manufacture has been completed and confirmed by the authorized inspector.

(4) As a deviation from this regulation, the release for the assembly of parts, subunits and components on the site may be effected with a certificate of quality if the approved documentation of shop fabrication is not yet available for formal reasons (e.g. missing fair copies of certificates, copying of the documentation not yet completed). This certificate of quality may be issued if

a) all tests specified in the design approval documents have been conducted,

b) all test results are available and meet the pre-set requirements; any deviation and tolerance processes shall have been concluded,

c) the documentation of manufacture is available after having been reviewed and checked for completion and factual correctness by the parties involved.

(5) Six weeks after its issue, the certificate of quality shall normally be replaced by the approved final documentation, including the final inspection report.

(6) The authorized inspector's confirmation of the conclusion of documentation for product forms, parts and components in accordance with VPU 1 shall be available before the system section or system is released for performance of the leakage or pressure test.

4.2.2 Final file of documentation at the licensee's plant

(1) All documents concerning manufacture and assembly work intended for the final file shall be handed over to the licensee after having been approved.

(2) The documents shall be kept in an orderly manner at the licensee's plant.

Note:
Details about the manner in which and the period for which the documents are to be kept are specified in KTA 1404.

4.3 Design approval and documentation of spare, stand-by and wear parts

(1) The procedure for the ordering of spare, stand-by and wear parts for design approval and documentation shall be effected in accordance with **Table 4-6**.

(2) The procedure for the refabrication of components and pipe systems for plants in operation shall be the same as that for the construction of new plants.

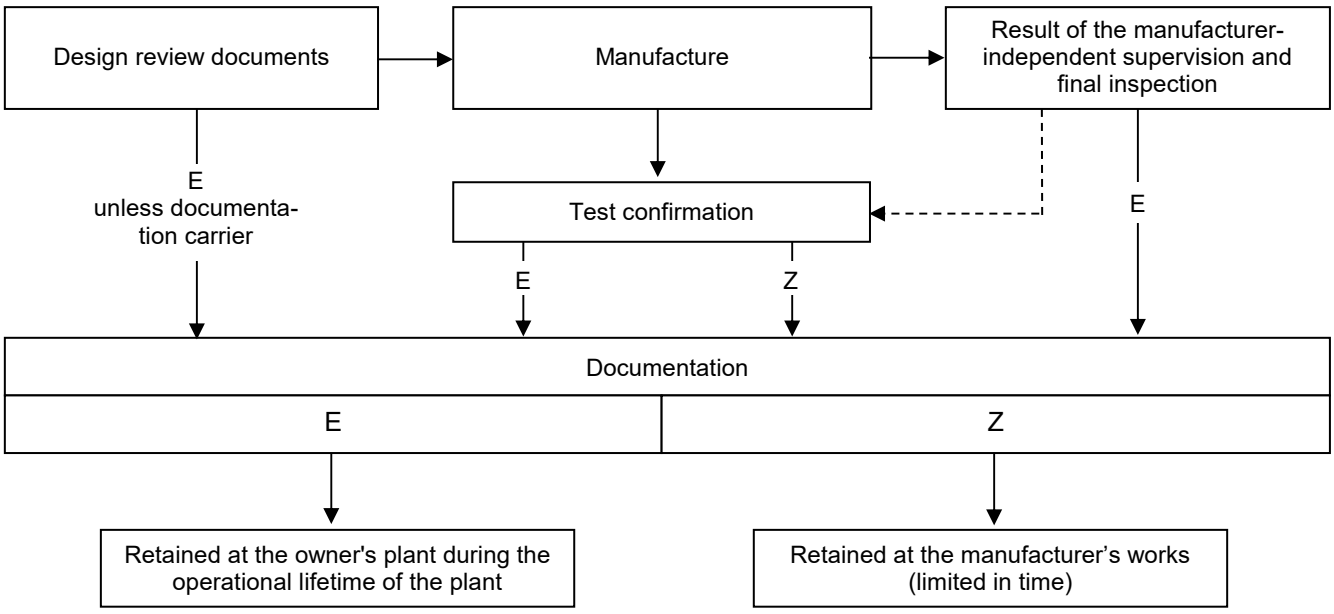


Figure 4-1: Relationship between design approval and documentation

	Pressure Vessels	Valves	Pumps	Pipes
VPU 1 [1)]				
Title page	X	X	X	X
Design data sheet [2)]	X	X	X	–
Pipe loading specifications [2)]	–	–	–	X
Assembly drawing Part drawing; if necessary, detailed drawing	X	X	X	X [3)]
Dimensioning [4)]	X	X	X	X
Materials list (or parts list)	X	X	X	X [5)]
Test and inspection sequence plan	X	X	X	X
Welding procedure specification	X	X	X	X
Heat treatment plan	X	X	X	X
Materials testing and specimen-taking plan	X	X	X	X
Pressure test plan	–	–	–	X
Repair plan, standard repair plan	X	X	X	X
Test instructions	X	X	X	X
Drawing for nameplate	X	–	X	–
Fabrication isometric drawing [6)]	–	–	–	X
Isometric parts list [6)]	–	–	–	X
VPU 2 [1)]				
Title page	–	–	–	X
Analysis of mechanical behaviour (stress analysis, fatigue analysis) [4)]	X	X	X	X [2)]
Calculation isometry [2)]	–	–	–	X
Proof of functional capability [4)]	X	X	X	X

Note:

Additional documents may be required in individual cases, insofar as they are specified in the individual Sections of this safety standard.

1) VPU 1: documents to be available as documents subjected to a design approval before the start of manufacture;
VPU 2: documents which are drawn up and subjected to a design approval at a later date (see **Annex C**).

2) The time at which the design data sheet and the pipe loading specifications shall be completed is specified in **Annex C**.

3) The component drawing for simple pipe components (e.g. straight pipes, bends, standard flanges) may be replaced by a collection of data.

4) Specified in KTA 3211.2.

5) Only for welded parts.

6) Documents to be subjected to a design approval in the course of manufacture (see stage-by-stage design approval in accordance with clause 4.1.1.1 (4)).

7) An evaluation of dimensional changes shall be effected after the checking of actual dimensions (Test No. 4.2.3 of the Inspection Sheet for final inspection in accordance with **Table 9-4**).

Table 4-1: Documents for design approval by the authorized inspector

(1) Design and Dimensions

ADB : design data sheet
A : elongation at fracture
DN : nominal diameter
EVA : external event (KTA 2201.1)
EVI : internal event
I : die-out length of stresses
KV_2 : impact energy absorbed using a striker with 2 mm radius
L : scan paths for non-destructive tests
P_b : primary bending stress
P_l : local membrane stress
PB : maximum allowable working pressure
P_{mNB} : nominal operating stress (KTA 3211.2)
PN : pressure level
RBA : pipe loading specifications
R_{eH} : yield point at room temperature
R_m : minimum tensile strength
R_{mRT} : tensile strength at room temperature
R_{mT} : tensile strength at allowable operating temperature
$R_{p0.2RT}$: 0.2% proof stress at room temperature
$R_{p0.2T}$: 0.2% proof stress at allowable operating temperature
$R_{p1.0RT}$: 1.0% proof stress at room temperature
$R_{p1.0T}$: 1.0% proof stress at allowable operating temperature
s : wall thickness of the main body
s_1 : wall thickness of a part connected to the main body
S : design stress intensity for stress limitation in combination with calculation equations; if necessary, verification of primary stresses
S_m : design stress intensity for stress limitation in combination with stress analyses
T´ : temperature during the pressure test
TB : maximum allowable operating temperature
Z : reduction of area

(2) Design Approval Documents

AW : work instruction
CHPP : plan for welding material tests
DBL : cover sheet
DSP : radiographic testing plan
DRPP : pressure test plan
ISO : isometry
IVZ : table of contents
KSP : component flowchart
MSL : list of measurement points
PA : test instruction
PFP : test and inspection sequence plan
PWP : plan for periodic tests and inspections
RPL : cleaning plan
SP : welding procedure specification
SSP : weld location plan
STL : weld location list
STPL : marking list
SYP : system flow plan
SZL : list of welding filler metals
VPU : design approval documents
WBP : heat treatment plan
WL : list of materials
WPP : materials testing and specimen-taking plan
ZG : drawing

(3) Tests and Inspections

AP : production control test
APM : production control test conducted on a monitoring production control test piece
APS : production control test conducted on a simulation-heat treated test piece
CHP : welding material test
DOP : documentation review
DRP : pressure test
EK : receiving inspection
ET : eddy current testing
FBB : face-bend test on butt weld
IBS : commissioning
LT : leakage test
MK : dimensional check
MT : magnetic particle test as surface inspection
MTP : mechanical test
PAU : product audit
PT : penetrant testing as surface inspection
RBA : pipe loading specifications
RBB : root-bend test on butt welds
RP : cleanliness test
RT-D : radiographic testing (digital radiography)
RT-F : radiographic testing (film radiography)
SBB : side-bend test transverse to butt weld
SUE : welding supervision
UB : marking transfer certificate
UT : ultrasonic testing
VK : packing check
VP : welding procedure qualification
VT : visual testing
VWP : material identification check
WBK : heat treatment check
WP : materials testing
WPM : materials testing on production monitoring test piece
WPS : materials testing on simulation heat treated test piece
WPV : materials testing in the quenched and tempered condition
ZfP : non-destructive testing

(4) Times of tests and inspections

NB : test/inspection after mechanical processing
ND : test/inspection upon pressure testing
NE : test/inspection upon final annealing
NS : test/inspection upon welding
NV : test/inspection upon quenching and tempering
NZ : test/inspection upon intermediate annealing

Table 4-2: Abbreviations (continued next page)

(5) Participation in testing

DU : performance of test
TE : participation in test
UEW : test supervision

(6) Participants in tests and inspections

B : purchaser / plant owner
H : manufacturer
H1 : tests and inspections to be conducted by the manufacturer in any case
H2 : test and inspections to be conducted at random by the manufacturer
QST : quality assurance office
S : authorized inspector
S1 : tests and inspections to be conducted by the authorized inspector in any case
S2 : tests and inspections to be conducted at random by the authorized inspector

(7) Documents

AB : non-conformance report
BA : operating records
BAU : final inspection report
PP : test record sheet
QB : quality certificate
SPK : welding record
SPS : welding record summary certificate
UB : marking transfer certificate
WBPK : heat treatment record
WPQR : Welding procedure qualification record

(8) Filing of documents, confirmation of the test performance:

AN : issue of a certificate
E : final file
E/S : final file summary certificate
ST : confirmation of the performance of the test by means of a person-related stamp or stamp plus initials
. . . /S : summary certificate for tests/inspections
Z : interim file
Z/S : interim file/summary certificate

(9) Material test pieces, welds, parts, components

AP...-S : production control test on simulated heat treated test pieces
AP...-M : production control test on accompanying heat treated test pieces
Ar : valves
ASG : build-up weld
B : heat exchangers and vessels
BG : subunit
BT : part
DHV : double bevel groove weld
EH : manual arc welding with rod electrodes
GW : base metal
HV : single bevel groove weld
KN : fillet weld
LN : longitudinal weld
O : test layer near the surface
P : pumps
PA : weld position: flat
PC : weld position: transverse
PE : weld position: overhead
PF : weld position: vertical up
PG : weld position: vertical down
R : pipes
RN : circumferential weld
SF : welding sequence
SG : weld metal
SN : weld
SPL : cladding
SST : weld location
STN : nozzle weld
SV : welded connection
SZ : welding filler metals and consumables
UP : submerged arc welding
W : root pass of a weld
WEZ : heat affected zone
WIG : tungsten inert gas welding
vWIG : fully mechanized tungsten inert gas welding
WP...-S : material test on simulation heat treated test pieces
WP...-M : material test on accompanying heat treated production control test pieces
...-R : marking of documents in the case of repairs
...-RM : marking of documents for standby material
...-L : marking of documents for lifetime samples

(10) Quality characteristics

A 1, A 2, A 3 : Test Groups A 1 ... A 3
PG 1 ... PG 4 : Part Groups PG 1 ... PG 4
K 2 : Class 2
OB 1, OB 2 : categories of surface condition
WI, WII : Material Groups WI or WII

(11) Other

AKZ : plant identification code
KKS : power plant identification system
QS : quality assurance

Table 4-2: Abbreviations (continued)

No.	Specifications	Design specification (ADB) Valves [1]	Design specification (ADB) Pressure Vessels/Pumps [1]	Pipe loading specifications (RBA) [1]
1	Marking of the plant component; Valve type designation	X [2]	X	X
2	Marking of the system	X [2]	X	X
3	Classification (class “K2”, seismic class)	X	X	X
4	Test Group in accordance with **Table 2-3**	X	X	X
5	Drawing number	X [3]	X	X
6	Special ambient conditions (temperature, dose rate)	X	X	X
7	Production data and permissible operating data (pressures, temperatures, power data, weights, leak tightness requirements); specifications concerning the drives of valves and pumps	X	X [4]	X
8	Operating medium	X	X	X
9	Materials and material group of the main parts (including pipe connections)	X [3]	X	X
10	Essential planning measurements (main dimensions, overall planning sketch, anchoring)	–	X	–
11	Arrangement and dimensions of main nozzles	X	X	–
12	Arrangement of inspection ports (sight glasses, manholes, headholes and handholes)	–	X	–
13	Forces and moments acting on nozzles	–	X	X
	Forces acting on integral supports	–	X	–
14	Loads resulting from external and internal events (EVA/EVI) (requirements for integrity, support stability, functional capability)	X	X	X
15	Transient loads (loading conditions, loads, frequency, service limit levels)	X	X	X
16	Superposition of loads	X	X	X
17	Structural loads (pumps, pressure vessels)	–	X	–

[1] With respect to items no. 7 and 13 to 17, references to detailed documents are also permitted.

[2] If identification code in accordance with KKS or AKZ identification system is available, this is to be specified.

[3] Not applicable if specified by type number.

[4] For pumps additional indication of head, capacity, rpm, acceptance class (for rotodynamic pumps to DIN EN ISO 9906), net positive suction head (NPSH) and allowable vibratory velocities.

Table 4-3: Required design data in the Design Data Sheet (ADB) and Pipe Loading Specifications (RBA)

No.	Specifications	Pressure Vessels	Pumps	Valves	Pipes [1]
1	Scale	X	X	X	X
2	Loads determining dimensioning: maximum allowable working pressure, allowable operating temperature, class (“K2”), test group, medium	X	X	X	X
3	Tightening parameters of pressurized fasteners to be adhered to	X	X	X	X
4	Required dimensions including tolerances for a) dimensioning, b) analysis of mechanical behaviour (including proof of functional capability), c) planning and testing	X	X	X	X
5	Contents, divided into pressure compartments	X	–	–	–
6	Weight of component (empty) or weight of part	X	X [2]	X [2]	X
7	Surface condition of welds (see **Table 5-4**)	X	X	X	X
8	Surface condition of joint sealing faces and functional faces	X	X	X [3]	X
9	Direction of flow	X	X	X	– [4]
10	Load deformation diagrams of functional springs	–	–	X	–
11	Location of all welds with specification of weld no. and allocation to the welding procedure specification	X	X	X	X
12	Scheduled surface protection (e.g. hardsurfaces, claddings, rubber linings)	X	X	X	X
13	Type and location of the component marking (see **Table 4-5** for specifications concerning the nameplate)	X	X	X	–
14	Terminal dimensions	X	X	X	X
15	Component designation (in addition, KKS or AKZ identification code in the case of system-dependent components and parts)	X	X	X	X
16	Material (if no materials list)	X	X	X	X
17	Balancing quality requirements to DIN ISO 21940-11	–	X	–	–

[1] For parts to be manufactured in accordance with drawings
[2] Individual indication of casing, internals, fluid filled, accessories and drive, where required.
[3] As far as a proof of leak tightness or of functional capability is required.
[4] Required in exceptional cases (e.g. in the case of metering orifices)

Table 4-4: Examples of specifications required in assembly drawings

No.	Specifications	Unit	Pressure Vessels	Pumps
1	Plant	–	X	X
2	Identification code in accordance with KKS or AKZ identification system	–	X	X
3	Manufacturer and supplier	–	X	X
4	Manufacturer's number (Works No.)	–	Xr	X
5	Maximum allowable (gauge/vacuum) working pressure	MPa	X	X
6	Allowable operating temperature	°C	X	X
7	Contents of the individual pressure compartments	l	X	–
8	Operating delivery rate	m^3/h	–	X
9	Operating delivery head	m	–	X
10	Year of construction	–	X	X
11	Certification stamp	–	X	X

[1] For pumps the data listed in DIN 24299-1 are required additionally.

Table 4-5: Required nameplate specifications for vessels and pumps

No.	Documents [1]	Review / Design approval	Fabrication supervision / Final inspection	Documentation [2]	Installation Inspection
	1	2	3	4	5
1	Single part manufacture (in acc. with drawings)				
1.1	Use of the initial manufacture documents subjected to review / design approval: a) What is not applicable is deleted in a copy of the initial documents (without factual alterations) or b) An extract from the initial document is prepared for the relevant parts (without factual alterations).	Renewed review / design approval only required in the case of deviation from the approved status. The inspection of the deletion / transcript shall be effected in the course of fabrication supervision/final inspection.	Tests based on replacement, standby and wear parts shall be conducted in accordance with initial manufacture. Tests which can only be effected in combination with the subunit (component) may be waived, e.g. pressure test.	Demonstrations and a) review documents in accordance with Column 1 with confirmation of the test performance or b) summary confirmation [5] for test steps which need only be confirmed by means of a stamp, using the title page of the design approval documents from initial manufacture. Each test step shall be listed in accordance with the responsibility for the tests and with specifications regarding allocation.	During installation, it shall be ensured that the correct parts are used. The parts shall be tested in accordance with the respective responsibility. Tests or inspections required in connection with the sub-unit, component (e.g. tightening torque, functional capability check) shall be laid down and be conducted and documented in accordance with the respective responsibility.
1.2	Preparation of separate design approval documents [3] for parts which are not part of the initial component fabrication (e.g. closure plugs for heat exchanger tubes).	First-time review / design approval required.			
2	Serial parts (e.g. bolts, seals) The requirements of the materials / parts list of the original review / design approval documents shall apply with respect to the provisions to be used and the certificates. A separate document is not required.	[4]	In accordance with the requirements specified in the provisions to be used.	Demonstrations in accordance with the requirements specified in the provisions to be used and specifications regarding allocation.	

[1] The correct allocation of the replacement, standby and wear parts to the component (in accordance with the materials or parts list) shall be ensured when ordering.

[2] In general, the documentation of the replacement, standby and wear parts is maintained separately from the component documentation.

[3] In detail, and insofar as relevant, title page, materials/parts list, drawing, test and inspection sequence plan, welding procedure specification.

[4] If alterations are made to the documents subjected to review / design approval, the altered documents shall again be subjected to review / design approval in accordance with the respective responsibility. This does not apply to alterations in the number of parts.

[5] Documents used for fabrication or testing which are already filed in the documentation of the components or that of the original parts need not to be additionally filed in the documentation of the replacement, standby and wear parts.

Table 4-6: Design approval and documentation for replacement, standby and wear parts

5 Welding

5.1 Welding design and welding principles

(1) The welding design is specified in Section 5 of KTA 3211.2.

(2) Basically, all welds on pressure-retaining walls shall be executed in the form of multiple-pass and through-welded welds. If the opposite side is accessible, back-welding shall be effected or the root shall be fully removed by machining. Single-pass welds are only permissible if their suitability has been demonstrated in a welding procedure qualification in which a weld was executed as a single-pass weld.

(3) In the case of pipe circumferential welds and nozzle welds that can only be single-side welded, full penetration of the weld shall be ensured. Gouging of the root (also employing internal dressing equipment) shall basically be performed. Where internal dressing is not required care shall be taken to ensure that a clear test result can be obtained in non-destructive testing and the requirements of Section 5.7.1 and 11 of this safety standard and the requirements of Table 8.5-1 of KTA 3211.2 are met.

(4) Where non-destructive ultrasonic testing is required according to clause 9.3.6.2.2, the welding design for difficult-to-test welded joints (e.g. welds between austenitic steels, welds between ferritic and austenitic steels) shall also be optimised with respect to the capability of being tested.

(5) The requirements to be met by the tolerances are specified in Section 9.3.3.

(6) In the case of different wall thicknesses of the product forms to be joined, adequate transition between the wall thicknesses shall be provided in the weld area to satisfy the requirements for layout suitable for testing purposes as per section 11.1.

(7) When machining surfaces

a) care shall be taken to ensure that only little heat is transferred into the component,

b) the input of inadmissible impurities (halogens), e.g. through the use of grinding tools, is avoided.

In the case of austenitic components containing reactor water which are subject to operating temperatures equal to or exceeding 200 °C in BWR plants, a qualification of the machining procedures is required with the aim of ensuring for the fluid-wetted surface, in addition to the requirements of a) and b) above

c) only slight cold working in the near-surface area,

d) only slight strain hardening in the surface area.

5.2 Prerequisites for welding

Welding work may only be started if the following prerequisites are met:

a) compliance with the requirements to be met by the manufacturer in accordance with Section 3,

b) conclusion of the design approval (VPU 1) in accordance with Section 4,

c) conclusion of the welding procedure qualifications in accordance with Section 8.1,

d) conclusion of all scheduled tests to be conducted on the product forms to be welded in accordance with KTA 3211.1 and all scheduled tests to be conducted on parts or prefabricated pipe parts (spools),

e) welding filler metals and welding consumables shall meet the requirements in accordance with Section 5.3,

f) all documents required for welding (welding procedure specifications, drawings) shall be available at the welding site after having been subjected to a design approval. Displaying of these documents at a central place near the welding site is permitted (e.g. in the case of assembly work),

g) it shall be ensured that the welding work is conducted at a location which is both free of draughts and protected against the weather. Special measures shall be taken at ambient temperatures below 5 °C.

5.3 Requirements to be met by welding filler metals and welding consumables

(1) The welding filler metals and consumables shall comply with the requirements in accordance with KTA 1408.1, KTA 1408.2 and KTA 1408.3.

(2) Basic coated rod electrodes or fluxes of basic characteristics shall preferably be used for ferritic welds. Moreover, welding filler metals with the following diffusible hydrogen content shall be provided for ferritic materials if $R_{p0.2RT}$ is equal to or greater than 370 N/mm²:

a) rod electrode weld metal:
equal to or smaller than 5 ml/100 g in the molten weld metal (H 5 to DIN EN ISO 2560);

b) submerged arc weld metal:
equal to or smaller than 5 ml/100 g in the molten weld metal (H 5 to DIN EN ISO 14174).

(3) In the case of seam welds, the strength and ductility of the weld metal shall at least correspond to that of the base metal. The tolerance range of the strength of the weld metal, as compared to that of the base metal, may only be increased if the deformation properties of the weld metal meet the minimum requirements of the base metal.

(4) For seam welds between ferritic steels and austenitic steels the following is permitted:

a) nickel alloyed filler metals,

b) austenitic welding filler metals.

(5) Nickel alloyed filler metals shall be required in the following cases:

a) in Test Group A1,

b) at operating temperatures equal to or higher than 300 °C,

c) if heat treatments become necessary after welding (see also **Table 7-1**),

in which case in the fluid-wetted root area of hot (temperature equal to or higher than 200 °C during continuous operation) reactor water containing pipes and components austenitic filler metals shall be used where permitted by geometry.

(6) Where for other fluid-wetted dissimilar welds on the systems outside the pressure retaining boundary welding filler metals made of nickel alloys are used, filler metal with a Cr content of at least 18 % (e.g. NrCr20Mn3Nb, Material No. 2.4806) shall be used for the root run.

(7) For austenitic materials to KTA 3211.1, clauses 7.1.1 (3), 7.3.1 (3) and 7.4.2 (3) for hot (operating temperature equal to or higher than 200 °C), reactor water containing pipes and components in BWR plants, filler metals with suitable analysis limits (low-carbon-quality) shall be used.

5.4 Weld edges

(1) The weld edges shall preferably be smoothed by machining (e.g. milling, planing, turning, grinding).

(2) In the case of weld edges made by means of thermal cutting (flame cutting, plasma arc cutting), the required cut quality and tolerance class to DIN EN ISO 9013 shall be specified by the purchaser on the drawing.

In the case of ferritic materials, the weld edges shall be smoothed until they are free from scale.

(3) If not demonstrated to the contrary in the welding procedure qualification, 2 mm of the surface shall be removed by machining upon thermal cutting in the case of ferritic materials if $R_{p0.2RT}$ is greater than 370 N/mm^2, in the case of materials for special loadings in accordance with **Table 8-1** and in the case of clad materials. In the case of thermal cutting of ferritic materials, pre-heating shall be effected in accordance with KTA 3211.1. In addition, at ambient temperatures equal to or lower than 5 °C, heating shall be effected. Deviating from check number 2.9 in **Table 9-1**, an additional surface inspection of the gouged area shall not be required if gouging and back welding is effected at the heat of the welding process.

(4) Weld edges made by means of plasma arc cutting of austenitic materials may remain undressed if the specifications in accordance with (5) and (6) are met.

(5) The weld edges, weld areas and part surfaces for build-up welds shall be free from scale and contaminants (e.g. fat, paint, rust) as well as dampness.

(6) If non-destructive tests are scheduled, the requirements to be met by the surface in accordance with Section 11 shall be complied with.

5.5 Performance of welding work

5.5.1 General

(1) The following specifications shall apply to all welds on pressure-retaining parts.

(2) The welding conditions specified in the welding procedure specifications shall be within the tolerances which are permissible in accordance with Section 8.1.1.3 for the scope of application of the welding procedure qualification.

5.5.2 Heat input

(1) With regard to heat input, the specifications in accordance with KTA 3211.1 shall be complied with.

(2) The scheduled preheat temperature shall normally be maintained in an area of at least 4 · s to DIN EN ISO 13916, but at least 100 mm, on both sides of the weld until welding work is completed. The preheat temperature shall also be maintained in the case of tack welds and welds of welded attachments. If preheating is not scheduled, the weld area shall be heated at ambient temperatures below 5 °C. The formation of condensed water shall be avoided by suitable measures. If, in the case of austenitic welds, measures are scheduled which are to lead to an accelerated drop in the working temperature, they shall be conducted with oil-free dry air or with water. If there is no subsequent cleaning, the water shall be fully demineralized.

5.5.3 Bead sequence in the case of ferritic welds

(1) An appropriate bead sequence (multiple-pass weld, building up from the weld edges) shall normally, to a far-reaching extent, prevent the heat affected zone from being coarse-grained or too hard. In the case of fluid-wetted welds with a permanent root which are to be welded from one side, the TIG process or an equivalent process shall be applied to the root.

(2) In the case of the cover pass welding, a wide overlapping of the base metal shall be avoided (excessive cover passes).

(3) The tempering bead technique in accordance with **Figure 5-1** shall be applied when

a) welding the steel grades 20 MnMoNi 5 5 and 15 NiCuMoNb 5 S,

b) welding the steel grades 15 MnNi 6 3, WStE355 S and P355NH, if no stress-relief heat treatment of the weld is performed.

When welding the tempering bead, the heat input shall be equal to or greater than the heat input used when welding the cover pass. In the case of wall thicknesses equal to or smaller than 16 mm, exceptions to the above-mentioned operating principle are permitted if the requirements regarding bead sequence and tempering bead in terms of fabrication cannot be met or if, in extreme cases, only one root and cover pass can be welded.

(4) Tempering bead techniques other than the stringer bead variation as represented in **Figure 5-1** may be used provided their suitability in terms of equivalence has been demonstrated by means of a welding procedure qualification.

(5) The rims of the weld edges shall be covered although the overlapping shall normally be kept to a minimum.

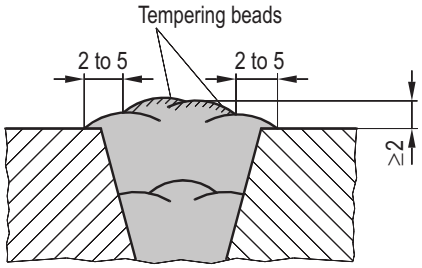


Figure 5-1: Tempering bead technique of ferritic welds using welding position flat (PA) as an example

5.5.4 Bead sequence in the case of austenitic welds

(1) Austenitic welds shall be welded with the minimum possible amount of heat input. This shall normally be effected by means of the stringer bead technique. In the case of onesided fluid-wetted welds without subsequent dressing of the root, the TIG or an equivalent process shall be used for the root.

(2) Tempering colours that may occur during welding shall be avoided by taking suitable measures. Tempering colours including colour no. 2 (Figure F.1 to DIN 25410) are permited. Decision on the acceptability of tempering colour 3 (Figure F.1 to DIN 25410) shall be made in each individual case.

5.5.5 Welds on parts with austenitic cladding

(1) **Figure 5-2** illustrates the basic design of a seam weld on clad parts. When executing the seam weld, sufficient removal of the cladding is necessary. After the seam weld has been executed, the cladding shall be closed in the form of single-pass or multiple-pass cladding.

(2) In the case of clad parts whose weld building sequence is effected from the outside only, appropriate requirements shall be specified by agreement with the authorized inspector.

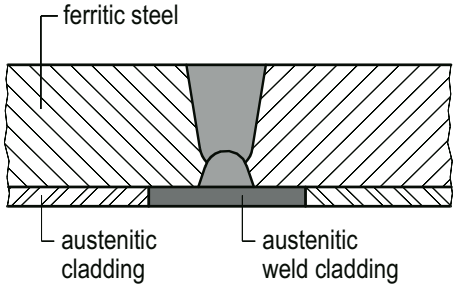


Figure 5-2: Seam weld of clad parts

5.5.6 Grooving of welds

(1) If grooving of welds is scheduled (e.g. before back-welding of the root or as a repair measure), the following processes may be used:

a) machining (e.g. grinding),

b) thermal processes in the case of ferritic materials.

Subsequently, the gouged areas shall be smoothed by grinding.

The specifications laid down in Section 5.4 (2) shall apply to preheating.

(2) It is permissible to waive the grooving of the root before welding the back welds if an appropriate welding procedure qualification is available.

5.5.7 Arc strikes and weld spatter

The arc striking of electrodes on parts outside the weld groove shall be avoided. If, however, arc striking outside the weld groove occurs, it shall be smoothed by grinding and subjected to a surface inspection in accordance with Section 11. Crack-like surface defects are not permitted. Weld spatter shall be removed.

5.5.8 Tack welds

Tack welds shall be welded under the same conditions as part welds. They may only remain on the part if they are sufficiently long (in general, equal to or greater than 50 mm, in the case of wall thicknesses less than 12 mm at least 4 times the thickness of the thicker part) and are of the same quality as the root weld.

5.5.9 Welded attachments

(1) Welded attachments on ferritic parts shall normally be made of a material belonging to the same material subgroup as the part or, if necessary, to a lower subgroup than the part (**Table 8-1**).

(2) Welded attachments shall be welded under the same conditions as part welds. The welds shall be executed as two-pass welds at least; the final pass shall not cause any melting of the base metal of the part.

(3) Welding shall be effected prior to the final stress relief heat treatment of the part. Exceptions to this are only permitted with the authorized inspector's agreement.

(4) The number of welded attachments not remaining on the part shall be kept to a minimum.

(5) Welded attachments shall not be removed by hammering off. Their removal shall normally be effected by means of machining. If thermal cutting becomes necessary, a minimum distance of 5 mm from the surface of the part shall be adhered to. The remainder shall be ground down to the surface of the part with the minimum possible amount of heat input; the points shall be recorded. After the welded attachments have been removed, the areas shall be subjected to a surface inspection in accordance with Section 11.

5.5.10 Use of current contact tubes

If weld heads with current contact tubes made of copper are used, the manufacturer shall ensure that any melting of the contact tubes is detected. If a contact tube starts to melt during welding work, welding shall be stopped immediately and the welding supervisory personnel shall be notified. The supervisory personnel shall specify any necessary measures. If melting of a contact tube is identified at a later point of time, a non-conformance report shall be prepared. Any further action to be taken shall be specified by the manufacturer's quality assurance department and be approved upon by the authorized inspector. Remedial work may not be carried out until this procedure has been completed. These events shall be recorded. After these measures have been taken, fabrication may continue with a new contact tube. In addition, the specifications in accordance with Section 13 shall be observed.

5.6 Supervision of welding work and records made by the welding supervisory personnel

The performance of welding work shall be supervised by the welding supervisory personnel of the manufacturer. For this purpose, records (reports) dealing with the performance of the supervisory steps shall be kept. Extent and frequency of the records are specified in **Table 5-1**. The manufacturer is free to choose the layout of the records (example see **Form A-12**). If similar types of welding work (e.g. pipes) are effected at the same time, a summarizing report is permitted (example see **Form A-13**).

Test Group	Entries	
	Frequency	Scope
A 1	At the start of welding work and at least 2 times per shift and fabrication section [1)]	a) component number b) welding procedure specification c) weld number d) time of the inspection e) adherence to the welding data in accordance with the welding procedure specification f) welder/operator g) reportable events h) insofar as required in accordance with KTA 1408, lot numbers of the welding filler metals
A 2 and A 3	At the start of welding work and at least 1 time per shift and fabrication section [1)]	
[1)] Each welding process shall be recorded at least once.		

Table 5-1: Records for welding work

5.7 Weld requirements

5.7.1 External condition

5.7.1.1 General

(1) For external irregularities on welds evaluation group B of DIN EN ISO 5817 applies.

(2) In deviation from the requirements of DIN EN ISO 5817 the following applies:

a) for misalignment - Section 5.7.1.2,,

b) for surface condition of the welds - Section 5.7.1.3,

c) for arc striking and weld spatter - Section 5.5.7,

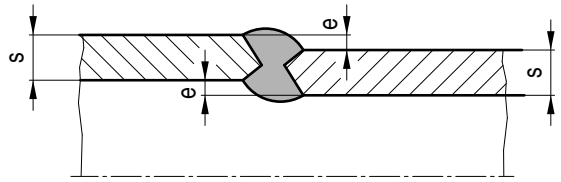
d) for non-destructive testing - Section 11.2.3 as well as Tables 11-5, 11-15 and 11-16.

(3) The surfaces of build-up welds may remain completely or partially undressed if the necessary testability and the requirements to be met by the function of the part permit this. Dressing is only permissible if it has been demonstrated in a welding procedure qualification or production control test that the required corrosion resistance exists up to 2 mm under the remaining surface.

5.7.1.2 Misalignment

5.7.1.2.1 Welds to be executed as double-sided welds

Table 5-2 shall apply to the misalignment of double-sided welds. If welds are smoothed by grinding, greater misalignment may be permitted, provided the authorized inspector agrees and if the testability requirements (angle of inclination in accordance with Section 11.1) and the required calculated wall thickness are complied with.



Test Group	Maximum misalignment e
A 1	0.1 · s, but ≤ 3 mm
A 2, A 3	0.15 · s, but ≤ 4 mm

Table 5-2: Maximum allowable misalignment of double-sided welds

5.7.1.2.2 Welds to be executed as one-sided welds

(1) The requirements in accordance with Section 5.7.1.2.1 shall apply to outer surfaces. **Table 5-3** shall apply to the misalignment after partial root welding or centering. If further welding work is executed on the seam, no essential changes shall occur in the misalignment.

(2) The tolerances of the pipe inside diameters shall be preset so that it is possible to fully ensure compliance with the misalignment as specified in **Table 5-3**. For this purpose, it may become necessary to use special measures, e.g. calibration or smoothing of the pipe ends.

(3) In the case of pipes, the conditions specified in **Table 5-3** require procedures in accordance with either (a) or (b) or c):

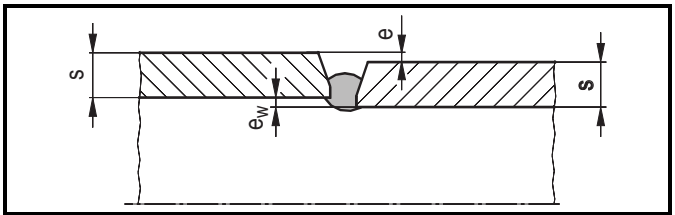
a) Welding of partial roots using an alignment clamp (partial roots are understood to be permanent root welds of sufficient length and number). With regard to the welding of partial roots, the necessary number and length of partial roots, which need to be adhered to in the course of further welding to ensure that no essential changes shall occur, shall be determined as a function of material, diameter and wall thickness.

b) The complete welding of a root using an internal alignment clamp (it may become necessary to leave the internal alignment clamp, also for the welding of support or filler beads).

c) weld preparation (adaptation of the inner diameter) to DIN 2559-2.

(4) By exact adaptation in the root area and the use of suitable welding procedures an even, flat root contour shall be obtained so that ultrasonic testing is not affected by echo indications due to external contour and proper assessment of the root by radiographic testing is made possible.

(5) The manufacturer shall demonstrate to the authorized inspector that the use of the abovementioned procedures fully ensures compliance with the misalignment as specified in **Table 5-3**. The manufacturer shall make this demonstration in the course of the first part welds unless appropriate demonstrations regarding other welds are already available.



Test Group	Diameter	Misalignment e_w
A 1, A 2	≤ DN 125	0.1 · s, but ≤ 1.0 mm
	> DN 125	0.1 · s, but ≤ 1.6 mm
A 3	> DN 50	0.15 · s, but ≤ 1.6 mm [1]
A 1 [2]	> DN 1000 mm and s > 20 mm	≤ 2.4 mm, locally 3 mm
A 2 [2], A 3 [2]		≤ 2.4 mm, locally 4 mm

Misalignment e in accordance with Section 5.7.1.2.1.

[1] In the case of > DN 125 and TB ≤ 100 °C: 0.15 x s, but ≤ 2.4 mm

[2] Vessel closure welds and other inaccessible welds.

Table 5-3: Maximum allowable misalignment e_w for one-sided welds after welding of partial roots or after centering

5.7.1.3 Surface condition, grinding of welds

(1) The condition of the weld surface shall permit the performance of the required tests, irrespective of the extent of testing. The requirements to be met by the surface condition of welds shall be complied with in accordance with **Table 5-4**.

(2) Care shall be taken to ensure that the workpiece is only slightly heated during the grinding process.

(3) Underflushing shall be avoided. It is not permitted if it adversely affects the testability of the weld or if the permissible primary stresses are exceeded.

Individual local underflushing equal to or smaller than 5 % below the calculated wall thickness is permissible without tolerance and additional demonstrations if the local expansion of the cavity is limited as follows:

Length and width equal to or smaller than $2 \cdot \sqrt{r \cdot s}$.

s : actual wall thickness outside the local underflushing,

r : inner curvature radius of the product form.

In the case of bottom heads, r refers to the adjacent cylinder or, in the case of the flange area, to the flange radius.

Larger underflushing shall be treated as deviation in accordance with Section 13.

(4) The cavities may show a deviation from the specified shape of the surface up to 10 degrees if the testability of the weld is not affected.

(5) If possible, shaping build-up welds resulting from weld underflushing shall be avoided. However, if they become necessary, the specifications in accordance with Section 8.1.3.3 shall apply.

5.7.2 Internal condition

The specifications laid down in Section 11 shall apply to internal irregularities.

Type of weld	Scope of Application	Surface Condition	Quality Requirements
Butt welds and nozzle welds	1. Ferritic butt welds a) outer surface [1]; b) inner surface ba) if the scanning conditions to Table 11-7 no. 1.1 are used in due consideration of the requirements of clause 5.1 (3), bb) if the scanning conditions to Table 11-7 no. 1.2 to 1.6 are used for ultrasonic testing, bc) for butt welds on the materials 20 MnMoNi 5 5 and 15 NiCuMoNb 5 S as far as accessible (for manual grinding) 2. Butt welds on austenitic steels with wall thicknesses s ≥ 8 mm [1] as well as butt welds between ferritic steels and austenitic steels a) outer surface b) inner surface in due consideration of the requirements of clause 5.1 (3) 3. Inner surface of butt welds on vessels if required to make decontamination possible 4. If specified as such on account of special operating conditions within the scope of the design approval 5. Inner surface of nozzle welds as far as accessible	Machined flat	No weld reinforcement No notches
Nozzle welds and attachment welds	1. Outer surface of nozzle welds 2. Attachment welds 3. If specified as such on account of special operating conditions within the scope of the design approval.	Profile ground	Weld contour in accordance with KTA 3211.2 Section 5.2.2 No notches
All types of weld	All welds for which surface condition „machined flat“ or „profile ground“ is not required.	Undressed (welding condition)	In accordance with Section 5.7.1 of this safety standard Grooves or notches affecting the test statement shall be eliminated [2] Weld contour in accordance with KTA 3211.2 Section 5.2.2

Note:
(1) Section 5.7.1.3 shall apply to weld underflushings.
*(2) Additional surface condition requirements for the scanning and opposite zones are contained in Section 11.2.3 and **Tables 11-7 to 11-11**.*

1) For s < 8 mm notch-free grinding will suffice.

2) If the quality requirements are not met in the as-welded condition, rework may be effected by means of grinding (permissible weld reinforcements may be retained).

Table 5-4: Requirements regarding the surface condition of welds

6 Forming of Parts

6.1 General requirements

(1) Hot and cold forming processes used in the manufacture of product forms (e.g die-formed parts, dished parts, pipe elbows and moldings) are dealt with in KTA 3211.1.

(2) The tolerance requirements are specified in Section 9.3.3.

6.2 Hot forming

(1) Hot forming of parts and product forms made of ferritic steels is understood to be forming effected at temperatures above the allowable temperature for stress relief heat treatment.

(2) Hot forming of parts and product forms made of austenitic steels is understood to be forming effected at temperatures equal to or higher than 400 °C.

(3) Product forms which are to be hot formed shall be heat treated and tested prior to forming in accordance with KTA 3211.1.

(4) The processing conditions for hot forming shall correspond to the specifications laid down in KTA 3211.1 or to the results of the forming process approval in order to ensure the required properties even after the final heat treatment of the part to be fabricated.

(5) If welded parts are hot formed, it shall be demonstrated that the properties of the weld metal comply with the require-

ments to be met by the part. If this cannot be demonstrated, the hot formed weld metal shall be removed and the part shall be re-welded.

6.3 Cold forming

(1) Cold forming of parts and product forms made of ferritic steels is understood to be forming effected between room temperature and temperatures below the allowable temperature for stress relief heat treatment. In this context, it shall be ensured that the allowable temperature is not exceeded in the course of the forming process.

(2) Cold forming of parts and product forms made of austenitic steels is understood to be forming effected at temperatures below 400 °C.

(3) Product forms which are to be cold formed shall be heat treated and tested prior to forming in accordance with KTA 3211.1.

(4) When cold forming parts and product forms, the degree of cold forming specified for ferritic steels of material group W I in Annex A of KTA 3211.1, for ferritic steels of material group W II a degree of cold forming of 5 % and for austenitic steels a degree of cold forming of 15 % shall normally not be exceeded. If this permissible degree of cold forming is exceeded or if the degree of forming is not verified, a heat treatment is basically required. To this end, a heat treatment plan to Section 4.1.1.3.8 shall be established. Heat treatment may be omitted if it has been demonstrated, by means of a review of the forming process, that the material properties specified in KTA 3211.1 are maintained or that any values deviating from these properties are sufficient with regard to the use of the part. This shall also include a review of corrosion resistance. In dependence of the material, it shall be proved that the material is corrosion-resistant in due consideration of the cold forming process; this may be proved irrespective of the part and the manufacturer.

(5) Welding work on part areas with degrees of cold forming greater than those permitted in accordance with KTA 3211.1 may only be performed with special verifications if there is no prior heat treatment.

(6) The degree of cold forming which depends on the outside diameter of the pipe d_a, the wall thickness s and the average bending radius r_m shall be determined as follows:

$$\frac{d_a - s}{2 \cdot r_m} \cdot 100\% \qquad (6\text{-}1)$$

Cold formed austenitic pipe bends with DN > 50 and operating temperatures equal to or exceeding 200 °C in BWR plants shall be subjected to solution annealing. Calibration work where required, shall basically be performed prior to solution annealing. Upon solution annealing, sizing or roll pass work is only permitted up to a maximum degree of forming of 2 %.

6.4 Review of the forming process

6.4.1 Formed parts (except pipes)

A review of the forming process shall not be necessary (for exceptions see clause 6.3 (4)).

6.4.2 Pipe bend

(1) Before fabrication is started, it shall be demonstrated on a formed pipe section or on a corrspondingly formed accompanying test piece that the forming process is suitable and that the requirements in accordance with KTA 3211.1 and KTA 3211.2 as well as the requirements in accordance with Sections 9 and 11 are complied with. When testing the bending process, the permissible degree of forming shall be determined as the ratio r_m/d_a.

(2) For the review, the following documents in accordance with Section 4 (insofar as they are required) shall be prepared by the manufacturer and reviewed by the authorized inspector:

a) test and inspection sequence plan,

b) heat treatment plan,

c) materials testing and specimen-taking plan.

(3) The following shall be taken into consideration for the review:

a) material,

b) heat treatment condition prior to bending,

c) wall thickness,

d) bending process,

e) heat input during forming,

f) degree of forming, specified as the r_m/d_a ratio (r_m : mean bending radius, d_a : outside diameter),

g) post-weld heat treatment.

(4) The tests to be conducted shall be specified by agreement with the authorized inspector, taking account of any available examination results.

(5) Taking into consideration the wall thickness and heat input, a smaller r_m/d_a ratio shall include a greater r_m/d_a ratio.

(6) The review of the bending process shall apply to the material examined and may be transferred to other materials with the agreement of the authorized inspector. In the case of austenitic materials, the review of the forming process for one austenitic material shall include the other austenitic materials with respect to the mechanical properties. In dependence of the material, it shall be proved that the material is corrosion-resistant in due consideration of the cold forming process; this may be proved irrespective of the manufacturer.

(7) The results of the forming procedure qualification shall be compiled in a report by the manufacturer with a specification of the scope.

(8) The validity of the forming procedure qualification is 12 months. An extension may be effected in accordance with Section 6.5.3.

(9) The scope of the review shall be confirmed by the authorized inspector.

6.5 Testing of formed parts

6.5.1 General

For testing of formed parts suitable fabrication documents (e.g. materials testing and specimen-taking plan, test and inspection sequence plan) shall be drawn up and submitted to the authorized inspector for design approval. These documents shall be subdivided into materials, dimensional range and heat treatment and shall contain all required tests and in-process inspections.

6.5.2 Testing of formed parts, except pipes

(1) If the permissible to clause 6.3 (4) degree of cold forming is not exceeded when parts are formed, the parts shall be subjected to a dimensional check and a visual check after forming. Additional tests shall not be necessary.

(2) If the permissible to clause 6.3 (4) degree of cold forming is exceeded when parts are formed, or if parts are hot formed, non-destructive and mechanical testing of the parts after the subsequent heat treatment shall be conducted and substantiated in accordance with the specifications laid down in KTA 3211.1. If mechanical testing cannot be conducted on the formed parts themselves, forming shall be effected on sufficiently large simulated test coupons which shall then be

added to the relevant heat treatment lot and tested. The parts shall be subjected to a dimensional check and a visual check after forming.

6.5.3 Testing of bent pipes

(1) The pipe blanks shall have been tested in accordance with KTA 3211.1.

(2) If the permissible degree of cold forming is not exceeded when pipes are bent, the following tests shall be conducted after bending:

a) dimensional check (wall thickness, ovality, bending radius, angle of bend),

b) visual check.

A review of the forming process in accordance with Section 6.4 shall not be necessary.

(3) If the permissible degree of cold forming is exceeded when pipes are bent without subsequent heat treatment, the following shall apply:

a) The forming process shall be reviewed in accordance with Section 6.4. The procedure parameters tested in this process shall be adhered to. A test bend conducted after 12 months shall suffice for the requalification of the forming process if the operating records from current fabrication confirm the application of the tested procedure parameters. If, in the case of a bend from current fabrication, essential parameters deviate from the scope of the initial review of the forming process, a supplementary review of the forming process shall be conducted on a test bend. The scope of the examinations for the supplementary review of the forming process and for the renewed qualification of a reviewed forming process shall be specified by agreement with the authorized inspector; the scope of these examinations may be reduced as compared to that of the initial review.

b) The following tests shall be conducted on the bent pipes:

   ba) dimensional check (wall thickness, ovality, bending radius, angle of bend),

   Note:

   To this see also section 9.3.3.4.

   bb) visual check,

   bc) surface inspection in the bent area on the outer and the inner surface in accordance with the requirements of KTA 3211.1 for pipe elbows.

   bd) In the case of ferritic materials ($R_{p0.2RT} \geq 300$ N/mm²) a random hardness test shall be conducted in the tension and pressure area if the strength values of the pipe blanks are significantly higher than those of the pipes included in the forming procedure qualification.

(4) In the case of hot bending and bending where the permissible degree of cold forming is exceeded and a subsequent heat treatment is effected, the following shall apply:

a) The forming process shall be reviewed in accordance with Section 6.4. The procedure parameters tested in this process shall be adhered to. A test bend conducted after 12 months shall suffice for the requalification of the forming process if the operating records from current fabrication confirm the application of the tested procedure parameters. If, in the case of a bend from current fabrication, essential parameters deviate from the scope of the initial review of the forming process, a supplementary review of the forming process shall be conducted on a test bend. A requalification of the forming process may be replaced by mechanical tests conducted on the bent pipe, e.g. in the course of the current lot-wise acceptance of the bends in accordance with (b). The scope of examinations for the supplementary review of the forming process and for the requalification of a reviewed forming process shall be specified by agreement with the authorized inspector; the scope of these examinations may be reduced as compared to that of the initial review.

b) The following tests shall be conducted on the bent pipes:

   ba) dimensional check (wall thickness, ovality, bending radius, angle of bend),

   Note:

   To this see also section 9.3.3.4.

   bb) visual check,

   bc) surface inspection in the bent area on the outer and the inner surface in accordance with the requirements of KTA 3211.1 for pipe elbows,

   bd) mechanical tests.

   Mechanical tests shall be conducted on one pipe bend per lot, i.e. on one bent prolongation (incipient bend) or on one additional bend in the heat treated condition scheduled for installation, in accordance with the specifications laid down in KTA 3211.1.

   The lot size is specified in **Table 6-1**.

   By agreement with the authorized inspector the lot size may be increased in accordance with the state of the forming process review.

Material	DN	Lot size (Number of pipe bends [1] for each - heat, - size range, - comparable heat treatment)
20 MnMoNi 5 5 15 NiCuMoNb 5 S	all	10
Materials belonging to Group W I	> 400	20
Austenitic materials	≤ 400	30
Materials belonging to Group W II	> 400	30
	≤ 400	50

[1] One bent pipe may have several bends.

Table 6-1: Lot sizes for mechanical tests of hot bends or cold bends with subsequent heat treatment

6.6 Parties involved in the tests

(1) The manufacturer shall conduct all tests and in-process inspections at a rate of 100 %.

(2) The authorized inspector shall conduct random tests and in-process inspections at the following rate:

a) Test Groups A1 and A2 : 25 %,

b) Test Group A3 : 10 %.

(3) All destructive tests shall be conducted in the presence of the authorized inspector and shall be certified by him.

6.7 Record on the bending of pipes

(1) The manufacturer shall use the fabrication documents in accordance with Section 6.5.1 to prepare a documentation on the forming work that has been conducted. This documentation shall specify the following:

a) the heating and forming equipment used,

b) the maximum degree of forming,

c) the heat input applied in the course of forming,

d) the tests that have been conducted.

(2) For parts which are normalized, quenched and tempered or solution annealed upon forming, data on the degree of forming may be omitted.

7 Heat treatment

7.1 Principles

7.1.1 General

(1) Heat treatment is understood to be all processes during which a part is subjected to time-temperature sequences for the purpose of conferring properties to it, thus making it suitable for its further processing or use, i.e. normalizing, quenching and tempering, tempering, stress relief heat treatment, solution annealing and stabilizing.

(2) Pre-heating and soaking after welding shall not constitute heat treatment as defined in this safety standard.

(3) Heat treatment plans shall be drawn up for all heat treatments conducted on parts or test pieces. In terms of layout and content, these plans shall comply with the specifications laid down in Section 4.1.1.3.8. In addition, the heat treatment plans shall take into consideration any process-based distinctive features of the heat treatment in accordance with KTA 3211.1 which influence the material. **Table 7-1** shall basically apply to the heat treatment of welded connections of different materials. When specifying the heating and cooling rates, the thermal transient loads of the part shall be taken into consideration.

(4) Heat treatments on parts, subunits and components shall normally be conducted on units which are as large as possible in order to cover many welds on one component by one heat treatment.

(5) Parts shall preferably be furnace heat treated as whole parts. Local stress relief heat treatment is only permissible in the case of component-specific boundary conditions (e.g. on-site assembly of pipes, closure weld of a vessel), complying with the requirements specified in Sections 7.1.2.4 and 7.2.4.

(6) In the case of stress relief heat treatment, a local heat treatment may be effected for circumferential pipe welds and in special cases, e.g. in the case of circumferential welds of components. In this context, appropriate measures shall be taken against possible restraint and its effects on the part.

7.1.2 Heat treatment equipment

7.1.2.1 General requirements

(1) The heat treatment equipment and process shall permit a sufficient accuracy and consistency of the heat control in the part for the type of heat treatment selected. This shall apply, in particular, to materials which need to be heat treated in narrow temperature ranges.

(2) The manufacturer shall test the function of the heat treatment equipment at regular intervals. These tests shall be recorded and the records shall be kept at the manufacturer’s works.

7.1.2.2 Temperature measurement

(1) In order to monitor the heat treatment process, thermocouples shall be attached to the part in the following cases:

a) large parts (e.g. shell courses, flange rings, heads, closure heads, large nozzles and subunits welded together from such parts),
b) larger annealing lots with expected irregular temperature distribution in the furnace (taking the furnace charge into consideration),
c) local heat treatments.

(2) Adequate instrumentation of the furnaces shall be sufficient in other cases.

7.1.2.3 Stationary heat treatment equipment

(1) Stationary heat treatment equipment shall be inspected at intervals of not more than 6 months. During such inspections, it shall be ensured that the temperature distribution in the furnace is comparable with the values determined in the initial qualification.

(2) The indicating accuracy of the measuring devices of heat treatment equipment (thermocouples, feeders, measuring and recording equipment) shall be tested at intervals of not more than 3 months.

(3) Thermocouples for measurements on the part (trailing couples and their feeders) shall be tested before each heat treatment.

7.1.2.4 Portable heat treatment equipment

If the heat treatment equipment is portable, a function test of the total equipment shall be conducted and the measuring device be calibrated each time after the equipment is moved. A transfer of parts of the equipment, e.g. from weld to weld, shall not constitute "a move of the equipment". When the equipment is being used, the function test shall not have been carried out more than 6 months previously.

7.2 Performance

7.2.1 Heat treatment of test pieces

(1) If test pieces are to be subjected to heat treatment for material tests, the time-temperature sequences of the part annealing shall be complied with on the test pieces; in this context, a sufficient number of test pieces shall be equipped with thermocouples.

(2) In the case of accompanying test pieces of parts of different cross sections, the test pieces may be attached to the part by means of fixtures. In this context, the corresponding cross sections shall be allocated to each other.

(3) Program-controlled furnaces may be used for a simulated heat treatment of test pieces. The time-temperature sequences for simulated heat treatment shall be selected in accordance with the requirements specified in KTA 3211.1.

(4) Each time-temperature sequence shall be recorded when conducting heat treatments.

7.2.2 Heat treatment of ferritic parts

7.2.2.1 Welded connections

(1) If quenched and tempered or normalized parts are welded, these shall basically be subjected to a heat treatment if this is scheduled in accordance with **Table 7-1**. Any deviations from this requirement are permitted only if substantiated by appropriate examinations. **Table 7-1** shall basically apply to the heat treatment of welded connections made of different steels.

(2) Basically, ferritic one-sided fluid-wetted welds shall be subjected to stress relief heat treatment in accordance with **Table 7-1**, irrespective of their wall thickness. This stress relief heat treatment may be waived in the following cases:

a) materials where $R_{p0.2RT}$ is equal to or smaller than 300 N/mm^2,
b) materials where $R_{p0.2RT}$ is greater than 300 N/mm^2 and equal to or smaller than 370 N/mm^2 in case of admission of fluid of the component cooling system, or
c) with the authorized inspector's special agreement.

7.2.2.2 Build-up welds

(1) Product forms and parts with claddings shall be subjected to stress relief heat treatment if this is required in accordance with KTA 3211.1. If claddings and seam welds on parts are to be subjected to a joint heat treatment, the annealing temperature to be specified shall be adapted to the different annealing temperatures for claddings and seam welds. In this context, **Table 7-1** shall be observed.

(2) Hardsurfaces shall be subjected to a heat treatment if

a) this is required on account of the welding filler metals used,

b) the material to be hard surfaced requires this. If this is the case, the heat treatment shall be conducted after buttering. If the heat treatment is conducted after the hardsurfacing, care shall be taken to ensure that the functional capability of the hardsurface and the functional safety of the part are not affected.

7.2.3 Heat treatment of parts made of austenitic steels

(1) Basically, stress relief heat treatment is not necessary for seam welds on austenitic steels.

(2) If special requirements are to be met by hot or cold formed parts or by non-formed welded connections, e.g. with regard to machining, dimensional accuracy, impairment due to stress corrosion cracking, intergranular corrosion resistance, the specification laid down in this section may not, in all cases, be sufficient to guarantee the safety of the part. In such cases, a heat treatment plan in accordance with Section 4.1.1.3.8 shall be prepared.

7.2.4 Local stress relief heat treatment

(1) In the case of local stress relief heat treatment, the width of the annealing area shall normally be two times the wall thickness (at least 100 mm, except for pipe dimensions equal to or smaller than DN 100); the weld shall normally be in the centre of this area.

Note:
The annealing area shall be the area showing the specified annealing temperature.

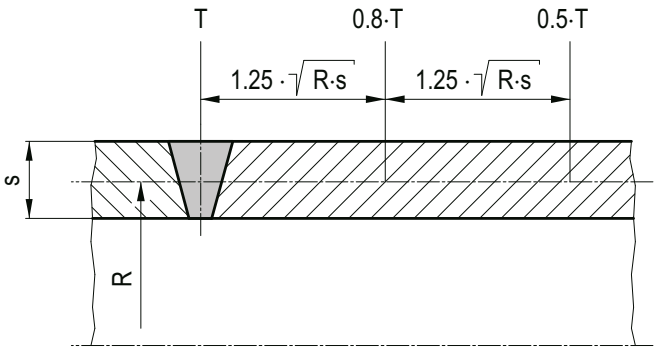
(2) In a sufficiently wide heated area beyond the annealing area, temperature gradients causing damage to the part or material (depending on the material in accordance with KTA 3211.1 and the dimensions) shall be avoided. In general, in the case of walls without geometric discontinuities, this requirement is met if,

a) in the case of wall thicknesses s greater than 30 mm,

$5 \cdot \sqrt{R \cdot s}$ R : mean radius of the component or part
s : wall thickness

is adhered to as the width of the heat input area and the temperature history in accordance with **Figure 7-1** is maintained;

b) in the case of wall thicknesses s equal to or smaller than 30 mm, the area of heat input is provided to be at least eight times the wall thickness and a sufficient insulation is effected beyond this width.



T : Heat treatment temperature, °C
R : Mean radius of pipe or part, mm
s : Wall thickness, mm

Figure 7-1: Temperature distribution in the case of local stress relief heat treatment

(3) If, in areas without geometric discontinuties, the heat input area is symmetrical to the weld, it will suffice to measure the temperature in accordance with **Figure 7-1** on one side of the weld. If, in the case of a comparable geometry of the parts and a comparable design of the heat treatment equipment, the pre-set temperature distribution in the heat input area (heating method, insulation), has already been demonstrated on two parts, it will suffice to measure the temperature on the weld.

(4) In the case of areas with geometric discontinuities, special measures shall be specified by agreement with the authorized inspector. These agreements may be made on the basis of substantiated permissible permanent deformations, experimental values (e.g. temperature measurements) or by means of analyses or tests.

7.3 Certificates

(1) A record (example see **Form A-6**) containing the following data shall be issued for the heat treatment:

a) specification of the parts and the accompanying test pieces,

b) confirmation of compliance with all specifications contained in the heat treatment plan (specifications of the actual temperature and time in accordance with the original temperature-time records),

c) heat treatment equipment used and type of heating,

d) number and location of the temperature measurement points and statements concerning the temperature measurement process,

e) specification of the furnace atmosphere (e.g. shielding gas atmosphere, neutral, oxidizing, reducing).

(2) Any deviations from the approved heat treatment plan shall be substantiated by the manufacturer.

Combinations of materials		Wall thickness s (mm)	Buttering of the higher alloyed ferritic side		Seam weld	
			Recommended welding filler metals	Heat treatment temperature [1] after buttering (°C)	Recommended welding filler metals	Heat treatment temperature [1] after welding (°C)
20 MnMo Ni 5 5	20 MnMoNi 5 5 22 NiMoCr 3 7 15 NiCuMoNb 5 S	–	–	–	similar to 20 MnMoNi 5 5	580 to 620 [2]
	15 MnNi 6 3	–	–	–	similar to 15 MnNi 6 3	565 to 590
	X6CrNiNb18-10 X6CrNiMoTi17-12-2 X6CrNiTi18-10 X6CrNiMoNb17-12-2	–	nickel alloy [3]	580 to 620	nickel alloy [3]	–
15 NiCuMoNb 5 S	15 NiCuMoNb 5 S	–	–	–	similar to 20 MnMoNi 5 5	580 to 620
	22 NiMoCr 3 7	–	–	–	similar to 20 MnMoNi 5 5	580 to 620 [2]
	15 MnNi 6 3	–	–	–	similar to 15 MnNi 6 3	565 to 590
	X6CrNiNb18-10 X6CrNiMoTi17-12-2 X6CrNiTi18-10 X6CrNiMoNb17-12-2	–	nickel alloy [3]	580 to 620	nickel alloy [3]	–
15 MnNi 6 3 P235GH - P355NH WStE 255 S – 355 S P275NH P275NL1 P355NH	15 MnNi 6 3	s ≤ 38	–	–	similar to 15 MnNi 6 3	–
		s > 38 [4]				530 to 580 [5]
	P235GH - P355NH WStE 255 S - 355 S P275NH P355NH	s ≤ 38	–	–	unalloyed or similar to 16Mo3 or similar to 15 MnNi 6 3	–
		s > 38 [6]				530 to 580 [5]
	P235GH 16Mo3 C 22.8 S P250GH P355QH1	s ≤ 30				–
		s > 30 [7]				530 to 580 [7]
	GP240GH+QT GS-C 25 S	–				560 to 580
	10CrMo9-10	–	similar to 20MnMoNi 5 5 [8] [9]	690 to 720 [10]	similar to 15 MnNi 6 3	530 to 580 [11]
15 MnNi 6 3 P235GH - P355NH WStE 255 S – 355 S P235GH P275NH P275NL1 P355NH	X6CrNiNb18-10 X6CrNiMoTi17-12-2 X6CrNiTi18-10 X6CrNiMoNb17-12-2	s ≤ 38	–	–	austenitic steel [12] or nickel alloy [3]	–
		s > 38 [13]	nickel alloy [3]	530 to 580 [5]	nickel alloy [3]	–

Table 7-1: Heat treatment temperature after welding and recommended welding filler metals for different combinations of materials (continued next page)

Combinations of materials		Wall thickness s (mm)	Buttering of the higher alloyed ferritic side		Seam weld	
			Recommended welding filler metals	Heat treatment temperature [1] after buttering (°C)	Recommended welding filler metals	Heat treatment temperature [1] after welding (°C)
P235GH 16Mo3 C 22.8 S P250GH P355QH1	P235GH 16Mo3 C 22.8 S P250GH P355QH1	s ≤ 30	–	–	unalloyed or similar to 16Mo3	–
		s > 30 [7]				530 to 580 [6]
	GP240GH+QT GS-C 25 S	–				560 to 580
	10CrMo9-10	–	similar to 20MnMoNi55 [8] [9]	690 to 720		530 to 580 [11]
	X6CrNiNb18-10 X6CrNiMoTi17-12-2 X6CrNiTi18-10	s ≤ 30	–	–	austenitic steel or nickel alloy [4]	–
	X6CrNiMoNb17-12-2	s > 30 [13]	nickel alloy [3]	530 to 580 [5]	nickel alloy [3]	
GP240GH+QT GS-C 25 S	GP240GH+QT GS-C 25 S	–	–	–	unalloyed or similar to 16Mo3	580 to 620
10CrMo9-10	10CrMo9-10	–	–	–	similar to 10CrMo9-10	690 to 720
	13CrMo4-5	–	–	–	similar to 13CrMo4-5	650 to 700
	X6CrNiNb18-10 X6CrNiMoTi17-12-2 X6CrNiTi18-10 X6CrNiMoNb17-12-2	–	nickel alloy [3]	690 to 720	nickel alloy [3]	–
X6CrNiNb18-10 X6CrNiMoTi17-12-2 X6CrNiTi18-10 X6CrNiMoNb17-12-2	X6CrNiNb18-10 X6CrNiMoTi17-12-2 X6CrNiTi18-10 X6CrNiMoNb17-12-2 G-X5CrNiNb19-11 GX5CrNiMoNb19-11-2	–	–	–	austenitic	–
G X4 CrNi 13 4 X3CrNiMo13-4	G X4 CrNi 13 4 X3CrNiMo13-4	–	–	–	similar to X3CrNiMo13-4	590 to 620 [14]

1) The specifications regarding heat treatment temperatures for welded connections conducted on similar materials of material group W I were taken from KTA 3211.1.

2) The highest temperature for stress-relief heat treatment shall not exceed the lowest tempering temperature.

3) Section 5.3 shall be taken into account.

4) As well as one-sided welds s ≤ 38 mm.

5) See also Section 7.2.2.1.

6) As well as one-sided welds s ≤ 38 mm and $R_{p0.2RT}$ > 300 N/mm^2.

7) As well as one-sided welds s ≤ 30 mm and $R_{p0.2RT}$ > 300 N/mm^2.

8) Welding filler metal for the buttering on 10CrMo9-10.

9) Only permissible if the welding filler metal is demonstrated to be suitable for the scheduled heat treatment temperature after buttering.

10) This temperature is recommended provided the strength values of the buttering of the weld metal do not fall below the values of the lower strength ferritic material to be connected.

11) Heat treatment may be waived in the case of s ≤ 38 mm.

12) Mixing to obtain the ferritic base metal by choice of alloy shall be taken into consideration.

13) As well as the buttering of one-sided welds $R_{p0.2RT}$ > 300 N/mm^2.

14) Renewal of annealing may be necessary in dependence of the requirements regarding mechanical properties.

Table 7-1: Heat treatment temperature after welding and recommended welding filler metals for different combinations of materials (continued)

8 Welding procedure qualifications and production control tests

8.1 Welding procedure qualifications

8.1.1 Principles

8.1.1.1 Requirements

(1) Before the start of fabrication, the manufacturer shall demonstrate in welding procedure qualifications that the scheduled welding processes are being coped with in accordance with the following requirements. Welding procedure qualifications (welding work, investigations and testing) shall be conducted in the presence of the authorized inspector.

(2) Basically, welding procedure qualifications may be performed in the course of an early production control test (combined welding procedure qualification/production control test). In such a case, the principles in accordance with Section 8.2.1 shall also be taken into consideration.

8.1.1.2 Validity

(1) The period of validity is 24 months after the successful completion of a welding procedure qualification. The effective date for the beginning of validity - within 3 months after completion of the welding work - is the date on which the authorized inspector issues his certificate on the test results. If the test results are determined at a later date, the effective date for the beginning of validity shall be 3 months after completion of the welding work. If fabrication has started and production control tests are performed within these 24 months, validity shall be extended for an additional 24 months after the successful completion of the production control test. With regard to the effective date for the beginning of the extended period of validity, see Section 8.2.1.2.

(2) If fabrication has not started within 24 months after the successful completion of the welding procedure qualification or is interrupted for more than 24 months, the first production control test after fabrication has started or re-started shall constitute a repetition of the welding procedure qualification. The specifications for the initial welding procedure qualification shall apply to the test scope of this production control test as well as to the beginning of validity and the period of validity. Where fabrication is interrupted for more than 12 months, the production control test as required by Section 8.2 shall have been conducted prior to the start of fabrication.

8.1.1.3 Scope

8.1.1.3.1 General

(1) The scope of a welding procedure qualification shall be specified in the authorized inspector's certificate. It is possible to extend the scope by means of production control tests (see Section 8.2). The welding procedure qualification test which is valid for a manufacturer’s works shall also be valid for welding work executed outside the works, e.g. on sites where it is monitored by the welding supervisory personnel.

(2) The specifications laid down in Sections 8.1.1.3.2 to 8.1.1.3.9 shall be taken into consideration for the scope of the welding procedure qualifications.

8.1.1.3.2 Materials to be welded together

(1) Transferability in accordance with **Table 8-1** is permissible within the scope of the welding procedure qualification.

(2) If the scope of a welding procedure qualification is extended to materials belonging to another material subgroup, the toughness requirements shall be observed. Compliance with more stringent requirements shall be demonstrated by means of additional notched bar impact tests. This demonstration may be effected within the scope of production control tests.

(3) Separate welding welding procedure qualifications shall be required for materials which are not classified into the material subgroups in accordance with **Table 8-1**.

8.1.1.3.3 Welding filler metals and welding consumables

(1) The welding procedure qualification shall apply to the welding filler metals used (rod electrodes including type of coating, strip or wire electrodes, filler rod and welding rod) and to the welding consumables used (shielding gases, flux). Where change-over is made to another brand of welding consumables of the same type, no renewal of procedure qualifica-tion is required if the consumables satisfy the requirements of DIN EN ISO 636, DIN EN ISO 2560, DIN EN ISO 3580, DIN EN ISO 3581, DIN EN ISO 6847, DIN EN ISO 14341 and DIN EN ISO 14343.

(2) In the case of shielding gases to DIN EN ISO 14175, a change of supplier is permitted if identical analysis results are ensured.

(3) The electrode-flux combination used in the welding procedure qualification shall be valid for submerged-arc welding; an exchange of standard wire or strip electrodes of a comparable chemical composition is permitted, regardless of the manufacturer.

(4) It is not permitted to change the flux type used in the welding procedure qualification.

(5) In the case of electron and laser beam welding, the welding procedures with and without filler metals shall be approved separately.

8.1.1.3.4 Welding positions

(1) The welding positions applied during fabrication shall be demonstrated in the procedure qualification.

(2) If a welding position is not included in an available welding procedure qualification, the scope may be extended by means of a production control test or an addition to the welding procedure qualification.

8.1.1.3.5 Weld execution

(1) Welding procedure qualifications for one-sided welds shall also apply to double-sided welds.

(2) Welding procedure qualifications for multiple-pass welds shall not apply to single-pass welds and vice versa.

8.1.1.3.6 Welding processes

(1) If several welding processes are used in one welding procedure qualification, the proportion of weld metal used in the welding processes employed, in relation to the height of the weld metal deposited, may deviate from the welding procedure qualification in the case of part welds.

(2) The tolerance ranges demonstrated within the scope of the qualification test for welding filler metals and consumables in accordance with KTA 1408.1 are permissible for the welding parameters.

(3) If several welding processes (combined process) are qualified on one test piece, the notched-bar impact specimens shall be taken from the weld metal and the HAZ such that each welding process is covered.

8.1.1.3.7 Heat treatment

(1) The heat treatment to be conducted during a welding procedure qualification shall be specified in accordance with

the heat treatment scheduled for the part. Welding procedure qualifications shall cover the part's heat treatment unless the holding time of the welding procedure qualification does not differ by more than ± 20 °C from the holding time of the part's heat treatment. This shall also apply to simulated repair welds. When specifying stress relief heat treatments, necessary repair welds shall be taken into consideration. The length and temperature of the stress relief heat treatments shall be based on the specifications laid down in **Table 7-1** or those in the material Annexes of KTA 3211.1. For the simulated stress relief heat treatment, all temperatures above 450 °C shall be combined into one heat treatment (without intermediate cooling). The total annealing time may be exceeded up to 20 % on the part (temperatures over 450 °C in the case of a welding procedure qualification).

(2) This shall not apply to heat treatments which are conducted on parts with austenitic claddings. The total annealing time on which the welding procedure qualification was based shall not be exceeded during such heat treatments.

8.1.1.3.8 Wall thickness and diameter range

(1) A welding procedure qualification conducted on a multiple-pass arc welding test piece shall apply

a) for the wall thickness range of 3 mm to x s to 2 · s, if the thickness of the test piece is equal to or greater than 3 mm and does not exceed 12 mm,

b) for the wall thickness range of 0.5 · s to 2 · s, if the thickness of the test piece exceeds 12 mm and is equal to or less than 100 mm.

(2) The wall thickness of the test piece shall be specified such that the destructive tests and non-destructive tests required for the wall thickness of the component may be conducted.

(3) In the case of electron and laser beam welding the test piece shall be arranged and contoured such that it represents the part and its geometry to the greatest extent possible.

(4) The scope of a welding procedure qualification for welded attachments, in relation to the part to be welded of wall thickness s_1 in accordance with **Figure 8-1**) shall apply to part welds in ranges from 0.5 · s_1 to 2 · s_1. There is no upper limitation for wall thickness s if s is equal to or greater than s_1.

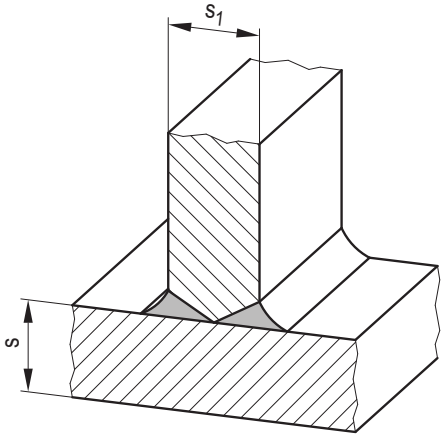


Figure 8-1: Wall thicknesses s and s_1 in a double bevel groove weld

(5) In the case of pipe welds executed as multiple-pass welds, in relation to the outside pipe diameter, 0.5 times the outside pipe diameter selected for the test shall be valid as the lower limitation. For the upper limit the following shall apply:

a) For a pipe outside diameter equal to or smaller than 168.3 mm the welding procedure qualification applies to two times the pipe outside diameter selected for the qualification.

b) At a pipe outside diameter greater than 168.3 mm there is no upper limit.

(6) In the case of nozzle and attachment welds, the specifications laid down in Section 8.1.2 shall apply.

(7) In the case of build-up welds, the specifications laid down in Section 8.1.3 shall apply, and in the case of tube-to-tubesheet welds, the specifications laid down in Section 8.1.5.

8.1.1.3.9 Aggravating circumstances

If there are aggravating circumstances (e.g. narrow spatial conditions, out-of-position welding, greatly curved surfaces of cladding welds), the welding procedure qualifications shall be adapted to a large extent to these circumstances or supplemented by a production control test.

8.1.1.4 Test pieces

(1) The materials shall have been tested in accordance with KTA 3211.1.

(2) The welding filler metals and consumables used in the welding procedure qualification shall meet the requirements in accordance with KTA 1408.1, KTA 1408.2 and 1408.3.

(3) Welding filler metals shall basically be welded with the same diameter as that to be used for the welding of the part. Other diameters may be used if the heat input during welding of the part is not more than 25 %

a) above the value obtained during test piece welding where requirements regarding the impact energy absorbed exist,

b) below the value obtained during test piece welding where hardness requirements exist,

in which case the heat input shall be calculated in accordance with DIN EN 1011-1.

(4) In the case of plates, the weld of the test piece shall normally be parallel to the main direction of forming.

(5) The dressing of the weld edges and the grooving of the root (gouging, grinding) shall normally fulfill the conditions regarding scheduled fabrication (see Sections 5.4 and 5.5.6).

(6) When specifying the dimensions of test pieces, the feasability of destructive and non-destructive tests (especially ultrasonic testing) shall be ensured. Prolongations of the weld for required substitute test specimens or simulated repair welds shall be provided; additional test pieces may become necessary (e.g. circumferential pipe welds) for this purpose.

(7) If, in the case of the test in accordance with **Table 8-4**, a specimen or set of specimens does not meet the requirements, the reason for their failure shall be established. A further two specimens or sets of specimens may be tested. These substitute specimens shall meet the requirements.

(8) The welding of test pieces shall be included in welding records.

(9) The tested specimens and the remaining parts of test pieces shall be retained until the report on the welding procedure qualification has been completed.

8.1.1.5 Simulated repair welds

(1) Repair welds on welded connections which are to be conducted with a welding process other than that used for the initial weld shall be simulated and tested in the welding procedure qualification.

(2) Repair welds conducted on one-sided welds whose root run has collapsed shall be simulated and tested in the welding

procedure qualification irrespective of the welding process used.

8.1.1.6 Documents

The following documents shall be drawn up before the welding procedure qualification is conducted:

a) welding procedure specification,

b) heat treatment plan (if a heat treatment is performed),

c) materials testing and specimen-taking plan.

8.1.1.7 Report

(1) The manufacturer shall draw up a report on the welding procedure qualification (WPQR) on which the authorized inspector shall issue a certificate.

(2) The manufacturer's report (WPQR) shall contain the following:

a) certifications of base metals, welding filler metals and consumables,

b) shape and dimensions of the test piece,

c) specifications relating to the welders, welding processes, welding conditions and welding data,

d) welding procedure specification and welding record,

e) heat treatment plan (where required) and heat treatment certificate or heat treatment charts,

f) materials testing and specimen-taking plan,

g) results of all tests.

(3) The authorized inspector's certificate shall contain:

a) summarized final result,

b) final evaluation,

c) delimitation of the scope of validity.

The contents of the WPQR and certificate shall permit a design approval of the welding procedure specification.

8.1.2 Seam welds

8.1.2.1 General

(1) **Table 8-2** contains a survey of tables and figures concerning the tests for seam welds.

(2) Longitudinal welds, circumferential welds and nozzle welds greater than DN 50 as well as welds of welded attachments where s_1 is greater than 16 mm shall be included in a welding procedure qualification conducted on one of these seam welds provided they are within the scope of validity in accordance with Section 8.1.1.3.

(3) If there are no other welding procedure qualifications available, welding procedure qualifications with a test scope in accordance with **Table 8-2** no. 5 b) shall be sufficient for nozzle welds equal to or smaller than DN 50, welds for welded attachments of a connection wall thickness s_1 smaller than 16 mm as well as for fillet welds.

(4) Welding procedure qualifications in position PA (flat position) conducted on plates, forgings or pipes where D_i is greater than 1000 mm shall only be valid for circumferential pipe welds where D_i is smaller than 1000 mm in the case of mechanical welding processes in position PA and in the case of shielded metal arc welds in position PA, pipe rotating.

(5) Where welding procedure qualifications are performed for electron and laser beam welding processes, the requirements of DIN EN 15614-11 shall be satisfied in addition to the specifications of cl. 8.1.2.

8.1.2.2 Simulated repair welds

(1) In the case of simulated repair welds required in accordance with Section 8.1.1.5, 50 % of the wall thickness shall be repaired such that the edges of the repair location cover both weld metal and base metal.

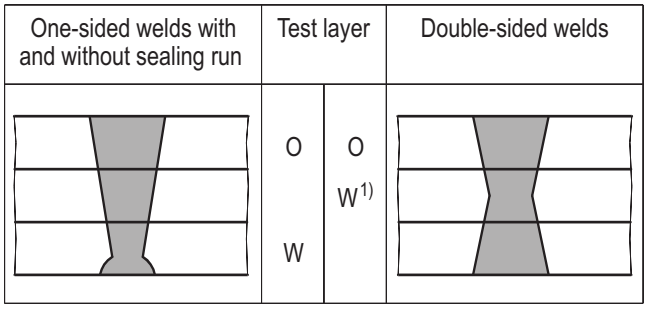
(2) In the case of one-sided welds of wall thicknesses equal to or smaller than 30 mm, the simulated repair weld shall cover the wall thickness existing at the time of the repair.

8.1.2.3 Welded connections between different ferritic materials

Without an additional welding procedure qualification, welded connections between different ferritic materials are only permitted if an available welding procedure qualification test in accordance with **Table 8-1** is valid for both materials. In this connection, the scope of the welding procedure qualification and the choice of the welding filler metals shall be effected in accordance with **Table 7-1**.

8.1.2.4 Test layers

Two test layers in accordance with **Figure 8-2** shall be provided in the case of ferritic materials and wall thicknesses s greater than 50 mm. In the case of combined processes the test layers shall be arranged such that each welding process is covered.



1) correspondingly displaced in the case of other weld geometries, e.g. 2/3 weld

Figure 8-2: Test layers in the case of ferritic materials for s > 50 mm

8.1.2.5 Seam welds between ferritic and austenitic materials

(1) A welding procedure qualification shall be conducted for seam welds between ferritic and austenitic materials.

(2) For seam welds between ferritic and austenitic materials, the tests to **Table 8-3** shall be conducted in the areas to **Figure 8-7**.

(3) The tests shall be conducted at the seam welds in their final state.

(4) The requirements for ferritic materials apply to testing of the heat affected zone on the ferritic side. For testing on the

a) weld metal,

b) weld metal of the buttering,

c) heat affected zones on the austenitic side and in the buttering

the requirements for austenitic materials apply.

(5) In addition,

a) a hardness test to **Figure 8-3** shall be made in the dilution zone between the ferritic material and the austenitic weld metal or nickel weld metal

and

b) a bend test (side-bend test specimen, see **Figure 8-4**) shall be performed.

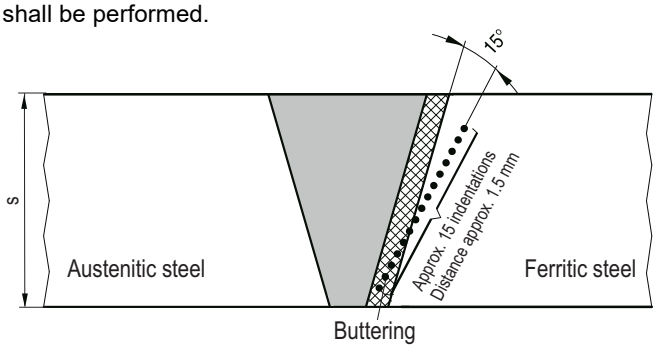
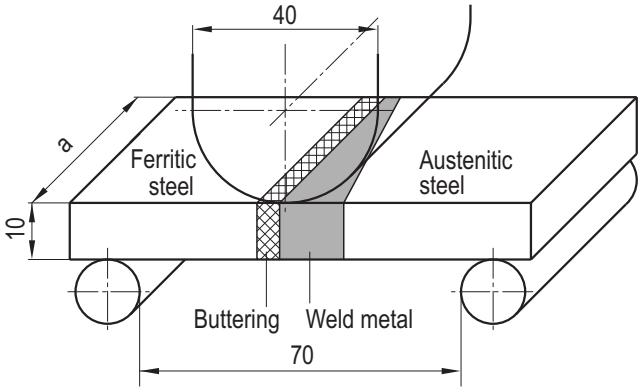


Figure 8-3: Hardness indentations HV 5 on buttered seam welds between ferritic and austenitic steels



Specimen thickness:	10 mm
Specimen width (a):	Product form thickness in base metal area (the weld may be ground flush)
Minimum length:	200 mm
Mandrel diameter:	40 mm
Mandrel position:	Transition from buttering to weld metal
Bending angle:	180 degrees

Figure 8-4: Specimen and test geometry of side-bend test on welded seams between ferritic and austenitic steels

8.1.3 Build-up welds

8.1.3.1 Austenitic and ferritic claddings

(1) Single-pass and multiple-pass claddings shall be regarded as separate welding processes. Welding procedure qualifications in which a single pass is welded shall only apply to single-pass welds. In the case of multiple-pass claddings (beginning with the second pass if there is the same heat control), at least two passes shall be welded in the welding procedure qualification.

(2) The welding procedure qualification conducted on test pieces of wall thicknesses smaller than 25 mm shall be valid for the wall thickness range of the part between $0.8 \cdot s$ and $1.5 \cdot s$. The welding procedure qualification conducted on test pieces of a wall thickness equal to or exceeding 25 mm shall be valid for wall thicknesses of the part of 25 mm and greater without limitation with the following exception: in the case of electron beam and laser beam build-up welding the value of “12 mm” instead of “25 mm“ shall apply.

The welding procedure qualification applies to all deposited layer thicknesses equal to or greater than that deposited layer thickness for which the chemical composition and the intergranular corrosion resistance have been proved (see **Figure 8-9**, sketch 1).

(3) It may become necessary to prevent the test pieces from shrinking when they are welded. Such shrinkage prevention shall be maintained in the case of subsequent heat treatment.

(4) A suitable selection of welding parameters shall make it possible to specify the penetration depth such as to ensure that, on the one hand, incomplete fusion is avoided and, on the other hand, the dilution with the base metal is not too intense (e.g. falling below the permissible delta ferrite content in the case of austenitic cladding).

(5) The test pieces shall be welded with the same welding processes as used during fabrication. Transitions between different cladding processes shall be included in the welding procedure qualification (see e.g. **Figure 8-9** sketch 4). Compensating welds on the bead interfaces shall be included in the welding procedure qualification if they are conducted using a welding process other than that employed for the initial weld.

(6) In the case of simulated repair welds in accordance with Section 8.1.1.5, the tests shall be conducted in accordance with **Table 8-7**, footnote 1. The requirements specified in **Table 8-8** apply. Manual repairs of semi-mechanized or fully mechanized welded claddings (e.g. submerged arc strip electrode) shall be permissible without a simulated repair weld if the test in accordance with (5) is conducted in the course of the welding procedure qualification.

(7) **Figure 8-10**, sketch 1 shows a recommended test piece.

(8) **Table 8-7** shall apply to the tests. The requirements are specified in **Table 8-8**.

8.1.3.2 Hardsurfaces

(1) The scope of a welding procedure qualification as regards base metals is specified in **Table 8-1**. In the case of welding procedure qualifications for hardsurfaces on butterings, the buttering material shall constitute the base metal.

(2) The welding procedure qualification shall be valid for welding filler metals which correspond to the same alloy short designation to DIN EN 14700, and the same supply form, e.g. welding rods, rod electrodes, electrode-flux combinations.

(3) Welding position PC (transverse position) shall include position PA (flat position), but not vice-versa.

(4) Single-pass and multiple-pass hardsurfacing shall be regarded as separate welding processes.

(5) The test piece shall be arranged and contoured such that it represents the part and its geometry. **Figures 8-10** and **8-12** illustrate recommended test piece forms and dimensions for hardsurfacings on sheets or plates and on tubes. The following specifications shall apply:

a) The surface condition of the test piece before hard surfacing shall be comparable to that of the part.

b) The manufacturer shall conduct a surface inspection (magnetic particle/penetrant testing) before welding begins.

c) If additional shrinkage prevention of the test piece is specified for the hard surfacing of metal sheets or plates (recommended if s is equal to or smaller than 25 mm), this shall be maintained during a subsequent heat treatment.

d) If buttering is specified, this shall be welded into a shaped indentation of the test piece and smoothed before the hard surface is applied to the surface of the test piece.

e) In the case of welding procedure qualifications which shall only be valid for special part welds and which only permit an objective evaluation of welds similar to the part, there may be a deviation from the test scope as specified in (8). In such a case, suitable examinations shall be specified by agreement with the authorized inspector.

f) If the size of a part (e.g. valve seat bush) does not permit the removal of certain samples or the performance of certain tests, suitable examinations shall be specified by agreement with the authorized inspector.

(6) The welding procedure qualification shall be valid for all wall thicknesses if welding was executed on a test piece where s is equal to or greater than 25 mm. In the case of test pieces of wall thicknesses s smaller than 25 mm, the scope of application shall be restricted to wall thicknesses equal to or smaller than 1.5 · s. In the case of electron beam and laser beam deposition welding the value of “12 mm” instead of the limit value of “25 mm“ shall apply.

(7) Repair welds in accordance with Section 8.1.1.5 shall be simulated within the scope of a welding procedure qualification or a pre-manufacturing production control test. Repairs conducted on hardsurfaces shall even be simulated if the welding process used for the initial weld is also employed for the repair. The scope of the simulated repair weld is specified by

a) the position of the assumed defect (weld metal or transition zone),
b) size and form of the grinding (larger areas of repair shall also apply to smaller areas of repair),
c) welding sequence,
d) heat treatment.

(8) **Table 8-9** shall apply to the tests and requirements. The conditions to be fulfilled for these tests are represented in **Figures 8-11** to **8-16**. If special requirements have to be complied with by the behaviour of the hardsurface with respect to corrosion, erosion, abrasion, etc., additional tests (e.g. analyses) may become necessary.

8.1.3.3 Shaping welds

(1) Welding procedure qualifications for seam welds shall also apply to local shaping welds (e.g. compensating welds).

(2) If the conditions for heat removal significantly deviate from those for seam welding, an additional welding procedure qualification shall be conducted by agreement with the authorized inspector.

(3) If whole parts are manufactured by means of shaping welding, this shall be effected in correspondence with KTA 3201.1.

8.1.4 Seam welds on clad parts

(1) The following welding procedure qualifications shall be conducted for seam welds on clad parts:

a) welding procedure qualifications for seam welds (ferritic materials) in accordance with **Table 8-3**,
b) welding procedure qualifications for build-up welds (austenitic materials) in accordance with **Table 8-7**.

(2) The welding procedure qualifications in accordance with (1) shall also apply to the welding of nozzles into roll-clad walls.

(3) A combined welding procedure qualification on clad test pieces may be conducted instead of the welding procedure qualifications in accordance with (1). The tests to be conducted and the requirements shall be specified in correspondence with **Tables 8-3** and **8-7** by agreement with the authorized inspector.

8.1.5 Tube-to-tubesheet welding

(1) Possible types of tube-to-tubesheet joints are represented in **Figure 8-17**.

(2) If other processes are applied as alternatives or in combinations for the manufacture of tube-to-tubesheet joints (mechanical rolling in, hydraulic expansion), the conditions for the welding procedure qualification shall be specified jointly with the authorized inspector. If a roll-clad or explosive-clad tubesheet is used instead of a clad tubesheet, the conditions for the welding procedure qualification shall be specified jointly with the authorized inspector.

(3) The requirements of AD 2000-Merkblatt HP 2/1 and of DIN EN ISO 15614-8 shall be met. In addition, the following specifications shall apply:

a) In the case of tube-to-tubesheet welding, a welding procedure qualification shall be provided for each welding process applied (in relation to the tube-to-tubesheet welding process and the cladding process for the tubesheet), for each position of the tubesheet or for each combination of individual welding processes including the weld build-up sequence.
b) 16 tubes shall be welded into the test sheet. 10 of these shall be provided for the initial weld and 6 for the simulated repair weld. The tube dimensions and the spacing on the test piece shall correspond to the geometric conditions of the part. In the case of deviations, any further action to be taken shall be specified jointly with the authorized inspector. If possible, the test sheet shall normally be of the same thickness as the tubesheet on the scheduled part (± 25 %). If the test sheet thickness exceeds 135 mm, a test sheet thickness of 100 mm will suffice.
c) If a test sheet with a cladding is used to weld in the tubes, a valid welding procedure qualification shall be available for this cladding. This cladding shall have been applied, executed, heat treated and subjected to non-destructive testing under the same conditions as the part weld.
d) If the tubes are expanded to achieve intimate contact before or after welding, this procedural step shall be recorded.
e) **Table 8-10** applies to the tests and requirements.
f) In the case of simulated repair welds which are performed using a welding process or weld preparation (e.g. setback of the weld) other than that used for the part weld, the tests required in accordance with **Table 8-10** shall be conducted after the welding in (expansion of tube to achieve intimate contact). This may also be effected in the course of the production control test.

8.1.6 Foundry welds on castings

The procedure qualification shall be performed to the requirements of KTA 3211.1.

8.2 Production control tests

8.2.1 General principles

8.2.1.1 Requirements

(1) In the course of fabrication, the manufacturer shall demonstrate by production control tests that the part welds fulfill the conditions of the welding procedure qualification. Production control tests (welding work, investigations and testing) shall be conducted in the presence of the authorized inspector.

(2) **Table 8-11** applies to the number of production control tests.

(3) Additional production control tests may become necessary

a) in order to extend the scope of the welding procedure qualification test with regard to:
   aa) welding position in accordance with Section 8.1.1.3.4,
   ab) weld execution in accordance with Section 8.1.1.3.5,
   ac) heat treatment in accordance with Section 8.1.1.3.7,

ad) wall thickness and diameter ranges in accordance with Section 8.1.1.3.8,

ae) aggravating circumstances in accordance with Section 8.1.1.3.9,

af) simulated repair weld in accordance with Section 8.1.1.5,

ag) transition to materials of another subgroup in accordance with **Table 8-1** (by extending the test scope).

The results shall be available before fabrication is started.

b) in order to extend the validity of the welding procedure qualification.

(4) Basically, the production control test shall be allocated to a part weld. In accordance with **Table 8-11**, it shall also be valid for other part welds (also for several components) which are in the same scope of the welding procedure qualification as the allocated production control test.

8.2.1.2 Extension of the validity of welding procedure qualification tests by production control tests

(1) Production control tests extend corresponding welding procedure qualifications by 24 months in compliance with the scope of the welding procedure qualification in accordance with Section 8.1.1.3. If the scope of the test is also to be extended, this extension shall be specified jointly with the authorized inspector. The extension of the validity of a welding procedure qualification is related to the completion of welding work conducted for the production control test. This shall take retroactive effect when the manufacturer's report and the authorized inspector's certificate on the test results of the production control test have become available.

(2) If fabrication is not started within 24 months after the successful completion of the welding procedure qualification or is interrupted for more than 24 months, the first production control test performed after fabrication has started or restarted shall constitute a repetition of the welding procedure qualification. The same tests as for the initial welding procedure qualification shall be conducted in the course of this production control test. Where fabrication is interrupted for more than 12 months, the production control test as required by Section 8.2 shall have been conducted prior to the start of fabrication.

(3) Available welding procedure qualifications which are still valid but do not fully meet the required test scope, may be extended by additional tests conducted for a production control test. This production control test shall be conducted before the start of fabrication.

8.2.1.3 Number and transferability of production control tests

(1) **Table 8-11** shall apply to the number of the production control tests. Production control tests conducted in the manufacturer's works may be recognized for the site if the authorized inspector agrees and if comparable welding conditions prevail.

(2) The specifications laid down in Section 8.1.2.1 apply to the transferability of production control tests.

8.2.1.4 Test pieces

(1) The materials shall have been tested in accordance with KTA 3211.1.

(2) The test pieces for production control tests shall be identical with an allocated part in terms of

a) material,

b) product form (sheet metal, pipe, forging, steel casting),

c) material heat and heat treatment lot in the case of longitudinal welds in accordance with **Table 8-11**, footnote 2,

d) dimensions (e.g. sheet thickness, wall thickness and diameter of tubes) of the base metal.

(3) The production control test allocated to a part weld shall also apply to other part welds if the materials come from different material heats, product forms and from different material manufacturers. In the case of a production control test, transferability to other materials in accordance with **Table 8-1** is permitted. The specifications laid down in Section 8.1.1.3.8 shall apply to the wall thickness and diameter ranges.

(4) The welding filler metals and consumables shall normally come from the same lots which were used for the allocated part weld.

(5) The heat treatment may be conducted on accompanying or simulated pieces. In the case of a simulated heat treatment, the same time-temperature sequence shall be maintained as that for the allocated part weld. In this connection, a heat treatment of repaired areas shall be taken into account (see Section 8.1.1.3.7). This shall also apply to multiple repairs conducted on the part. For the simulated stress relief heat treatment, all intermediate stress relief heat treatments shall be added up and conducted with only one heat treatment at the same temperature. Ultimate annealings at higher temperatures shall be simulated separately.

(6) When the test pieces are welded, the working conditions applied to the allocated part weld shall be adhered to (in particular, also, the same welding process, welding position, joint geometry, preparation of weld edges, gouging, weld building sequence, weld parameter range and, if applicable, restricted spatial conditions). The test pieces shall normally be welded by the same welders who perform the respective allocated part welding. In the case of test pieces from longitudinal welds, the test piece shall be welded as an extension of the weld. In the case of plates, the weld shall normally be in the rolling direction.

(7) Test pieces shall be welded before, during or immediately after the allocated part weld. In the case of production control tests conducted in order to extend the scope of a welding procedure qualification (Section 8.2.1.1), the test pieces shall be tested before the start of fabrication.

(8) If a specimen or a set of specimens does not meet the requirements when tested in accordance with **Table 8-4**, the reason for their failure shall be established. A further two specimens or set of specimens may be tested. These substitute specimens shall meet the requirements.

(9) The welding of the test pieces shall be included in welding records.

(10) The tested specimens shall be retained until the report on the production control test has been made available. The remaining items of test pieces should be retained until the completion of the final inspection on the associated part weld.

8.2.1.5 Repair welds

A pre-manufacturing production control test is required for repairs on parts if the welding process used for the repair has not already been included in a welding procedure qualification.

8.2.1.6 Documents

Before the performance of the production control test, the following documents shall be available after having been approved by the authorized inspector:

a) welding procedure specification (part weld),

b) heat treatment plan (if a heat treatment is performed),

c) materials testing and specimen-taking plan.

8.2.1.7 Report

(1) The manufacturer shall prepare a report on the production control test on which the authorized inspector shall issue a certificate.

(2) This report shall contain the following:

a) documents subjected to a design approval: welding procedure specification, heat treatment plan, materials testing and specimen-taking plan, test instructions,

b) certifications relating to materials, welding filler metals and consumables,

c) welding record,

d) heat treatment record,

e) results of all tests and

f) comments regarding unusual events (e.g. failure of specimens, tolerated deviations from the documents subjected to design approval, distinctive features concerning structural constitution in the base metal, heat affected zone or weld metal).

(3) The authorized inspector's certificate shall contain:

a) summarized final result,

b) final evaluation,

c) delimitation of the scope of validity.

8.2.2 Seam welds

(1) **Table 8-2** contains a survey of tables and figures concerning the tests to be conducted.

(2) For production control tests of seam welds between ferritic and austenitic materials the procedure specified in Section 8.1.2.5 applies.

(3) In the case production control tests on electron beam and laser beam welded joints the same requirements as those for welding procedure qualifications to cl. 8.1.2.1 (5) shall apply additionally.

8.2.3 Build-up welds

8.2.3.1 Austenitic and ferritic claddings

Table 8-7 shall apply to the tests. The requirements are specified in **Table 8-8**.

8.2.3.2 Hardsurfaces

(1) **Table 8-9** shall apply to the tests and requirements.

(2) Insofar as possible, test pieces which are similar to actual parts shall normally be welded in production control tests. If the size or shape of these test pieces does not permit the performance of the scheduled tests, suitable tests shall be specified upon agreement with the authorized inspector.

8.2.3.3 Shaping welds

(1) Production control tests conducted on seam welds in accordance with **Table 8-2** no. 1 to 4 and 5a include shaping welds.

(2) If parts are completely manufactured by means of shaping welding, this shall be effected in correspondence with KTA 3201.1.

8.2.4 Seam welds on clad parts

(1) The following production control tests shall be conducted for seam welds on clad parts:

a) production control tests for seam welds (ferritic materials) in accordance with **Table 8-3**,

b) production control tests for build-up welds (austenitic materials) in accordance with **Table 8-7**.

(2) The production control tests in accordance with (1) shall also apply to the welding of nozzles into roll-clad walls.

(3) A combined production control test on clad test pieces may be conducted instead of the production control tests in accordance with (1). The tests to be conducted and the requirements shall be specified in correspondence with **Tables 8-3** and **8-7** upon agreement with the authorized inspector.

8.2.5 Tube-to-tubesheet welding with or without expansion for intimate tube contact

(1) Possible types of tube-to-tubesheet joints are represented in **Figure 8-17**.

(2) If other processes are applied as alternatives or in combinations for the manufacture of tube-to-tubesheet joints (mechanical rolling in, hydraulic expansion), the conditions for the production control test shall be specified jointly with the authorized inspector. If a roll-clad or explosive-clad tubesheet is used instead of a clad tubesheet, the conditions for the production control tests shall be specified jointly with the authorized inspector.

(3) The following specifications shall apply:

a) The required times of the production control tests are specified in **Table 8-10** and the required number in **Table 8-11**.

b) Supplementary to the general principles specified in Section 8.2.1, the test specimens shall fulfill the following conditions:

   ba) The material and the heat treated condition of the test sheet shall normally correspond to the material and the heat treated condition of the tubesheet of the part. The same cladding shall be provided for the test sheet as for the tubesheet. If possible, the test sheet shall normally be of the same thickness as the tubesheet on the part (± 25 %). If the thickness of the tubesheet exceeds 135 mm, a test sheet thickness of 100 mm will suffice. The test specimen shall be such that it is possible to weld and test the number of tube-to tubesheet welds specified in **Table 8-11** (taking into account any repairs which may become necessary). For this purpose, the test sheet shall be divided into suitable test sections.

   bb) The tubes used for the test specimen shall be the same as those used for the part.

   bc) The welding filler metals for the test piece shall be from the same lot as those for the part weld.

c) **Table 8-10** applies to the tests and requirements. The first test section shall be tested after the first layer. The following test sections may take several test sections into consideration. If possible, the test shall normally be completed within a short time and, at the latest, within 3 days after the welding.

Material			Material subgroup to DIN CEN ISO/TR 15608	
	Material group W I / W II in accordance with KTA 3211.1			Scope [1) 2)]
Ferritic materials	W I	C 22.8 S	1.1	A welding procedure qualification performed on a material of material subgroups 1.1, 1.2 and 1.3 is valid for all steels of material subgroups 1.1, 1.2 and 1.3 with the same or lower specified yield strength.
		GS-C 25 S		
		WStE 255 S		
		WStE 285 S	1.2	
		WStE 315 S		
		WStE 355 S		
		15 MnNi 6 3	1.3	
		20 MnMoNi 5 5	4.2	For each material a separate welding procedure qualification shall be conducted.
		15 NiCuMoNb 5 S		
	W II	P235GH (1.0345)	1.1	A welding procedure qualification performed on a material of material subgroups 1.1, 1.2 and 1.3 is valid for all steels of material subgroups 1.1, 1.2 and 1.3 with the same or lower specified yield strength. A transfer to steels of material group W I to KTA 3211.1 is permitted only if it is assured that the toughness requirements of material group W I are met.
		P250GH (1.0460)		
		P355QH1 (1.0571)		
		GP240GH+QT (1.0619+QT)		
		P235GH (1.0345)		
		P275NH (1.0487)		
		P275NL1 (1.0488)	1.2	
		P355NH (1.0565)		
		16Mo3 (1.5415)	1.2 [3)]	
		15 MnNi 6 3	1.3	
Austenitic materials		X6CrNiTi18-10 (1.4541)	8.1	A welding procedure qualification is valid for all steels of material subgroup 8.1.
		X6CrNiNb18-10 (1.4550)		
		X6CrNiMoNb17-12-2 (1.4580)		
		X6CrNiMoTi17-12-2 (1.4571)		
		GX5CrNiMoNb19-11-2 (1.4581)		
		G-X5CrNiNb19-11 (1.4552)		
Materials for heat exchanger tubes		13CrMo4-5 (1.7335)	5.1	
		10CrMo9-10 (1.7380)	5.2	A welding procedure qualification is valid also for material subgroup 5.1.
Materials for special applications		X3CrNiMo13-4 (1.4313)	7.2	A welding procedure qualification is valid for all steels of material subgroup 7.2.
		G-X4 CrNi 13 4 (1.4317)		

1) Transferability is only possible if the weld filler metals used during the welding procedure qualification test are also suited for the materials intended.

2) For welds joining dissimilar metals the transferability criteria of the respective individual materials listed in this table apply.

3) Depending on the material standard either material group 1.1 or 1.2 applies.

Table 8-1: Welding procedure qualifications and production control tests: Assignment of materials to material groups in accordance with KTA 3211.1 and material subgroups to DIN CEN ISO/TR 15608

<table>
<tr><th>Seam weld</th><th>Tests to be conducted
Number of specimens
Specimen orientation [1]
(see Table 8-11 for the number of production control tests)</th><th>Test requirements
Test conditions</th></tr>
<tr><td>(1) LN (longitudinal weld)
(2) RN (circumferential weld) position PA
pipe (part) rotating
(3) RN position PC
pipe axis vertical
(4) RN position PH
pipe axis horizontal
but position PK in the case of fully mechanized TIG welding</td><td>Table 8-3 Tests and number of specimens for seam welds
Figure 8-2 Test layers
Figure 8-5 Location of the specimen for the notched bar impact test
Figure 8-6 Hardness test in the case of ferritic seam welds
Figure 8-7 Test areas for seam welds between ferritic and austenitic steels
Figure 8-8 Specimen-taking areas in test pieces for circumferential pipe welds</td><td rowspan="4">Table 8-4 Test requirements for seam welds
Table 8-5 Test temperatures and test requirements for notched bar impact tests
Table 8-6 Test requirements for the bend test</td></tr>
<tr><td>a) > DN 50
or
s_1 > 16 mm
(Figure 8-1)</td><td>as for (1) to (4)</td></tr>
<tr><td>(5) Nozzle welds [2]
single bevel,
double bevel welds,
fillet welds
b) ≤ DN 50
and
s_1 ≤ 16 mm
(Figure 8-1)</td><td>The following tests shall be conducted on one test specimen:
a) surface inspection (MT/PT),
b) 1 macrosection,
c) 1 microsection,
d) hardness test in the case of ferritic materials where
R_{eH} or $R_{p0.2\ RT}$ > 300 N/mm²</td></tr>
<tr><td>(6) Simulated repair weld</td><td>Table 8-3, footnote 9 shall be taken into consideration.</td></tr>
</table>

[1] In the case of seam welds made of different ferritic materials (different material subgroups in accordance with **Table 8-1**), the specified test scope shall apply to each of the two weld edges (also if buttering layers are applied to one of the weld edges).

[2] Separate production control tests are only required if the production control tests of a seam weld do not apply.

Table 8-2: Survey of tables and figures for welding procedure qualifications and production control tests on seam welds

Type of Test (In this connection, also see Fig. 8-8)			Extent of testing and number of specimens per test layer (test requirements in accordance with Table 8-4)							
			Welding procedure qualifications				Production control tests			
			LN RN position PA, pipe (part) horizontal rotating RN position PC, pipe axis vertical	RN position PH, pipe axis horizontal, but position PK in the case of fully mechanized TIG welding [1]			LN RN position PA, pipe (part) horizontal rotating RN position PC, pipe axis vertical	RN position PH, pipe axis horizontal, but position PK in the case of fully mechanized TIG welding [1]		
				12:00	03:00 or 09:00	06:00		12:00	03:00 or 09:00	06:00
Non-destructive tests			Extent of testing 100 %, test methods according to Table 9-5							
Tensile test [2]	Welded connection (DIN EN ISO 4136)	Room temp.	2	1	1	1	1	1	1 [5]	1
	Weld metal [3] (DIN EN ISO 6892-1 and DIN EN ISO 5178)	Room temp.	1	1 [6]			1	–	–	–
		T [4]	–	–			1	–	1	–
Notched bar impact test [7] [8] (DIN EN ISO 148-1 and DIN EN ISO 9016) If specimens to DIN EN ISO 148-1 with a minimum specimen width of 5 mm are not possible, bend test to DIN EN ISO 5173 as an alternative	Weld metal in the case of material groups	W I [9]	3	1	3	1	2 [10]	1 [5]	2 [10]	1
		W II [9]	1	1	1	1	1	1 [5]	1	1
		Austenitic steels [9]	1	1	1	1	1	–	1	–
	HAZ in the case of material groups	W I	1 [11] + 3	1	1 [11] +3	1	2 [10]	1 [5]	2 [10]	1
		W II	1 [11] +1	1	1 [11] +1	1	1	1 [5]	1	1
		Austenitic steels	1 [11] + 1	1	1 [11]	1	1 [11] + 1	1	1 [11]	1
	Bend test (DIN EN ISO 5173) in place of the notched bar impact test [12]		2	2	2	2	2	2	2	2
Bend test (DIN EN ISO 5173) [8]		O [9]	2 [13]	1	2 [13]	1	1	– [9]	– [9]	– [9]
		W	2 [13]	1	2 [13]	1	1	1 [5]	1	1
Metallographic examinations	Macrosection transverse [9]		1	1	1	1	1	1	1	1
	Microsection transverse [9]		1	1	1	1	1 [14]	1 [14]	1 [14]	1 [14]
	Determination of the delta-ferrite content of austenitic steels [15]		X	X	X	X	X	X	X	X
Hardness test HV 10 / HV 5 (DIN EN ISO 9015-1), not required in the case of austenitic steels [8] [9]			X	X	X	X	X	X	X	X
Intergranular corrosion resistance in the case of austenitic steels (DIN EN ISO 3651-2 method A)			X	–	X	–	X	–	X	–
Chemical composition of the weld metal in the case of submerged arc welding; for all other welding processes with filler metals only if no chemical analysis of the weld filler metal is available.			X	–	–	–	X	–	X	–

1) In the case of fully mechanized TIG welding (orbital welding head) the positions 3:00 and 9:00 (uphill and downhill) shall be tested separately, position "downhill" without impact energy vs. temperature curve.
2) Tensile test specimens to DIN 50125 may also be used.
3) Tensile test in the weld metal is only required in the case of material subgroups 1.3 (if heat treated), 4.2, 5.1, 5.2 and 7.2 if s > 20 mm.
4) The hot tensile test is required if the allowable operating temperature (TB) > 200 °C in Test Groups A1 and A2 and > 300 °C in Test Group A3. The test temperature shall cover the allowable operating temperature (TB).
The hot tensile test may be conducted during the welding procedure qualification instead of the production control test if the welding procedure qualification is used as a production control test, thus ensuring an allocation to the part weld.
5) Not applicable in the case of ferritic materials where $R_{eH} \leq 300$ N/mm^2.
6) Arbitrary location of specimen-taking.
7) In the case of combined welding processes and s > 12 mm, the impact test specimens shall be taken such that each welding process is covered.
8) See section 8.1.2.5 for seam welds between ferritic and austenitic steels.
9) For the welding procedure qualification (or alternatively, the pre-manufacturing production control test), an additional test (set of specimens) shall be required in each case if a simulated repair weld is to be included (see Section 8.1.1.5). In this test, the transition between the initial weld and the simulated repair weld shall be covered. A bend specimen shall be tested for each position if the simulated repair weld is conducted during the production control test. A simulated repair weld in position PE (overhead position) includes all other positions.
10) The second set of specimens may be waived if the test requirements are met at 0 °C for production control tests without part allocation and at the lowest application temperature for production control tests with part allocation.
11) One set of impact test specimens to DIN EN ISO 15614-1 with specimen location as per sketch 4 of **Figure 8-5**.
12) One bending each over root and cover pass. No further bend tests in test layers O and W are required.
13) May be replaced by side-bend test specimen if s > 12 mm.
14) Not applicable in the case of material group W II.
15) Not applicable in the case of seam welds between ferritic and austenitic steels.

Table 8-3: Welding procedure qualifications and production control tests for seam welds: Extent of testing

Type of Test		Geometry of Specimens, Requirements, Assessment (Test Scope and Number of Specimens in accordance with **Table 8-3**)	
Non-destructive tests		Requirements	in accordance with Section 11
Tensile test	Welded connection at room temperature	Geometry of specimen	in accordance with DIN EN ISO 4136
		To be determined	R_m, position of fracture and fracture appearance
		Requirement	as specified for base metal (KTA 3211.1)
	Weld metal at room temperature	Geometry of specimen	round tensile test specimen to DIN 50125 (L_0 = 5d)
		To be determined	$R_{p0.2}$, R_m, A and Z (in the case of austenitic steel, $R_{p1.0}$ in addition)
		Requirement	as specified for base metal (KTA 3211.1) [1]
	Weld metal at T	Geometry of specimen	round tensile test specimen to DIN 50125 (L_0 = 5d)
		Test temperature	The allowable operating temperature (TB) shall be covered.
		To be determined	$R_{p0.2}$, R_m, A and Z (in the case of austenitic steel, $R_{p1.0}$ in addition)
		Requirements R_p and R_m	as specified for base metal (KTA 3211.1)
Notched bar impact test		Geometry of specimen	V notch specimens as large as possible with a minimum specimen width of 5 mm
		Specimen orientation	as per sketches 1 to 3 of **Figure 8-5**
		Test temperature	in accordance with **Table 8-5**
		To be determined	KV_2, lateral expansion [2], ductile fracture percentage [2]
		Requirement	in accordance with **Table 8-5**
Bend test		Specimen to be bent with root (RBB) or cover pass (FBB) on the tension side. Side-bend test (SBB) for seam welds between ferritic and austenitic steels. Mandrel diameter and requirement: in accordance with **Table 8-6**.	
Metallographic examinations	Macrosection transverse to weld	To be examined	total cross section substantiation by means of photographs
		To be assessed	bead sequence, complete fusion, slags, pores
		Requirement	thorough bead sequence, complete fusion, isolated slags and pores are permissible
	Microsection transverse to weld (magnification generally 200:1)	To be examined	cover pass and root areas (including HAZ) substantiation by means of photographs
		To be assessed	structure
		Requirement	only isolated structural discontinuities are permitted
	Determination of the delta-ferrite content in the case of austenitic steels	Requirement	if possible, delta-ferrite content 4 % to 10 %, closed lattice not permitted
Hardness test HV 10 / HV 5, not required for austenitic materials		Hardness test	in accordance with **Figure 8-3** or **Figure 8-6**
		Requirement	≤ 350 HV 10 / ≤ 350 HV 5 [3] (≤ 300 HV 10 / ≤ 300 HV 5 in the case of a fluid-wetted surface on materials subjected to stress relief heat treatment)
Resistance to intergranular corrosion in the case of austenitic steels		Requirement	Resistance to intergranular corrosion shall be demonstrated 2 mm under the fluid-wetted weld surface
Chemical composition of the weld metal in the case of submerged arc welding; for all other welding processes with filler metals only if no chemical analysis of the weld filler metal is available.		To be determined	In the case of ferritic and martensitic steels: C, Si, Mn, P, S and relevant main alloy elements In the case of austenitic steels: C, Si, Mn, N, P, S, Cr, Ni, Mo and stabilizing elements In the case of nickel weld metal: C, Si, Mn, N, P, S, Cr, Ni, Mo, Fe, Ti, Nb
		Requirement	in accordance with the qualification test of the welding filler metals and welding consumables or standard analysis conducted by the manufacturer

1) For austenitic weld filler metal the following deviating requirement applies: The elongation at fracture shall be at least 30 %.

2) Not for austenitic steels.

3) In the heat-affected zones the hardness shall not exceed 350 HV 5. Hardness peaks exceeding this value in narrow zones shall be examined additionally where 350 HV 10 shall not be exceeded. Individual hardness peaks may be acceptable if proved to be limited locally.

Table 8-4: Welding procedure qualifications and production control tests for seam welds: Test requirements

Material group	Test temperature		Test Requirements	
	Welding procedure qualification	Production control test	Impact Energy Absorbed [2]	Lateral Expansion
W I	0 °C, 33 °C and 80 °C [1] The temperature at which the test requirements are met shall be determined and recorded by interpolation between 0 °C and 33 °C. This temperature is the lowest allowable operating temperature.	In the case of allocation to a component: lowest operating temperature Otherwise: 0 °C and 33 °C [1] The lowest temperature at which the test requirements are met shall be determined and recorded by interpolation between 0 °C and 33 °C. (If the minimum requirement is met at 0 °C, the second set of specimens shall be waived.)	≥ 68 J (smallest single value)	≥ 0.9 mm
W II	0 °C or 20 °C, if the lowest temperature at loading ≥ 20 °C		≥ 41 J/29 J (mean value/smallest single value)	—
Austenitic steels	Room temperature		a) > DN 150 or s > 16 mm unannealed: ≥ 70 J / ≥ 60 J annealed: ≥ 55 J / ≥ 40 J (mean value/smallest single value) b) ≤ DN 150 or s ≤ 16 mm unannealed: ≥ 60 J / ≥ 40 J annealed: ≥ 55 J / ≥ 40 J (mean value/smallest single value)	—
Materials for special applications	Room temperature		As specified for base metal in accordance with KTA 3211.1.	—
Nickel alloy weld metal	Room temperature		subjected to stress relief heat treatment and unannealed: ≥ 80 J / ≥ 56 J (mean value /smallest single value)	—

[1] If only one set of specimens is required for a welding position, the test temperature of 0 °C shall be preferred if the test requirement of 68 J can be safely complied with.

[2] Where specimens with a width less than 10 mm are used, the impact energy obtained shall be converted to the standard specimen proportionally to the specimen width if the test was perfomed in the upper shelf. Otherwise, the conversion of the impact energy to a standard specimen value shall be fixed in each individual case.

Table 8-5: Welding procedure qualifications and production control tests: Requirements for notched bar impact tests in weld metal and HAZ

Material	Mandrel diameter d	Angle of bend	
		Without incipient crack	Permissible deviation
Ferritic steels			Tears resulting from existing pores or small discontinuities are permissible. Cracks without a discernible cause shall not be longer than 1.6 mm.
R_{mRT} < 430 N /mm²	2 · specimen thickness a	180 degrees	
R_{mRT} ≥ 430 N /mm² and < 460 N /mm²	2.5 · specimen thickness a	180 degrees	
R_{mRT} ≥ 460 N /mm²	3 · specimen thickness a	180 degrees [1]	
Austenitic steels	3 · specimen thickness a	180 degrees	
Seam welds between ferritic and austenitic steels with or without buttering	3 · specimen thickness a	180 degrees	
Martensitic steels	3 · specimen thickness a	180 degrees [1]	

[1] The following shall apply if the condition is not fulfilled:

a) In the case of an angle of bend ≥ 90 degrees
Strain (with L_0 = width of weld + wall thickness symmetrical to the weld) ≥ minimum elongation at break A of the base metal

b) In the case of an angle of bend < 90 degrees
Strain over the width of weld > 30 % as well as faultless fracture appearance

Table 8-6: Welding procedure qualifications and production control tests: Requirements for the bend test (DIN EN ISO 5173)

Type of Test		Test Scope / Number of Specimens							
		Welding procedure qualifications				Production control tests			
		Cladding							
		Austenitic		Ferritic		Austenitic		Ferritic	
		Material subgroup of the base metal in accordance with Table 8-1							
		1.1	4.2	1.1	4.2	1.1	4.2	1.1	4.2
		1.2	5.1	1.2	5.1	1.2	5.1	1.2	5.1
		1.3	5.2	1.3	5.2	1.3	5.2	1.3	5.2
Non-destructive tests		Visual testing within welding supervision: 100 % Surface inspection: 100 % Ultrasonic testing: 100 %							
Bend tests	Side-bend specimen [1], transverse (for each welding process and each transition to different welding processes)	2	2	2	2	2	2	2	2
	Side-bend specimen [1] 15 degrees (submerged-arc strip weld and for each transition manual - strip)	2	2	2	2	–	–	–	–
Metallographic examinations	Macrosection [1]	X	X	X	X	X	X	X	X
	Microsection	X	X	X	X	–	X	–	X
	Determination of the delta-ferrite content in the case of austenitic steels	X	X	–	–	X	X	–	–
Intergranular corrosion resistance [1] (DIN EN ISO 3651-2 method A) in the case of austenitic steels		X	X	–	–	X	X	–	–
Hardness test HV 10 / HV 5 [1] (DIN EN ISO 6507-1 and DIN EN ISO 6507-4) on the macrosection		X [2]	X	X [2]	X	X	X	X	X
Chemical composition of the cladding		X	X	X	X	X	X	X	X

[1] For the welding procedure qualification (alternatively, the pre-manufacturing production control test), an additional test (set of specimens) is required in each case if a simulated repair weld is to be included as well (see Section 8.1.1.5). In this test, the transition from the initial weld to the simulated repair weld shall be included.

[2] In the case of welding procedure qualifications on base metals of material subgroup 1.1 hardness testing may be omitted.

Table 8-7: Welding procedure qualifications and production control tests for weld claddings: Extent of testing

Type of Test		Specimen orientation, Test requirements	
Non-destructive tests		The requirements of evaluation group B to DIN EN ISO 5817 applicable for build-up welds shall apply for visual testing within welding supervision. The requirements of Section 11 shall apply for surface inspection and ultrasonic testing	
Bend test	side-bend specimens transverse and 15 degrees (for strip welding) side-bend specimens transverse (for manual welding)	Geometry of specimen, specimen orientation and specimen dimensions	in accordance with **Figure 8-9** sketch 3 and **Figure 8-10** sketch 2
		Test performance	in accordance with **Figure 8-14**
		Requirement	angle of bend 180 Degrees
		Assessment	in accordance with **Figure 8-11**
Metallographic examinations	Macrosection transverse	Specimen orientation	general view in accordance with **Figure 8-9**, sketch 4, specimen orientation in accordance with **Figure 8-10**, sketch 2
		Requirement	The structure shall normally not have any cracks which are visible in a 10:1 enlargement or in non-destructive tests. Isolated pores and slags are permissible. The HAZ of the base metal shall be crack-free.
	Microsection transverse (at least 100:1)	Specimen orientation	in accordance with **Figure 8-10**, sketch 2
		To be examined	- HAZ base metal and overlapping zone, - 1 time each transition zone between different welding processes
		Requirement	structural discontinuities are only permissible if they are isolated.
	Determination of the delta-ferrite content in the case of austenitic claddings	Requirement	if possible, delta-ferrite content 4 % to 10 %, closed network not permissible.
Hardness test HV 10 / HV 5		Specimen orientation	in accordance with **Figure 8-9**, sketch 2 and **Figure 8-10**, sketch 2
		Requirement	The hardness in the ferritic base metal shall normally not exceed 350 HV 10/350 HV 5 (320 HV 10 in the case of heat treated materials of material groups 1.2, 1.3, 4.2 and 5).
Resistance to intergranular corrosion in the case of austenitic claddings		Specimen orientation	in accordance with **Figure 8-9**, sketch 1 and **Figure 8-10**, sketch 2
		Requirement	resistance to intergranular corrosion shall be demonstrated 2 mm below the permanent surface.
Chemical composition	Ferritic cladding	Sampling	on the permanent surface in accordance with **Figure 8-9**, sketch 1 and **Figure 8-10**, sketch 2
		To be determined	Si, Mn, P, S and other alloy elements in accordance with the welding filler metal manufacturer's standard analysis
		Requirement	in the case of multiple-pass claddings: qualification test or manufacturer's standard analysis
	Austenitic cladding	Sampling	2 mm below the permanent surface in accordance with **Figure 8-9**, sketches 1 and 6
		To be determined	C, Si, Mn, Cr, Ni, N, P, S and stabilizing elements (Mo and other elements insofar as they are an alloying element)
		Requirement	in the case of single-pass claddings: standard values of the comparable austenitic base metal in the case of multiple-pass claddings: qualification test or manufacturer's standard analysis

Table 8-8: Welding procedure qualifications and production control tests for austenitic and ferritic claddings: Test requirements

Type of Test		Number of Specimens, Specimen orientation, Test Requirements	
Non-destructive tests		Visual testing within welding supervision: 100 % Surface inspection (PT): 100 % - buttering and hardsurface Ultrasonic testing (for coalescence), insofar as possible: 100 % Requirements in accordance with Section 11.6.2.2 or, alternatively, longitudinal macrosection.	
Bend test [2] The following are tested in the bend test: a) the coalescence between the hardsurface and, if applicable, the buttering and the base metal b) the influence of the weld on the base metal		2 side-bend specimens	In the case of soft-facings [1]; geometry of the specimen and test performance: in accordance with **Figure 8-14**, specimen orientation in accordance with **Figure 8-10**, sketch 2
		2 bend specimens	In the case of hard-facings [1]: Geometry of specimen and test performance in accordance with **Figures 8-15** and **8-16**, specimen orientation in accordance with **Figure 8-10**, sketch 2.
		Requirement: The specimen shall be bent by 180 degrees or to fracture. Large-area spalling as a result of incomplete fusions is not permissible. If the angle of bend < 90 degrees , additional examinations shall be necessary, e.g.: - fractographic assessment, - bend test with machined hardsurface/buttering, - bend test on uninfluenced base metal from the test specimen (comparison test), - Notched bar impact test in the HAZ.	
Metallographic examinations [3]	Macrosection transverse	1 general view: transverse to the direction of welding progress, specimen orientation in accordance with **Figure 8-10**, sketch 2 Requirement: Worm-holes reaching the base metal or buttering and systematic defects (pores, incomplete fusions) are not permissible. Isolated pores are permissible, incomplete fusions are permitted unless the non-destructive test reveals an inacceptable magnitude. Cracks in the base metal or buttering are not permissible. Isolated cracks in hardfacings not reaching the buttering or base metal are permissible.	
	Microsection transverse (100 : 1)	Specimen orientation: in accordance with **Figure 8-10**, sketch 2 To be examined: Base metal, buttering and hardsurface including the heat affected zones. The object of assessment shall be the structure, substantiated by photographs. Requirement: Microcracks in the HAZ of the base metal and in the buttering are not permissible. Isolated, non-systematic structural discontinuities are permissible (in cases of doubt, they shall be examined using additional microsections).	
Hardness test [3] (DIN EN ISO 6507-1 and DIN EN ISO 6507-4, DIN EN ISO 6508-1)	Hardness sequence	Hardness test in accordance with **Figure 8-13** Specimen orientation: in accordance with **Figure 8-10**, sketch 2 Requirement: ≤ 350 HV 10 in the HAZ of the base metal and of the buttering (≤ 320 HV 10 in the case of heat treated materials of material groups 1.2, 1.3, 4.2 and 5); higher values are permissible if: - a heat treatment of the test specimen has not been scheduled, as such a treatment would impair the characteristics of the hardsurface and - their permissibility has been demonstrated by means of bend specimens.	
	Surface hardness	To be examined: The surface hardness of the hardsurface shall be tested in accordance with HRC or HV at several measuring points on the ground surface. In this process, the associated layer thickness of the hardsurface shall be recorded. Requirement: The hardness range as pre-specified by the manufacturer shall normally be adhered to.	

[1] Hard-facings: hardness greater than the hardness in the base metal.
Soft-facings: hardness equal to or smaller than the hardness in the base metal.

[2] Waived in the production control test.

[3] If a simulated repair is to be conducted, this area shall also be included.

Table 8-9: Welding procedure qualifications and production control tests for hardsurfaces (hard-facings and soft-facings): test requirements

Time of Test	Test, Test Requirements
Before drilling	Surface inspection (PT, MT) of the tubesheet, crack-like indications are not permitted. Assessment: Base metal in accordance with KTA 3211.1, Weld cladding in accordance with Section 11.
Before inserting the tubes	Measuring of the tube diameter, tube wall thickness, bore hole diameter, weld preparation and spacing.
After tube-to-tubesheet welding (possibly after expansion for intimate wall contact)	Visual testing of all welded tubes for freedom from notches, clean welding of tube edges, bead overlap, freedom from porosity.
	Measuring of the weld metal overlap c in accordance with **Figure 8-17**. The overlap shall be recorded. The permissible overlap shall be specified for each part under consideration.
	Penetrant testing of all tube-to-tubesheet welds Requirement: in accordance with Section 11.7.
	Radiographic testing of all tube-to-tubesheet welds not subjected to tube press-out test or to tube pull-out test. Requirement: in accordance with DIN EN ISO 15614-8 Section 8.2.4.
	Metallographic examinations: a) A macrosection (transverse) shall be performed on approx. 50 % of the tube-to-tubesheet welds (for the production control test - an additional 2 tubes with repairs). A transverse microsection shall be performed on a test weld at two locations. The locations shall normally be offset by 180°. One of these places shall include an area which has been subjected to two heat inputs. In the case of several starting positions, one transverse microsection shall be made for each starting position. b) Macrosection made on a tube-to-tubesheet weld during the production control test, section parallel to the surface, section plane in the center of the welding bead. c) Microsection (at least 100:1) (only in special cases during a production control test); the specification of the number shall be effected after the evaluation of the macrosections. The assessment of the sections shall be made in accordance with the requirements to DIN EN ISO 15614-8 Section 8.2.5.
	Hardness test on ferritic tube-to-tubesheet welds The hardness traverses 1 and 2 in accordance with **Figure 8-17** shall be recorded on one tube-to-tubesheet weld. Requirement: The hardness shall normally not exceed 350 HV 1.
	Where tube-to-tubesheet joints are strength-welded, a tube press-out test or tube pull-out test shall be performed on tow welded-in tubes. The minimum strength requirements of the base metal shall be met.

Table 8-10: Welding procedure qualifications and production control tests for tube-to-tubesheet welds: Test requirements

Weld	Number of production control tests within the scope of the welding procedure qualifications [1]					
	Pressure Vessels		Pipes		Valves and Pumps	
	A1	A2, A3	A1	A2, A3	A1	A2, A3
LW (longitudinal weld) (production control test welded as extension of the LW)	1 for each vessel [2]	1 for every 10 LW	1 if 10 LW or less [2]	1 if 20 LW or less	1	1
	2 if more than 5 shell courses per vessel [2]		2 if more than 10 LW [2]	2 if more than 20 LW		
CW (circumferential weld) (production control test welded separately) [3]	1 if 50 CW or less	1	1 if 50 CW or less	1		
	2 if more than 50 CW		2 if more than 50 CW			
Nozzle welds and attachment welds (single and double bevel groove welds, fillet welds) [4]	1 if 25 welds or less	1	1 if 25 welds or less	1	1 if 25 welds or less	1
	2 if more than 25 welds		2 if more than 25 welds		2 if more than 25 welds	
	1 if ≤ DN 50 or s ≤ 16 mm		1 if ≤ DN 50 or s ≤ 16 mm		1 if ≤ DN 50 or s ≤ 16 mm	
Weld cladding	1	1	1	1	1	1
Force-transmitting build-up weld [4]	1	1	1	1	1	1
Hardsurface	1	1	1	1	1	1
Production welding (castings)	–				in accordance with KTA 3211.1	
Connection between heat exchanger tubes and heat exchanger tubesheets	Manual and semi-mechanized welding: 1 tube-to-tubesheet weld per welder and shift Fully-mechanized welding: 1 tube-to-tubesheet weld per piece of equipment and at the beginning of each shift 1 tube-to-tubesheet weld for each re-adjustment of the welding equipment or in the case of interruption		–	–	–	–

[1] Unless specified in greater detail in the table, one production control test shall be welded per year (every 24 months if only the validity of the period of qualification for the welding procedure qualification is concerned).

[2] In the case of quenched and tempered materials, production control tests shall be conducted for each base metal heat and for each heat treatment lot (quenching and tempering); however, two base metal heats may be covered by one production control test.

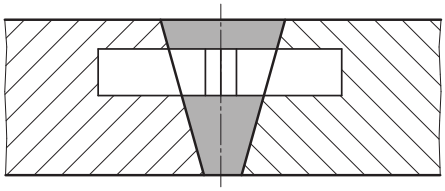
[3] Production control tests for circumferential welds shall be waived if these are covered by production control tests of longitudinal welds.

[4] Waived if covered by production control tests of longitudinal or circumferential welds.

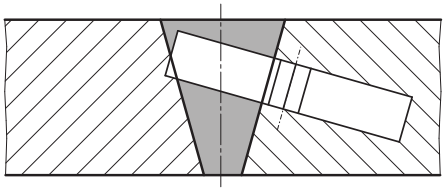
Table 8-11 also applies to dissimilar connections between austenitic and ferritic steels and to welded connections between different ferritic steels.

Table 8-11: Number of production control tests

Sketch 1: Position of the impact test specimen in the weld metal



Sketch 2: Position of the impact test specimen in the HAZ

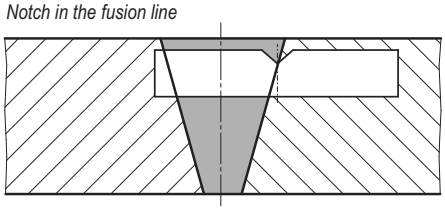


If the described position of the test specimen is not possible due to geometric reasons (wall thickness, curvature radius) or if there is a bevel angle ≤ 10°, the specimen position to sketch 3 shall be taken, the position to sketch 4 if s < 10 mm.

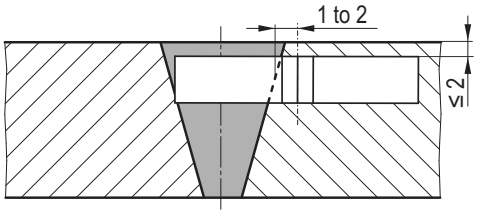
In the heat affected zone the notch shall be located 0.5 mm ± 0.3 mm adjacent to the fusion line.

Sketch 3: Position of the impact test specimen in the HAZ

Note:
Notch in the fusion line

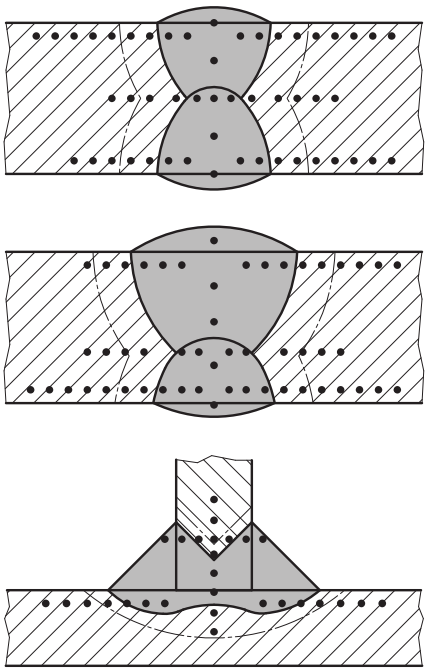


Sketch 4: Position of the impact test specimen to DIN EN ISO 15614-1 in the HAZ

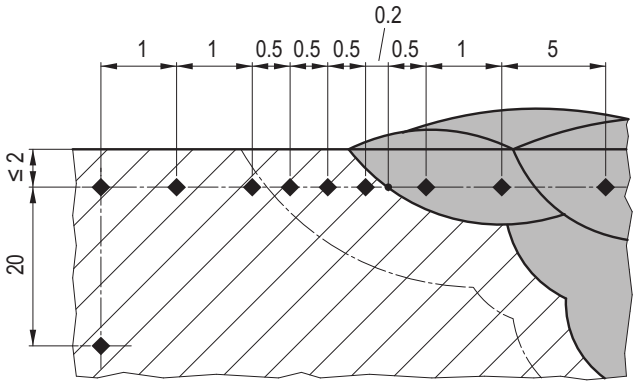


In the heat affected zone, the notch shall be 1 mm to 2 mm adjacent to the fusion line.

Figure 8-5: Position of the impact test specimen in the weld metal and in the heat affected zone



Examples of locations of hardness indentations



Distance of measuring points over the HAZ in case of hardness testing

Figure 8-6: Position of the hardness indentations HV 5 on transverse microsections of ferritic welded joints

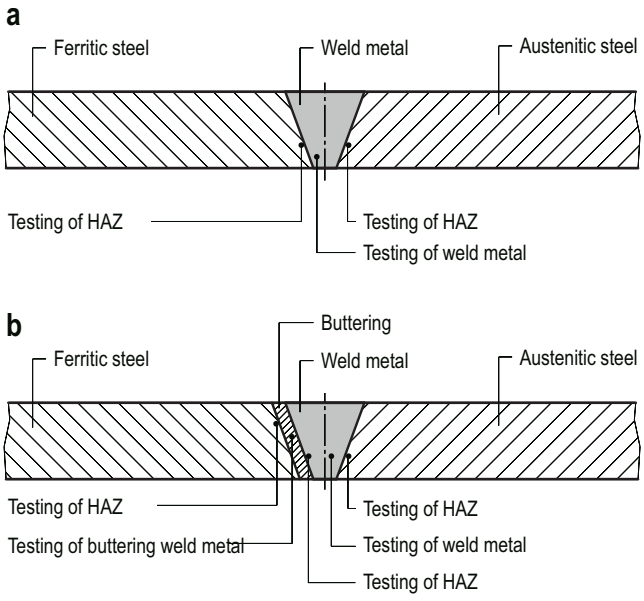
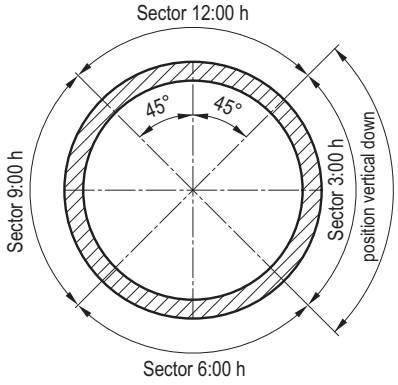


Figure 8-7: Testing areas for seam welds between ferritic and austenitic steels



Sketch 1: Specimen-taking locations

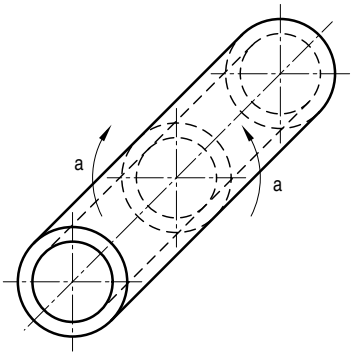
Specimen-taking locations for out-of-position welded circumferential welds

a) pipe axis vertical: welding position PC; any position on circumference

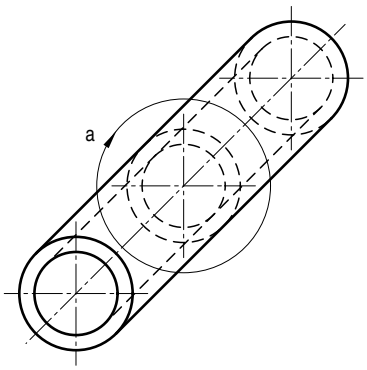
b) pipe axis horizontal: welding positions PH or PK: specimen locations in sectors 12:00 h, 6:00 h, 3:00 h and 9:00 h as per sketch.

   For fully mechanized TIG (pulse) orbital welding wih orbiting welding head, the vertical down position shall additionally be considered.

   If the number of specimens specified for the respective position cannot be taken, an additional circumferential weld shall be welded.

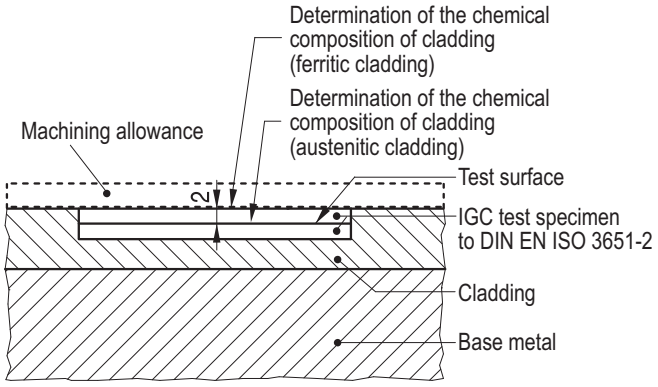


Sketch 2: Pipe position for welding position PH (vertical up)
a : The arrow shows the welding progress direction

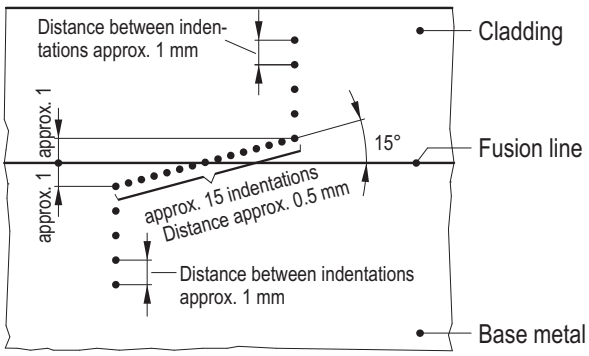


Sketch 3: Pipe position for welding position PK (orbital welding)
a : The arrow shows the welding progress direction

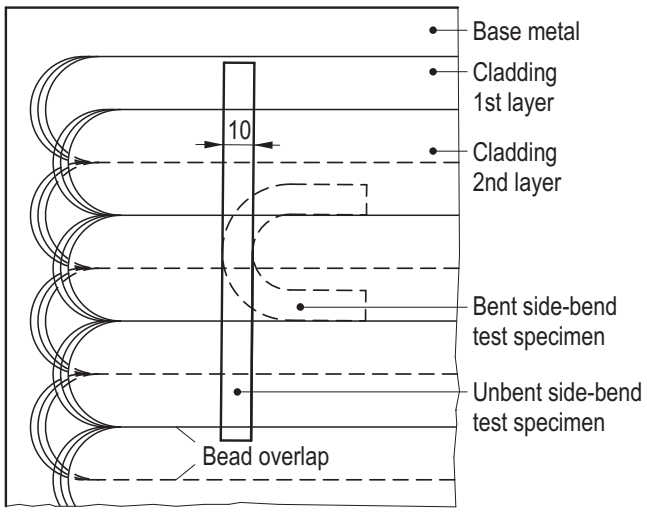
Figure 8-8: Specimen-taking areas in test pieces for circumferential pipe welds



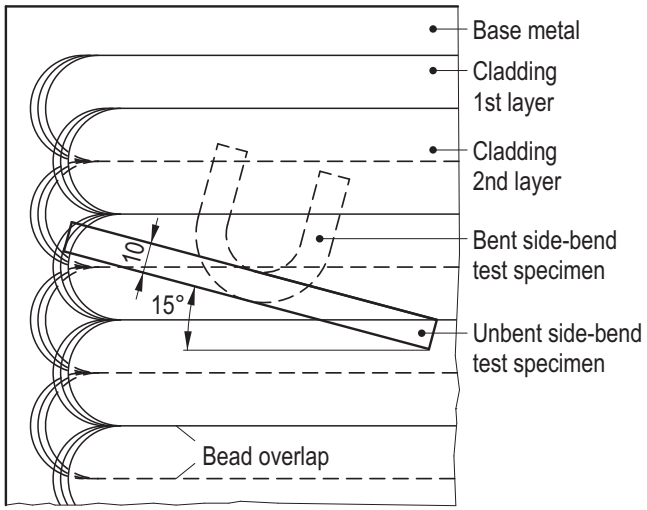
Sketch 1: Corrosion test and verification of the chemical composition



Sketch 2: Hardness test



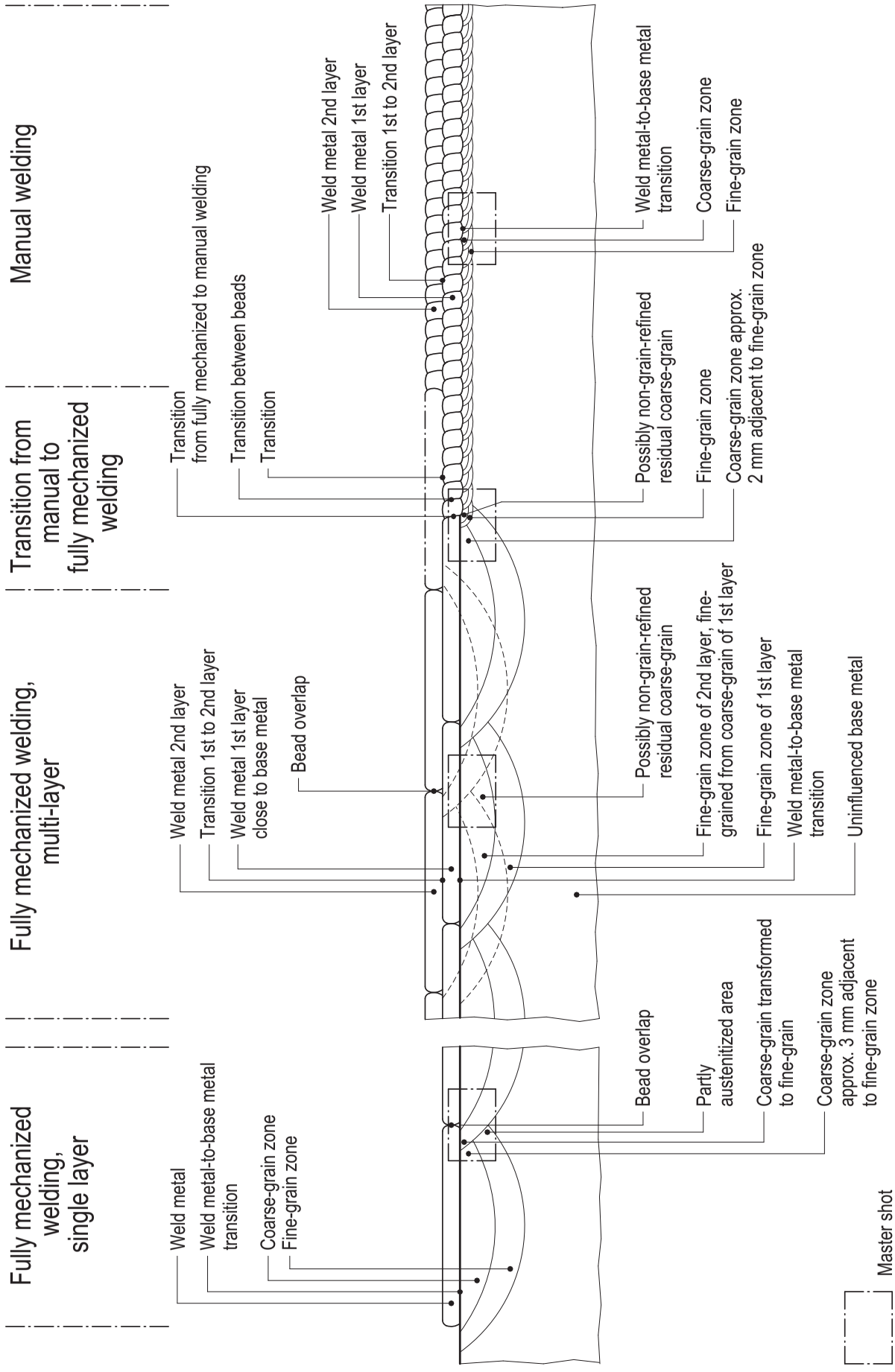
a transverse to the welding direction



b 15° to the welding direction

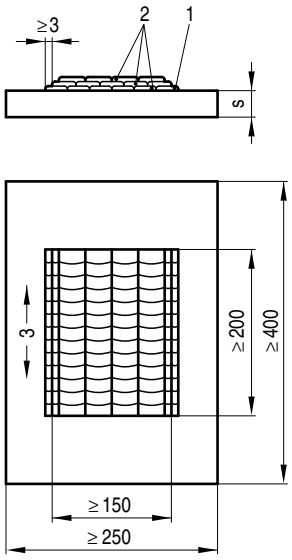
Sketch 3: Side-bend test (for weldings with strip electrodes)

Figure 8-9: Specimen orientation and testing areas on weld cladded test pieces (continued next page)



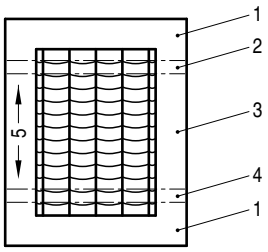
Sketch 4: Survey for metallographic examinations

Figure 8-9: Specimen orientation and testing areas on weld cladded test pieces (continued)



1 : Buttering layer, if required
2 : Number of layers or build-up thickness acc. to welding procedure specification
3 : Direction of welding
s : Wall thicknes of the base metal

Sketch 1: Test piece flat plate

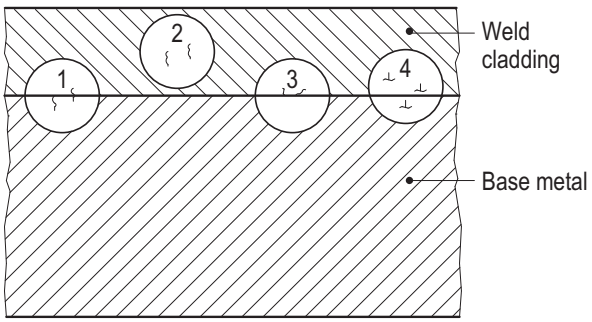


1 : Run-in and run-out (≥ 25 mm) of the build-up welding (discarded parts)
2 : Area for 1 side bend test specimen transverse (except strip welding cladding) and 1 bend test specimen (hardfacing)
3 : Area for:
- 1 macrosection
- specimens for determining the ferrite content (FN-number), for the IGC test (cladding) and for the chemical analysis
- 1 microsection with hardness test
- specimens for requalification tests

4 : Area for 1 side bend test specimen transverse (except strip welding cladding) and 1 bend test specimen (hardfacing)
5 : Direction of welding

Sketch 2: Specimen location flat plate

Figure 8-10: Specimen orientation and testing areas of test pieces for build-up welds



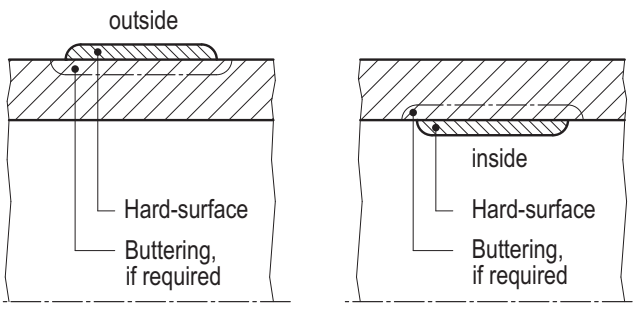
Defect type 1: Discontinuities affecting the base metal are permitted only if the bending strain exceeded the elongation at fracture of the base metal.

Defect type 2: Discontinuities in the weld cladding which do not contact the fusion line are permitted as isolated defects up to a length of 1.6 mm.

Defect type 3: Discontinuities in the weld cladding which are in contact with the fusion line are permitted as isolated defects up to a length of 1.6 mm.

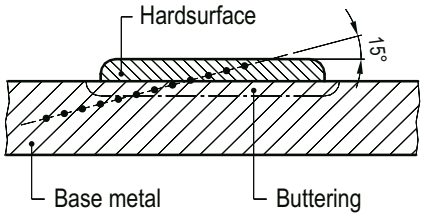
Defect type 4: Discontinuities which are due to allowable structural discontinuities already existing in the unbent condition will not be rejected.

Figure 8-11: Assessment of separations on side-bend specimens in the bent condition



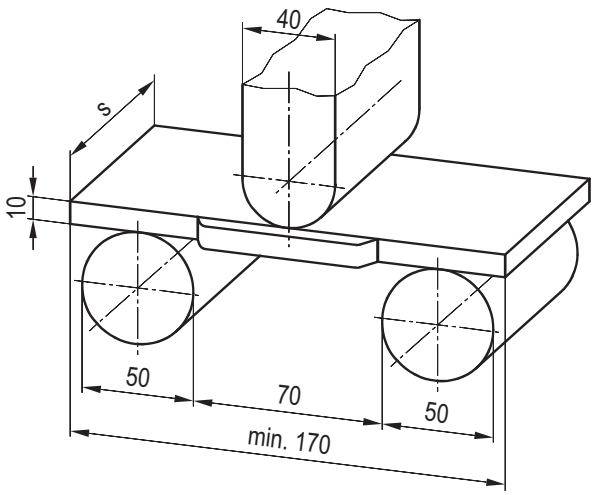
≥ DN 150, Pipe length ≥ 250 mm

Figure 8-12: Test piece for hardsurfaces on pipes



Distance of measuring points along the 15° line approx. 1 mm

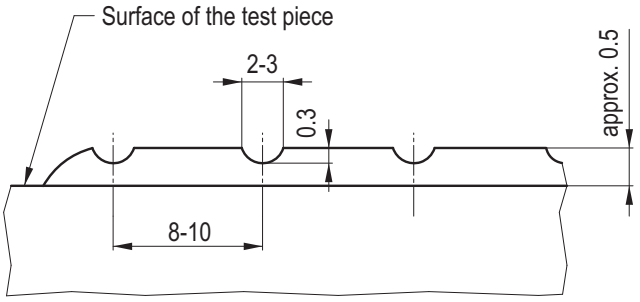
Figure 8-13: Hardness profile of hardsurfaces



Specimen and side-bend test geometry in correspondance with DIN EN ISO 5173. Rounding of edges as per DIN EN ISO 5173.

Figure 8-14: Bend test (side bend test) for weld claddings

a To alleviate incipient cracking grooves may be ground in the hard surface overlay prior to bending. Inadmissible heating of the test specimens shall be avoided.



> 0.3 up to 0.5 mm (by mechanical dressing)

Width of free bend test specimens: 25 mm up to 30 mm
Thickness of free bend test specimens: 10 mm

b Incipient cracking of the hard surface overlay with smaller roller distances and smaller mandrel diameters for preparation of bend test.

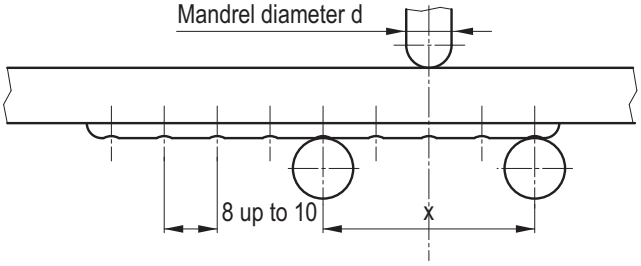
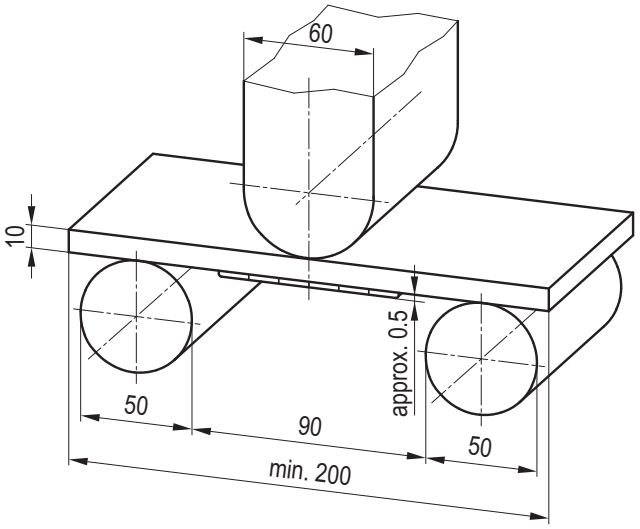


Figure 8-15: Crack initiation into the hard-facing

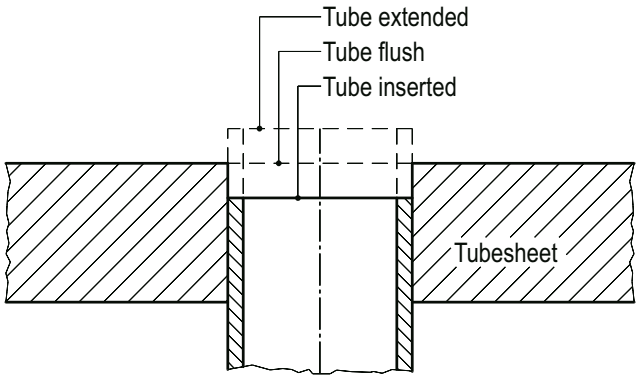


Specimen and side-bend test geometry in correspondance with DIN EN ISO 5173.

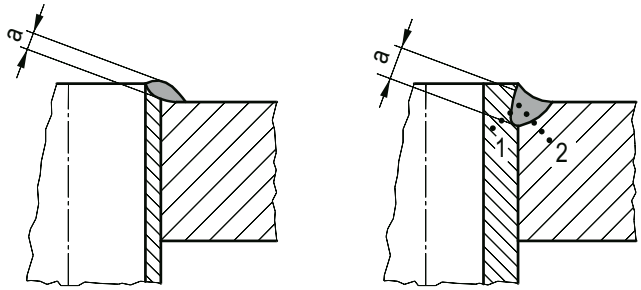
Rounding of edges in the specimen tensile zone to DIN EN ISO 5173.

Figure 8-16: Bend test for hardfacings

Possible welded connections

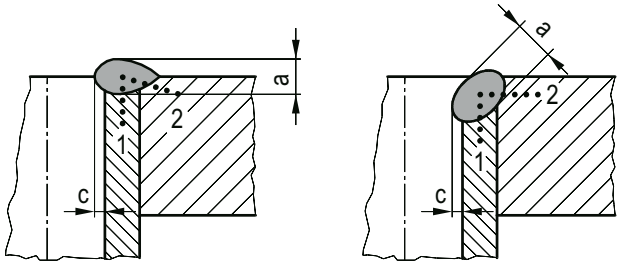


a Tube extended



b Tube flush

c Tube inserted



Single- or multi-layer welds

a : Weakest section of welded joint, starting from gap run-out
c : Excess weld metal
1, 2 : Hardness indentations

Figure 8-17: Examples of different types of tube-to tubesheet welded joints

9 Marking, Fabrication Supervision and Final Inspection

9.1 Marking

9.1.1 General

(1) Only marked product forms may be used for the manufacture of parts and components. The marking may also be effected by means of key numbers or abbreviations.

(2) Upon agreement with the authorized inspector the manufacturer shall specify in writing a marking system which shall ensure the identification of the parts, their allocation to the corresponding documents and an unambiguous traceability.

(3) The manufacturer shall ensure that the parts remain marked in the course of processing.

(4) The marking shall be permanent and attached to the parts such as not to cause any damage.

Note:

Permissible marking procedures for product forms, parts, welds and components include, e.g.

a) non-chloride coloured tapes or rubber stamps (ink impression or etching with non-chloride acids, e.g. oxalic acid) for thin-walled parts of a wall thickness equal to or smaller than 5 mm,

b) electric engraving,

c) laser marking,

d) die stamp for parts with a wall thickness greater than 5 mm.

(5) If it is not possible to affix a mark on the parts themselves, they may be identified by means of tags or stored in marked vessels.

(6) Residual material to be retained or processed shall be marked.

9.1.2 Transfer of material identification markings

(1) The transfer shall be effected such that the allocation of certificates to the parts is just as easy as in the case of the original marking; if necessary, a certificate issued for this purpose shall be used. Suitable measures (e.g. transfer of markings before parts are separated) shall ensure that mix-ups do not occur when markings are transferred.

(2) In the case of materials which require acceptance test certificate 3.2 to DIN EN 10204, the authorized inspector shall supervise and confirm the transfer. In the case of small items, the transfer may be effected by the manufacturer if this has been agreed in writing with the authorized inspector.

(3) In the case of materials which are delivered with certificates issued by the material manufacturer in accordance with DIN EN 10204 (up to and including 3.1), the component manufacturer may effect the transfer if a respective written agreement has been made with the authorized inspector. The name of the employee responsible for the transfer and the factory marking to be used shall be specified in this agreement.

(4) If, in the case of parts in accordance with (2) and (3) which are further processed on the building site, the marking is transferred in the manufacturer's works by the responsible personnel, certificates on the transfer shall be added to these parts. The certificates shall show that the transfer was effected with the agreement of the authorized inspector. They may be replaced by a suitable marking of approval on the certificate concerning the material tests in accordance with DIN EN 10204.

9.1.3 Marking of welds and components

9.1.3.1 Welds

(1) Before testing is started, the marking and numbering of the welds shall be specified in a sketch or drawing for the following parts:

a) vessels and pumps per component,

b) valves per valve type,

c) pipes per piping system.

(2) The origin and the main direction (direction of rotation) or the counting direction of the reference system for volumetric testing shall be marked permanently. This marking shall be effected outside the required scan paths for the non-destructive tests.

(3) If welds have to be dressed, e.g. for non-destructive tests, their position shall be marked unambiguously, permanently and retrievably.

(4) The documents concerning this marking shall be attached to the documentation.

9.1.3.2 Vessels and pumps

The marking of vessels and pumps shall be effected on their nameplates. The representation of the nameplate with the required specifications shall be effected on the assembly drawing or on a separate drawing. **Table 4-5** contains the minimum specifications which shall be shown on the nameplate. In addition, the connection nozzles shall be marked with the direction of flow.

9.1.3.3 Valves

(1) The marking of valves shall be effected on the valve casings or on a separately attached plate. The following relevant data for each valve shall be attached permanently:

a) identification code in accordance with KKS or AKZ identification system if specified in the ADB (Design Data Sheet),

b) type,

c) DN of the valves (inlet and outlet in the case of different DNs),

d) manufacturing serial number (if there are several valves with the same manufacturing serial number, an additional index shall be attached to each valve),

e) direction of flow,

f) valve manufacturer,

g) part marking,

h) manufacturer's certification stamp.

(2) A coding of the specifications in accordance with (1) (a) to (g) is permissible in the case of valves. The coding system shall be specified in the documents.

9.1.3.4 Pipes

(1) The following specifications shall apply to the marking of pipe parts:

a) Parts (if fabricated in accordance with the drawing):

aa) designation of the parts (e.g. identification number),

ab) component manufacturer's stamp,

ac) component manufacturer's certification stamp.

If there are several identical parts in each drawing which have the same part number, an unambiguous allocation to the respective documents shall be ensured by means of an additional index.

b) Pipe bends and pipe parts welded together in the course of prefabrication (spools):

ba) plant,

bb) fabrication isometric drawing number,

bc) position number in the fabrication isometric drawing,

bd) component manufacturer's certification stamp.

(2) A coding of the above-mentioned specifications in accordance with (1) shall be permissible with the exception of the certification stamp. The coding system shall be specified in the documents.

9.2 Fabrication supervision and final inspection

9.2.1 General

Fabrication supervision shall ensure that the quality requirements are met. The final inspection shall provide a final demonstration of compliance with the quality requirements.

9.2.2 Parties involved

(1) The specifications laid down in **Tables 9-1** to **9-3** shall apply to the tests and inspections to be conducted by the manufacturer and the authorized inspector.

(2) All destructive tests shall be conducted in the presence of the authorized inspector and shall be certified by him.

9.2.3 Fabrication supervision

9.2.3.1 Fabrication supervision effected by the manufacturer

(1) The basis for fabrication supervision is the Checklist (**Table 9-1**). Depending on manufacture, additions to this Checklist may become necessary.

(2) The manufacturer shall prepare a component-specific checking plan containing the required tests and checks in accordance with the Checklist as well as any additional tests and checks which may become necessary.

Note:

System-based QA measures conducted by the manufacturer shall remain unaffected.

(3) The manufacturer shall ensure that the tests and checks specified in the checking plan are actually conducted. The checking plan shall be available before the start of the relevant part of fabrication.

(4) A checking plan shall not be necessary if the checks to be made are included in the test and inspection sequence plan (e.g. if the number of tests is small).

(5) For the performance of the tests and checks, a difference is made between H 1 and H 2:

H 1 : tests and checks to be conducted by the manufacturer in any case;

H 2 : tests and checks to be conducted by the manufacturer which may be conducted as random tests if fabrication is under full control by the manufacturer.

The extent of the random checks shall be specified with regard to the test group, the part group, the processing safety of the material and the manufacturing process. In the case of controlled fabrication (many years of fabrication experience, low frequency of defects), the extent may be based on a small number of random tests. If deviations are detected in the course of random tests or checks, the extent of the tests shall be increased. If necessary, additional checking steps shall be taken.

(6) **Tables 9-2** and **9-3** contain specifications concerning the preparation of the checking plan and the performance of the tests and checks. Standard checking plans are permissible for items of serial production.

9.2.3.2 Fabrication supervision effected by the authorized inspector

(1) The authorized inspector shall prepare a component-specific checking plan on the basis of the Checklist (**Table 9-1**). This plan shall specify the tests and checks which he shall conduct.

(2) For the performance of the tests and checks, a distinction is made between the following:

S 1: tests and checks to be conducted by the authorized inspector in any case;

S 2: random tests and checks to be conducted by the authorized inspector (no mandatory hold points).

(3) **Tables 9-2** and **9-3** contain specifications concerning the preparation of the checking plan and the performance of tests and checks.

9.3 Performance of final inspection

9.3.1 General

(1) The basis for final inspection is the Inspection Sheet for final inspection in accordance with **Table 9-4**. The manufacturer shall prepare a component-specific test and inspection sequence plan specifying all the required final inspections or partial final inspections. The manufacturer shall ensure that the tests and checks specified in the test and inspection sequence plan are actually conducted. The confirmation of the conducted tests shall be effected by means of a stamp and where required a record in accordance with the requirements specified in the Inspection Sheet for final inspection.

(2) **Tables 9-2** and **9-3** contain specifications concerning the preparation of the test and inspection sequence plan and the performance of the final inspection.

9.3.2 Random tests

(1) Random tests conducted by the manufacturer require that the manufacturing processes have been qualified. Insofar as random tests are specified in **Tables 9-4** and **9-5**, the following specifications apply:

a) Vessels and pumps

In relation to the weld lengths, random tests shall be effected per component in the case of Test Group A1 and per consignment lot and nuclear power plant in the case of Test Groups A2 and A3. The weld length to be tested may be distributed over several welds if this results in a sufficient weld length for the test. If this is not possible, the total test length shall be taken from one weld.

b) Valves

The scope of the tests shall refer to a consignment lot and the unit subjected to a design approval in the case of valves equal to or smaller than DN 300 and in the case of Test Group A3. The weld length to be tested may be distributed over several welds if this results in a sufficient weld length for the test. If this is not possible, the total test length shall be taken from one weld. However, at least one weld or one item shall be tested 100 %. In the case of valves greater than DN 300, the test scope shall refer to the component in the case of Test Groups A1 and A2.

c) Pipes

In the case of parts, the extent of the tests shall refer to the number of similar weld types per consignment lot. In the case of prefabricated pipe parts (spools) and assembly welds, the extent of the tests shall refer to the number of similar weld types per manufacturer, piping system and nuclear power plant.

(2) For ultrasonic testing, the authorized inspector or manufacturer - depending on the degree to which they are involved - shall independently specify the areas to be tested.

(3) For surface inspection and radiographic testing, the manufacturer shall specify the welds or weld sections to be tested jointly with the authorized inspector.

(4) The following shall apply to an increased extent:

a) If the manufacturer detects an impermissible indication during the test, the extent of testing shall be doubled. If there are further impermissible indications, the extent of testing shall be extended to 100 %.

b) If, within the extent of the tests, the authorized inspector detects impermissible indications on a weld tested by the manufacturer, a joint verification shall be conducted using the test techniques employed in the previous test. If the test result is influenced by the tester, another weld which has been tested by the same tester shall be tested in addition to the original test extent. If further impermissible indications are once more detected, all welds of a component or piping system which have been tested by this tester shall be subjected to a verification by the authorized inspector. If, in the course of the joint verification, an influence of the test technique is found, the tests shall be repeated using a test technique which has been discussed and agreed upon.

c) If, within the extent of the tests, the authorized inspector detects impermissible indications in welds which have not been tested by the manufacturer, the following procedure shall be adopted:

   ca) The manufacturer shall double the test extent.

   cb) The authorized inspector shall conduct renewed random tests on welds which have not been tested by the manufacturer. If he once again detects impermissible indications, the manufacturer shall extend the test extent to 100 %.

   cc) The authorized inspector shall conduct further random tests.

9.3.3 Fabrication tolerances

9.3.3.1 General

Unless otherwise specified in the Design Data Sheet, the pipe loading specifications or the design approval documents, the tolerances in accordance with DIN ISO 2768-1 and DIN ISO 2768-2 shall be adhered to.

9.3.3.2 Tolerances for pressure vessels

(1) The percentage ovality U shall be calculated in accordance with the following equation:

$$U = 200 \cdot \frac{D_{max} - D_{min}}{D_{max} + D_{min}} \qquad (9\text{-}1)$$

The following table specifies the permissible ovalities as a function of the wall thickness and diameter ratio as well as of the loading.

Ratio between wall thickness and diameter s/D	Loading (in %) resulting from	
	internal pressure	external pressure
≤ 0.01	2.0	1.5
≤ 0.1	1.5	1.5
> 0.1	1.0	1.0

(2) In relation to the cylindrical length, the permissible deviation from the straight line is 0.5%.

(3) The tolerance of the mean outside diameter in the case of vessels is ± 1.5 % (calculated from the circumference).

(4) The tolerances of the mean inside diameter in the case of heat exchangers are:

a) D_i equal to or smaller than 500 mm:
   D_i of the baffle plate diameter + 2 mm.

b) D_i greater than 500 mm and equal to or smaller than 1000 mm:
   D_i of the baffle plate diameter + 4 mm.

c) D_i greater than 1000 mm:
   D_i of the baffle plate diameter + 6 mm.

9.3.3.3 Tolerances for pipes

(1) The following shall apply to tolerances (maximum tolerance deviation):

a) in the case of hot finished seamless pipes made of austenitic material:
   tolerance class D2/T2 to DIN EN 10216-5 if $D_a \leq 219.1$ mm
   and
   tolerance class D1/T2 to DIN EN 10216-5 if $D_a > 219.1$ mm,

b) tolerance class D4/T4 to DIN EN 10216-5 in the case of cold formed pipes made of austenitic material,

c) in the case of welded pipes made of austenitic material:
   tolerance class D4/T3 to DIN EN 10217-7 if $D_a \leq 168.3$ mm
   and
   tolerance class D3/T3 to DIN EN 10217-7 if $D_a > 168.3$ mm,

d) in the case of seamless pipes made of ferritic material of material group W I:
   DIN EN 10216-2 Table 10,

e) in the case of hot finished seamless pipes made of ferritic material of material group W II:
   DIN EN 10216-2 Table 7,

f) in the case of cold formed seamless pipes made of ferritic material of material group W II:
   DIN EN 10216-2 Table 11,

g) in the case of electric welded pipes made of ferritic material:
   DIN EN 10217-2 Table 7,

h) in the case of submerged arc welded pipes made of ferritic material:
   DIN EN 10217-5 Table 7.

(2) The following ovalities in accordance with equation 9-1 are permitted:

a) under internal pressure: 2 %;

b) under external pressure: 1 %.

9.3.3.4 Tolerances for pipe elbows and pipe bends

(1) The ovality in accordance with equation 9-1 shall not exceed 5 %. The ovality at the welding edges shall not exceed 2 %.

(2) The specifications laid down in Section 9.3.3.1 shall apply to linear and angular dimensions.

(3) The ratio r_m/d_a of pipe bends shall be equal to or greater than 1.5. A ratio r_m/d_a equal to or greater than 2 shall preferably be obtained.

(4) Permissible wrinkling shall be specified within the scope of the qualification report on the manufacturing process, in which case the requirements of KTA 3211.2 Section A 5.2.2.2 shall be met.

(5) The wall thickness distribution obtained by induction bending shall meet the following requirements:

a) The expected values of wall increase on the intrados and wall thinning on the extrados are shown in **Figure 9-1** for standard bends in dependence of the r_m/d_a ratio. The tolerance range shown in **Figure 9-1** shall basically be adhered to as dimensional check requirement for acceptance inspection.

b) Where the bends show wall thickness values outside the tolerance ranges for standard pipe bends, they shall be treated as size deviation (dimensional deviation from standard bend). In this case, the manufacturer shall establish a non-conformance report giving the actual dimensions. The acceptability of the actual distribution of wall thicknesses over intrados and extrados and its influence on the analysis of the mechanical behaviour to KTA 3211.2 shall be evaluated in each individual case by means of a calculation.

c) The minimum design wall thickness to KTA 3211.2, clause A 5.2.2.4 shall be adhered to at the extrados.

d) The values and distribution of wall thicknesses shall be obtained on the bend. The actual values shall be measured during acceptance of bends on the cross-sections in the middle and at the ends of the bent area at the extrados, intrados and in the neutral fibre, and be recorded. In addition, the wall thickness shall be measured at both straight ends of the straight pipe not influenced by bending in prolongation of the extrados and intrados, and be recorded.

   The average wall thickness value of the unbent pipe shall be taken as reference value for the wall thickness increase at the extrados and the wall thinning at the intrados. This value is obtained from the values measured on the non-influenced straight pipe outside the bending area at the same pipe circumferential angle (average value from those obtained at the pipe ends).

e) The distribution of wall thicknesses on fabricated bends shall be comparable, with same r_m/d_a ratios, to the wall thicknesses of the bent pipe from which specimens were taken for mechanical testing. This is obtained if the tolerance ranges according to **Figure 9-1** have been adhered to.

(6) For cold-bent pipes and bends a wall thickness reduction at the extrados with simultaneous wall thickness increase at the intrados is permitted without further substantiation by way of calculation if a value of 15 % related to the nominal wall thickness is not exceeded and the design wall thickness requirement to KTA 3211.2 Section A 5.2.2.4 is met. Greater fabrication wall thicknesses at the intrados (limited guide value for material notch: up to 25 % related to the nominal wall thickness) are permitted if they are substabtiated by way of calculation.

9.3.4 Inspections within welding supervision

(1) The requirements of Sections 5.4 to 5.7 apply.

(2) DIN EN ISO 17637 shall be taken as a basis for visual testing prior to, during and upon welding.

(3) Section 9.3.5 shall apply to the check of the misalignment on joints to be welded from one side.

9.3.5 Check of the misalignment on joints to be welded from one side

(1) If welds are not to be dressed from the inside after welding, an inspection of the alignment required in accordance with Section 5.7.1.2.2 shall be conducted after assembly in order to ensure compliance with the requirements for a proper welding of the root.

(2) The inspection of the alignment and misalignment shall normally be a visual inspection and, insofar as required, conducted by means of verification using a gage. Measurements of the misalignment along the outer surface and the wall thickness (in a tacked and finish-welded condition) shall only be required in special cases.

(3) Adherence to the permissible misalignment in accordance with **Table 5-3** shall be confirmed.

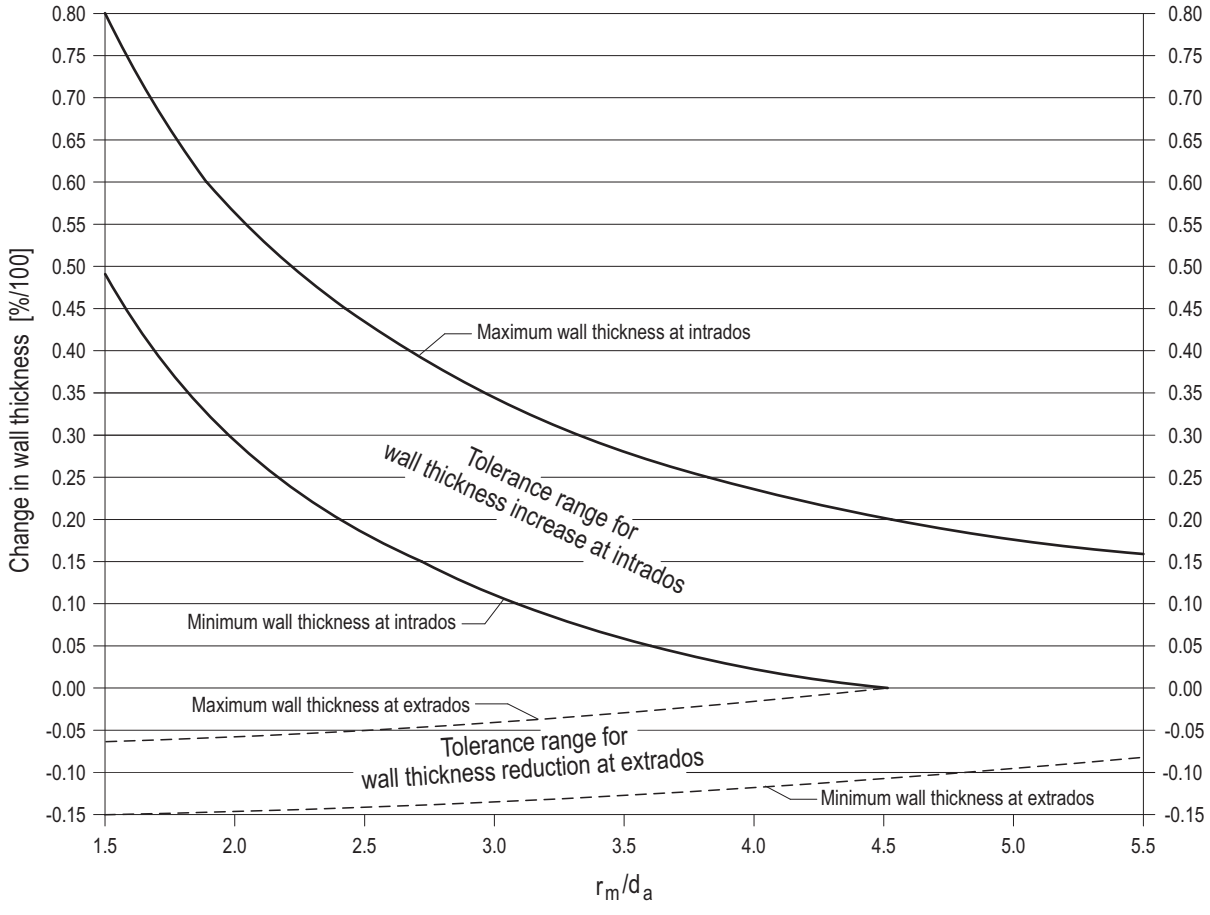


Figure 9-1: Expected values for wall thickness increase at intrados and wall thickness reduction at extrados of standard induction bends in dependence of the r_m/d_a ratio

9.3.6 Non-destructive tests (NDT)

9.3.6.1 Point in time of non-destructive tests and examinations

(1) NDT prior to welding

a) Ultrasonic testing of weld edges and welding areas shall be performed prior to the machining of fusion faces, where such faces have to be machined. The tests shall be performed whenever it has not been performed on the product forms before in accordance with KTA 3211.1 (see also **Table 9-1**).

b) The surface inspection of the fusion faces shall be performed in the final machined condition.

(2) NDT upon welding

a) The tests shall be performed in the final condition and, if heat treatments are provided, basically upon the last heat treatment (including stress relieving).

b) Where the surface inspection upon the final heat treatment can only be performed to a limited extent, the examination of those areas which can only be examined to a limited extent shall be performed at an earlier point in time.

c) Radiographic testing may also be performed prior to the heat treatment if ultrasonic testing is performed upon the heat treatment.

d) Where claddings are no more accessible upon final heat treatment, the test shall be performed prior to the final heat treatment, but at least upon stress relieving.

(3) Tests and examinations prior to and upon first hydrostatic testing

Higher stress locations shall be subjected to the same testing procedures prior to and after the first hydrostatic test in accordance with Section 9.3.14.

9.3.6.2 Extent of non-destructive tests and examinations

9.3.6.2.1 Tests and examinations prior to welding

(1) Prior to welding the fusion faces of the joint to be welded shall be examined for surface defects.

(2) Ultrasonic testing of the areas to be welded shall only be performed if it has not already been performed on the product forms in accordance with KTA 3211.1 (see also **Table 9-4**).

(3) In the case of welded joints between ferritic and austenitic steels the following applies additionally:

a) Prior to dressing the fusion faces the butterings shall be completly tested for bonding by means of straight-beam scanning. Where heat treatment is performed, this examination shall be made upon the heat treatment.

b) Prior to welding the connecting weld, the butterings shall be examined for surface defects by penetrant testing.

(4) Surfaces to be build-up welded shall be examined for surface defects unless this examination has already been performed to KTA 3211.1. In the case of limited accessibility or insufficient magnetizability penetrant testing may be use instead of magnetic particle testing.

9.3.6.2.2 Tests and examinations upon welding

(1) During the tests the respective examination area specified under Section 11, which consists of weld metal and adjacent base metal, shall be covered completely.

(2) The respective test and examination method to be applied and the extent of tests and examinations shall be taken from **Table 9-5**. Other test methods (e.g, eddy-current testing, digital radiography) are permitted provided their suitability for achieving the test objective has been demonstrated. In addition, the requirements laid down in the following clauses (3) to (7) apply.

(3) Welded joints between ferritic steels

In the case of limited accessibility or restrictions due to geometry, penetrant testing may be use instead of magnetic particle testing by agreement with the authorized inspector.

Where the inner surface is neither accessible for magnetic particle nor penetrant testing, the following tests shall be performed:

a) in the case of nominal wall thicknesses equal to or exceeding 8 mm, ultrasonic testing in which case it shall be ensured that the angle of incidence to **Table 11-6** is adhered to

or

b) in the case of nominal wall thicknesses less than 8 mm radiographic testing in accordance with the stipulations of cl. 11.2.4.2.

Where ultrasonic testing according to clause 11.3.4.3 or 11.3.4.4 cannot be performed completely after the final heat treatment, supplementary measures shall be taken after the last heat treatment in addition to the incomplete ultrasonic test. A supplementary measure may be an ultrasonic test as per clause 11.3.4.3 or 11.3.4.4 at another stage of fabrication, e.g. upon at least one stress relief heat treatment, testing with additional beam angles, the reduction of the recording level, the use of specific probes or an additional radiographic test.

(4) Welded joints between austenitic steels as well as between ferritic and austenitic steels

a) Where the inner surface of butt welds is inaccessible to penetrant testing the following is required:

aa) for wall thicknesses equal to or greater than 16 mm, an ultrasonic test of the inner surface to Section 11.4.2.3,

ab) in the wall thickness area $8 \leq s \leq 16$ mm, an ultrasonic test of the inner surface to Section 11.4.2.3 or a radiographic test in accordance with the stipulations in Section 11.2.4.2; the same test method shall be used that is intended for future in-service inspections,

ac) for wall thicknesses less than 8 mm, radiographic testing in accordance with the stipulations in Section 11.2.4.2.

b) In the case of welded joints between ferritic and austenitic steels the interface between weld and ferritic base metal shall be tested for bonding upon welding of the connecting weld by means of the ultrasonic or radiographic method. The following shall be performed:

ba) ultrasonic testing for wall thicknesses s equal to or greater than 16 mm,

bb) ultrasonic or radiographic testing in the wall thickness range s equal to or greater than 8 mm and less than 16 mm,

bc) radiographic testing for wall thicknesses s smaller than 8 mm.

Where the use of ultrasonic testing is restricted for these areas, a radiographic test shall be performed additionally.

c) Where the examination area can only be covered by radiographic testing to a limited extent, e.g. the area of weld fusion face on nozzles, ultrasonic testing shall be performed additionally. Such test techniques shall be used in ultrasonic testing as to cover the area testable to a limited extent only. The procedural requirements shall be laid down in a test instruction.

(5) Claddings shall be tested in their completed condition

a) by penetrant testing,

b) by ultrasonic testing in accordance with Section 11.6.2.1.2.

(6) In the case of hard surface overlays and butterings for hard surface overlays the entire surface of the hard surface overlay and of the adjacent buttering shall be subjected, in the finished condition, to penetrant testing and ultrasonic testing in accordance with Section 11.6.2.2.

(7) Shaping welds shall be tested in their finished condition

a) by surface inspection, where in the case of limited accessibility or insufficient magnetizability penetrant testing may be use instead of magnetic particle testing,

b) by ultrasonic testing in accordance with Section 11.6.2.3.2 in the case of ferritic shaping welds, and in accordance with Section 11.6.2.5.2 and **Table 9-6** in the case of austenitic shaping welds.

9.3.6.3 Performance of non-destructive tests and inspections

The non-destructive tests and inspections shall be performed in accordance with Section 11.

9.3.6.4 Attendance at non-destructive tests and inspections

The authorized inspector shall attend the non-destructive tests and inspections with due consideration of **Table 9-4**:

a) ultrasonic testing

aa) manual ultrasonic testing shall be performed and be evaluated by the authorized inspector independently of the tests made by the manufacturer,

ab) in the case of mechanized tests and examinations the authorized inspector shall attend the sensitivity calibration of the test equipment, spot-check the performance of tests and examinations and evaluate the results obtained,

b) radiographic testing

the radiographs obtained by radiographic testing shall be evaluated by the authorized inspector. The performance of the radiographic tests shall be spot-checked by the authorized inspector,

c) surface inspection (magnetic particle and penetrant testing)

the authorized inspector shall attend the tests to be performed by the manufacturer and evaluate the results obtained.

9.3.7 Hardness tests on ferritic welds

(1) The hardness tests shall be conducted as random tests if hardness numbers equal to or greater than 320 HV 10 are detected in the welding procedure qualification or production control test or if there is substantiated reason to believe that the hardness numbers exceed 350 HV 10.

(2) Each of the hardness tests shall be conducted at three measuring points:

a) on the base metal (at least 10 mm away from the heat affected zone),

b) in the heat affected zone of the base metal on both sides of the cover pass,

c) in the weld metal (middle of the cover pass).

9.3.8 Check of actual values of the main dimensions of the finished and assembled piping system

In the case of piping systems, the comparison between specified and actual conditions (e.g. supporting lengths, pipe lengths, laying angles) shall be effected by means of physical inspections. For the required values, tolerances shall be specified taking into consideration design margins. If the tolerance ranges are exceeded, changes in accordance with agreed measures shall be required. These changes shall be recorded. If necessary, the calculation and design documents shall be revised. This procedure shall be discussed and agreed upon with the authorized inspector (e.g. tolerance concept).

9.3.9 Leak test, pressure test

9.3.9.1 General requirements

(1) Leak tests shall be conducted if special leak tightness requirements are laid down in the Design Data Sheet or the pipe loading specifications.

(2) Leak tightness requirements, demonstration procedures, test pressure and medium shall be specified in the test and inspection sequence plan.

(3) Gas leak tightness tests shall be conducted before the first hydrostatic pressure test.

(4) An initial pressure test shall be conducted on components or, in the case of pipes, on systems or system sections as the final step in final inspection.

(5) For the pressure test, the test pressure, test temperature, test medium and holding period shall be specified in the test and inspection sequence plan.

(6) If a component is no longer cleaned after a pressure or leak test, the test media shall meet the cleanliness requirements to be met by the component in accordance with Section 12. Oil-free and fat-free air or nitrogen shall be used as the medium for pressure and leak tests employing gas.

(7) When the leakage and pressure test in the manufacturer's works have been completed, the component shall be dried. In the case of piping systems, appropriate measures shall be taken to prevent corrosion damage (e.g. suitable medium, drainage of the system).

9.3.9.2 Leak test

(1) Leak tests for vessels, pipes and pumps generally refer to detachable connections, tube-to-tubesheet connections, heat exhangers and cast casings. Depending on the leak tightness requirements, the demonstration procedure which is suitable in accordance with **Table 9-7** shall be applied.

(2) In the case of valves, the following specifications shall apply to the test performance and the leak tightness requirements, unless further requirements laid down in the Design Data Sheet are to be met:

a) cast casings and detachable connections:
P11 to DIN EN 12266-1

b) backseat:
P21 to DIN EN 12266-2; test at the opening of the packing ejector, if any

c) seat (isolation):
P12 to DIN EN 12266-1
test pressure in the case of safety valves: 0.9 times the set pressure

The respective leak tightness requirement shall be laid down in the Design Data Sheet. Other leak test procedures to DIN EN 12266-1 or DIN EN 12266-2 shall only be permissible upon agreement with the authorized inspector.

9.3.9.3 Pressure test

9.3.9.3.1 Time of the test

(1) The time of the pressure test shall be specified so that the tester is able to inspect all pressure-retaining parts. If the parts or components cannot be inspected in their final condition, an early pressure test (partial final inspection) shall be conducted on the parts or components when they are still in a testable condition.

(2) The pressure test shall be effected:

a) after the final heat treatment,

b) after cladding and mechanical processing,

c) before the application of coatings and linings.

(3) In the case of valves and pumps, the pressure test may be effected as an early pressure test separately for single items or as a pressure test for the total component. This shall be specified in the test and inspection sequence plan.

(4) In the case of castings, an early hydrostatic pressure test shall be conducted (if necessary, following an advance leak test).

9.3.9.3.2 Performance of the test

(1) The pressure test shall normally be conducted as a hydrostatic pressure test.

(2) If a hydrostatic pressure test is not possible or not appropriate, the pressure test may also be effected as a gas pressure test while adhering to the relevant occupational safety rules. If this is the case, oil-free and fat-free air or nitrogen shall be used.

(3) In the case of hydrostatic pressure tests conducted at test pressures greater than 100 bar and fluid temperatures above 50 °C, special protective measures shall be provided.

(4) In the case of components which are divided into various pressure compartments by means of partitions, the pressure test shall be effected separately for each pressure compartment at the relevant test pressure. The pressure compartments which are not to be tested shall be depressurized. In the case of vessels with several compartments, each compartment shall be individually subjected to a pressure test. Deviations from this rule are permitted if there is a wall between two pressure compartments whose only purpose is to cope with the differential pressure and if operational measures ensure that none of the compartments is pressurized independently of the other. In such cases, this differential pressure shall first be applied to each of the neighbouring compartments and subsequently the test pressure shall be applied simultaneously to the compartments affected.

(5) It shall be possible to check the pressure indicated by the pressure gauge during the test (possibility of connecting a reference pressure gauge). Suitable measures shall prevent the test pressure from being exceeded.

(6) The component shall be positioned such that it can be fully vented when being filled with the test medium.

(7) The outer walls shall be dry.

(8) The maximum allowable working pressure shall not be exceeded before the authorized inspector arrives. It is only after consultation with the authorized inspector that the pressure shall be slowly increased until the test pressure is reached.

(9) If strain measurements are scheduled, pressure shall not be applied to the component before the strain measurement have been effected (except for leak tests).

(10) In the case of components for which the static pressure of the liquid column is to be taken into account, the pressure test shall be effected in the assembly position intended for operation. If, during the pressure test, the position of the component deviates from the position intended for operation, the static pressure of the liquid column shall be taken into account.

(11) The component shall have been provided with the prescribed identification marking such as a nameplate, at the latest at the time of the pressure test, and if there are several pressure compartments, at that of the last pressure test. Deviations shall be specified in the test documents.

(12) Auxiliary means such as flanges, closure heads, bolts, seals and additional welded connections may only be used to close the components for pressure tests if the closures scheduled for the operating condition of the component are not part of the supply scope of the component. The auxiliary means used shall be capable of withstanding the stresses occurring during the pressure test (materials, dimensioning).

(13) After performance of the pressure test, all detachable auxiliary means shall be immediately and completely removed or marked such that the possibility of erroneously using them during operation of the component can be excluded.

(14) The fasteners of the components (original bolts) shall be used. The replacement of single bolts (e.g. in the case of damage) is permitted without a renewed pressure test.

(15) Inspection holes used to verify the leak tightness of covered welds shall be open during the pressure tests.

(16) Pressure tests upon assembly/erection of components and pipes in the plant shall be performed to approved pressure test plans.

9.3.9.3.3 Test pressure

(1) In the case of a hydrostatic pressure test on components made of cast steel, rolled and forged steel, the test pressure level - in relation to the highest point of the pressure compartment - shall be $1.3 \cdot PB$ (PB in accordance with design data sheet or pipe loading specification), unless the test and inspection sequence plan specifies a different value.

(2) The test pressure for isolating elements of valves is $1.3 \cdot PB$.

9.3.9.3.4 Test temperature

(1) In the case of parts or components made of austenitic steels, the test temperature shall be above 0 °C.

(2) In the case of parts or components made of ferritic materials, the test temperature shall be specified such that the fracture toughness requirement - equal to or greater than 41 J (mean value) - is met by base metal, weld metal and heat affected zone.

9.3.9.3.5 Holding period

(1) For vessels, pumps and pipes, the required holding period (holding time of the test pressure) is 1 minute per mm wall thickness of the pressure-retaining wall and at least 30 minutes. In special cases, a deviating holding period may be specified in the design approval document.

(2) For valves, the required holding period is:

a) valves equal to or smaller than DN 100 : 3 min,

b) valves greater than DN 100 : 5 min.

9.3.10 Partial final inspection

(1) The manufacturer shall arrange the timing of the tests so that the authorized inspector is able to test all parts. If the parts or components cannot be tested in their final condition, partial final inspection shall be conducted.

(2) In the course of the partial final inspection, the authorized inspector shall also check that the parts are accompanied by the corresponding certificates.

9.3.11 Testing of the freedom of movement and ease of operation of all movable functional parts of valves

(1) Each valve shall be subjected to a functional test in the manufacturer’s works. This test shall demonstrate the freedom of movement of the movable parts and the operational

capability of the accessories and the control systems without operating medium.

(2) This demonstration shall be effected for

a) isolation and control valves with motor, pneumatic or hydraulic drives by means of:
   aa) repeated opening and closing without medium (in the case of an original drive - measurement of the opening and closing times and inspection of the adjustment certificate issued by the manufacturer of the actuator),
   ab) check of the position indicators,
   ac) check for freedom of movement.
b) isolation valves controlled by their own media by means of:
   ba) repeated opening and closing by their own medium; as an alternative, the actuation may by effected by means of nitrogen, oil-free and fat-free air or demineralized water,
   bb) check of the position indicators,
   bc) check for freedom of movement.
c) manual isolation valves by means of:
   ca) repeated opening and closing without medium,
   cb) check for freedom of movement,
   cc) check of the position indicators.
d) check valves by means of a check for ease of operation.

(3) For valves where the assembly position governs the function the intended assembly position shall be considered in the functional test.

9.3.12 Requirements for and proof of functional capability of safety valves

(1) AD 2000-Merkblatt A 2 shall be adhered to at least regarding the requirements for and proof of functional capability of safety valves.

(2) Regarding proof of functional capability, the relevant tests to be conducted in each case shall be specified in the test and inspection sequence plan.

9.3.13 Acceptance inspection of pumps

(1) Pumps shall be subjected to acceptance inspection after the pressure test. The data to be recorded during this test shall be specified in a measuring report.

The requirements to be met in acceptance inspection including the standards which shall be taken as a basis shall be specified during design approval. The information on head, capacity, maximum power consumption, efficiency, and net positive suction head (NPSH) shall be taken from the Design Data Sheet (ADB).

(3) The pump vibration-free running shall meet the requirements of DIN ISO 10816-7.

9.3.14 Non-destructive tests conducted after the pressure test

(1) Upon the initial pressure test non-destructive tests and examinations shall be performed on highly loaded areas as per **Table 9-8**. The areas and the weld lengths to be examined shall be specified in the test and inspection sequence plan jointly with the authorized inspector in due consideration of the design, materials and fabrication processes on the basis of the results of the design approved stress analysis or strain measurements.

(2) The necessity of including tolerated deviations from fabrication processes (e.g. locations of less than required wall thicknesses, misalignment, indications in the volume) into the extent of testing shall be decided upon by agreement with the authorized inspector within the course of tolerance acceptance procedure.

(3) The specifications for the tests conducted before the first-time pressure test shall apply to the test procedures, dimensional limits, requirements and acceptance standards.

9.3.15 Baseline non-destructive tests for inservice inspections on welds

(1) The non-destructive tests and examinations performed in the course of fabrication are considered baseline inspections for in-service inspections if they are performed with the same test methods and techniques provided for future in-service tests and inspections. Where non-destructive tests and inspections are not required upon the initial pressure test as per **Table 9-8**, the last tests performed prior to the initial pressure test are accepted.

(2) In the case of welds between ferritic and austenitic steels with nickel-alloy weld metal at the fluid-wetted surface a test for transverse defects in accordance with the specifications of KTA 3211.4 shall be performed in opposite scanning directions during baseline inspection in addition to the requirements of Section 11.5. This additional test is also required if an austenitic root equal to or less than 3 mm is located between the nickel-alloy weld metal and the fluid-wetted surface.

(3) Baseline inspections will be required anew if the test procedures other than those performed during fabrication inspection are used for in-service inspections.

(4) In Test Groups A1 and A2, survey lists for recordable ultrasonic indications

a) for vessels (per component),
b) for pipes (per system)

shall be prepared by the manufacturer and attached to the final documentation; these lists shall be subdivided according to the welds and shall specify the associated record numbers. This shall also apply to deviations from the requirements to be met by non-destructive testing, as tolerated in accordance with Section 13.

9.4 Receiving inspections of components on the site

(1) Component-specific provisions shall be arranged with the authorized inspector for on-site receiving inspections.

(2) The results of the receiving inspections shall be confirmed by the authorized inspector. This confirmation shall be attached to the component documentation.

9.5 Inspection prior to First Commissioning

(1) Upon erection/anchoring as well as installation in the plant, an acceptance inspection of pressure vessel plants shall be performed prior to first putting into operation. This acceptance inspection covers an inspection for orderly condition required for an as-specified operating mode. During this inspection the assembly, installation, erection/anchoring as well as the functioning of the safety-relevant equipment shall be examined.

(2) The inspection shall be performed in correspondence with the “Technical Rules for Operational Safety (TRBS)” and be certified by the authorized inspector. The authorized inspector’s certificate shall become part of the plant documentation.

(3) The type, extent and requirements of the inspection prior to first putting into operation shall be laid down in writing and be submitted to the authorized inspector for approval.

Abbreviations used

H : manufacturer
H1 : tests and inspections/checks to be conducted by the manufacturer in any case
H2 : tests and inspections/checks to be conducted by the manufacturer which may be conducted as random tests during controlled fabrication
S : authorized inspector
S1 : tests and inspections/checks to be conducted by the authorized inspector in any case
S2 : tests and inspections/checks to be conducted by the authorized inspector as random tests (no mandatory hold point).

Check Number	Requirement in accordance with	Tests and Inspections/Checks	H	S
1		**Manufacturing Preconditions**		
1.1	Section 3.1 Section 3.2 KTA 1401	Review of the general manufacturing preconditions	H1	S1
1.2 a)	Section 3.3	Control of validity of the welder's performance qualification test, comparison with the list of welders	H1	S1
b)	Section 3.3.4	Control of validity of the certificates of supervisors and NDT operators as per DIN EN ISO 9712 and visual capability certificates	H1	S1
1.3	Section 9.1.2	Check of the authorization to transfer markings	H1	S1
1.4	Section 7.1.2	Check of the heat treatment equipment	H1	S1
1.5 a)	Section 3.1; KTA 1401	Control of the fabrication equipment including associated measuring equipment	H1	–
b)	Section 3.1; KTA 1401	Demonstration of regular checking of welding equipment and associated measuring equipment	H1	S1
c)	Section 3.2	Proof of validity of certificates for measuring and testing equipment	H1	S1
1.6	Section 4.1	Check of availability of valid design approval documents	H1	S1
1.7	Section 8.1	Check of availability of the required welding procedure qualifications	H1	S1
1.8	Section 6	Control of availability of the test report on forming processes	H1	S1
2		**In-process Tests and Inspections**		
2.1	Manufacturer's specifications	Receiving inspection of the product forms	H1	–
2.2	Section 5.3	Receiving inspection of the welding filler metals and welding consumables plus material identification test before the start of fabrication	H1	–
2.3	Section 9.1.2	Inspection of the transfer of stamps on the product forms	H1	S1
2.4	Section 5.3	Check of the storage, handling and drying of the welding filler metals and welding consumables	H2	S2
2.5	Manufacturer's specifications	Ultrasonic testing of butterings before heat treatment	H2	–
2.6	Section 5.4; Welding procedure specification	Check of the pre-heating for thermal cutting purposes	H2	S2
2.7	Section 5.4	Check of the machining of thermally cut edges and weld edges	H2	S2
2.8	Manufacturer's specifications	Surface inspection (MT, PT) of the		–
		- weld edges	H1	
		- surfaces for build-up welds	H1	
		- hollowed out root areas	H2	
		- remaining root pass of single-side welds	H2	
2.9	Section 5.4	Check of cleanliness of weld areas	H2	S2
2.10	Section 5.5.2	Check of pre-heating for tacking purposes	H2	S2
2.11	Section 5.5.8; Welding procedure specification	Check of tacked condition	H2	S2
2.12	Sections 5.5 and 5.6, Table 5-1	Control for		
		a) fulfillment of the requirements in the welding procedure specification (recording of this fulfilment by the welding supervision),	H2	S2
		b) recording of the welders (welder number), weld-related,	H1	S2
		c) recording of the lot numbers of welding filler metals and welding consumables	H1	S2

Table 9-1: Checklist for fabrication supervision
(continued next page)

Check Number	Requirement in accordance with	Tests and Inspections/Checks	H	S
2.13	Secions 5.7.1 and 9.3.4; Welding procedure specification	Visual testing of the welds in the welded condition	H1	S2
2.14	Secions 5.5.3 and 5.7.1; Welding procedure specification	Visual testing of the welds with tempering beads before dressing	H1	S2
2.15	Section 9.1.3	Control of identification markings of the welds	H1	S2
2.16	Manufacturer's specifications	Non-destructive testing before heat treatment	H2	–
2.17	Section 7; Welding procedure specification, Heat treatment plan	Check of the heat treatment after welding	H1	S2
2.18	Section 5.5.9	Inspection of the due and proper removal of temporary welded attachments with recording of position of temporary welds	H1	–
2.19	Section 12	Inspection of cleanliness, tempering colours	H1	S2
2.20	Section 8.2	Scheduling and performance of production control tests		
		a) Time scheduling and provision of materials	H1	–
		b) monitoring	H1	S2
		c) testing	H1	S1
2.21	Drawing	Check of execution of the tube-to-tubesheet joints on heat exchangers (drilling tolerance, tube-to-tubesheet weld, expanded tube connection, final tube expansion) and tube supports	–[1)]	S2
2.22	Section 9.2.3	Check of the recording by H in the checking plan	–	S2
2.23	Section 11	Check of performance of non-destructive tests by the manufacturer	–	S2
2.24	Section 9.3.9.1; Section 9.3.9.2	Leak test, in particular, the connection between tube and tubesheet in the case of heat exchangers	–[1)]	S2
3		**Repairs, Deviations**		
3.1	Section 13	Inspection of the allocation to relevant categories:		
		a) category 1,	H1	S2
		b) categories 2, 3	H1	S1
3.2	Section 13	Control of availability of the approved repair documents for categories 2 and 3	H1	S1
3.3	Section 13	Inspection for the elimination of defects	H1	S1
3.4	Section 13	Inspection for the performance of repairs (in accordance with check numbers 2.1 to 2.23)		
3.5	Section 13	Inspection of the repair documentation	H1	S1
3.6	Section 13	Inspection of the tolerance applications	H1	S1
4	Section 12	**Checking of Preservation, Packaging**	H1	–
5		**Documentation in the course of Manufacture**		
5.1	Section 4.2	Review of the in-process preparation of documentation	H1	S2

[1)] For the manufacturer: Inspection Step

Table 9-1: Checklist for fabrication supervision (continued)

Fabrication Supervision		Final Inspection
by the manufacturer	by the authorized inspector	
Requirements		**Requirements**
Section 9.2.3.1 with Checklist in accordance with Table 9-1	Section 9.2.3.2 with Checklist in accordance with Table 9-1	Section 9.3 with Inspection Sheet for final inspection in accordance with Table 9-4 and Section 4
Preparation of the Checking Plan for each Design Approval Document and Delivery Unit [1), 2)]		**Preparation of the Test and inspection sequence plan**
By the manufacturer; standard checking plans may be used: a) on the basis of the Checklist by means of: - additions (components, designations for parts and welds), - deletions of non-applicable inspection numbers, - requirement for the scope of the random tests, - specification of the areas of responsibility for the supervisory personnel and quality assurance office or b) using appropriate manufacturer forms (e.g. operation sheets or QA system requirements)	Authorized inspector's own checking plan: a) on the basis of the Checklist by means of: - additions (components, designations for parts and welds), - deletions of non-applicable inspection numbers, - requirement for the scope of the random tests. or b) using appropriate forms. The preparation shall be effected before or immediately after the start of fabrication.	By the manufacturer; standard test and inspection sequence plans may be used
Scope of the Tests and Inspections		**Scope of the Tests**
a) Manufacturing preconditions 100 % b) In-process inspections in accordance with Section 9.2.3.	a) Manufacturing preconditions 100 % b) In-process inspections in accordance with Section 9.2.3.	In accordance with Table 9-4
Review of the Checking Plan		**Design approval of test and inspection sequence plan**
By the manufacturer's quality assurance office	—	By the authorized inspector

1) In the case of pipes, it is permissible to make reference to the period of fabrication, the system or total order.
2) See also para. 9.2.3.1 (4).

Table 9-2: Fabrication supervision and final inspection: Preparation of the checking plan and test and inspection sequence plan

Fabrication Supervision		Final Inspection
by the manufacturer	by the authorized inspector	
Performance		
Supervisory personnel or quality assurance office in accordance with checking plan. The tests are mandatory hold points for the fabrication.	In-process inspections, S1 - hold points S2 - no hold points	by the manufacturer and authorized inspector
Coordination for the Performance		
The manufacturer informs the authorized inspector of the chronological sequence of the fabrication steps so that the authorized inspector is then able to plan the inspection and testing steps to be conducted by him. The authorized inspector shall be informed in due time of any deviations from the sequence; this may be done verbally.		The tests are mandatory hold points. In the case of random tests, the times of the tests shall be discussed and arranged by the manufacturer and authorized inspector.
Confirmation or Recording		
By means of stamps or initials in the checking plan with a specification of the date and a statement on the fulfillment of the requirements. Insofar as this is required, operating records shall be kept, e.g. in the case of welding work. In the case of non-destructive tests, indications liable to record shall be recorded.	By means of stamps or initials in the checking plan with a specification of the date.	By means of stamps or records in accordance with Table 9-4.
In the case of percentage or random tests, attendance or supervision, the test parties involved shall only confirm those tests and inspections which were performed or attended or supervised by them. The respective extent of testing and the examined area (e.g. location, test length, test sections, etc.) shall be clearly indicated in the test record or test and inspection sequence plan.		
Documentation		
Summary confirmation in the test and inspection sequence plan. Checking plan and work instructions (test performance, assessment) shall be put into the final file.	Summary confirmation (both manufacturing pre-conditions and in-process inspections) in the test and inspection sequence plan. The checking and inspection plan shall be put into the final file.	In the test and inspection sequence plan in accordance with Section 4.
Deviations		
Evaluation and treatment in accordance with Section 13		

Table 9-3: Fabrication supervision and final inspection: Performance of in-process inspections and final inspection

Abbreviations used:

Ar : valves
B : vessels and ancillary equipment
P : pumps
R : pipes
H : manufacturer
S : authorized inspector
DU : test performance
ÜW : test supervision
TE : test participation
ST : stamp
AN : issue of a demonstration
E : final file
E/S : final file/summary certificate

Test No.	B	Ar	P	R	Requirements in accordance with	Description of the tests		Test by, scope in %	Test activity, furnishing of certificates	Document file
1						**Tests and Supervision Before and In the Course of Fabrication** [16]				
1.1	x	x	x	x	Checking plan	Check for fulfilment of manufacturing pre-conditions		H S	DU ST DU ST	– –
1.2	x	x	x		Section 9.1 Materials list	Check of material certificates and material identification with confirmation in the materials list		H [1] S [1]	DU ST DU ST	– –
				x	Section 9.1; Isometric; Isometric item list; Design approval document	Receiving inspection at the processor's shop or on the site. To be taken into special consideration: verification that the allocation of the parts and pre-fabricated pipe parts (spools) to the system meets the requirements and is confirmed in the isometric item list.		H [2] S [2]	DU ST DU ST	– –
1.3	x	x	x	x	Section 9.3.6.2.1	Ultrasonic testing of weld edges and welding areas		H	DU AN	E
1.4	x	x	x	x	Section 9.3.5; Section 5.7.1.2.2	Control for fulfilment of misalignment and air gap requirements in the tacked condition of welds to be welded from one side		H 100 S 10	DU ST ÜW ST	– –
1.5	x	x	x	x	Section 5.7.1	Visual testing of accessible weld surfaces.		H 100	DU ST	–
						Adherence to the requirements for the external irregularities, in consideration of the surface requirements for the NDT processes to be conducted, shall be confirmed.		S 10 [18]	ÜW ST	–
1.6	x	x	x		Design approval document (Drawing); Welding procedure specification	Coating thickness measurements of weld claddings and hardsurfaces in their final condition or measurements before welding and in their final condition.		H all surfaces S random tests	DU ST ÜW ST	– –
1.7	x	x	x	x	KTA 3211.1	Surface inspection (MT, PT) of subsequently machined surfaces of castings and forgings and of sealing faces				
							A1	H 100 S 25	DU AN TE [9] ST [3]	E
							A2/A3	H 100 S 10	DU ST [3] TE [9] ST [3]	E –
						This surface inspection is not required for bore holes in heat exchanger tube sheets.				
1.8	x	x	x	x	Section 11	Determination whether weld edges on austenitic product forms that are to be examined to KTA 3211.1 can be subjected to ultrasonic testing unless performed by the product form manufacturer		H 100 S 100	DU AN DU AN	E E
1.9	x	x	x	x	Section 7; Heat treatment plan	Check of the heat treatment certificate		H S	DU AN DU [9] –	E [4] –
1.10	x	x	x	x	Section 9.3.7	Hardness tests HV 10 on ferritic welded connections		H random tests	DU AN	E
2						**Non-destructive Tests Conducted on Welds and Build-up Welds in their Fabricated Final Condition including butterings and hardsurfaces** [5] [16]				
2.1						Surface inspection (MT, PT)				
2.1.1	x	x	x	x	Section 9.3.6; Section 11	Surface inspection of outside welds				
						Butt welds, nozzle welds and attachment welds	A1/A2	H 100 S 25	DU AN TE [9] ST [3]	E –
						Butt welds (LW, CW)	A3	H 25 S 25	DU AN DU AN	E E
						Nozzle welds and attachment welds	A3	H 100 S 25	DU AN TE [9] ST [3]	E –
2.1.2	x	x	x	x	Section 9.3.6; Section 11	Surface inspection of inside welds [19]				
						Butt welds and nozzle welds	A1/A2	H 100 S 25	DU AN TE [9] ST [3]	E –
						Butt welds (LW, CW)	A3	H 25 S 25	DU AN DU AN	E E
						Nozzle welds	A3	H 100 S 25	DU AN TE [9] ST [3]	E –

Table 9-4: Inspection sheet for final inspection for components and piping systems

Test No.	B	Ar	P	R	Requirements in accordance with	Description of the tests		Test by, scope in %	Test activity, furnishing of certificates	Document file
2.1.3	x	x	x		Section 9.3.6; Section 11	Surface inspection on build-up welds and weld claddings *Note:* *In the case of tubesheets - before drilling.*		H 100 S 25	DU AN TE[9] ST[3]	E
2.1.4	x	x	x	x	Section 9.3.6; Section 5.5.7; Section 5.5.9 (5); Section 11	Surface inspection on ground arc strikes, tack welds and temporary welds which have been removed and ground		H 100 S 25	DU AN TE[9] ST[3]	E
2.1.5	x				Section 9.3.6; Section 11	Surface inspection of tube-to-tubesheet welds of heat exchangers				
							A1/A2	H 100 S 25	DU AN TE[9] ST[3]	E
							A3	H 25 S 10	DU AN DU AN	E E
2.1.6		x	x	x	Section 9.3.6; Section 11	Surface inspection of hardsurfaces and butterings		H 100 S 25	DU AN TE[9] ST[3]	E
2.2						Ultrasonic testing (UT) [8] *Note:* *In the case of test numbers 2.2.1 to 2.2.6, the test numbers in accordance with **Tables 11-7** to **11-11** shall be specified in the test and inspection sequence plan. In the case of pipes, the test numbers may be entered into the UT records as an alternative. In such a case, verification of the correct choice of test number shall be effected at the latest at the same time as the release for the pressure test.*				
2.2.1	x	x	x	x	Section 9.3.6; Section 11, Table 11-7, UT-No. 1.1 - 1.6	UT on ferritic butt welds (longitudinal and circumferential welds) $s \geq 8$ mm [6] and $\geq$ DN 80				
							A1/A2	H 100 S 25	DU AN[7] DU[7] –	E –
							A3	H 25 S 25	DU AN[7] DU[7] –	E –
2.2.2	x	x	x	x	Section 9.3.6; Section 11, Table 11-8, UT-No. 2.1 - 2.4	UT on ferritic nozzle welds $\geq$ DN 125 mm and s or $s_1 > 15$ mm				
							A1/A2	H 100 S 25	DU AN[7] DU[7] –	E –
							A3	H 25 S 25	DU AN[7] DU[7] –	E –
2.2.3	x	x	x	x	Section 9.3.6; Section 11, A1: Table 11-9, UT-No. 3.1, 3.2 A2/A3: Table 11-10, UT-No. 3.4, 3.5	UT on ferritic attachment welds (single, double bevel groove) $s_1 > 15$ mm				
							A1/A2	H 100 S 25	DU AN[7] DU[7] –	E –
							A3	H 25 S 25	DU AN[7] DU[7] –	E –
2.2.4	x	x	x	x	Section 9.3.6; Section 11, Table 11-9, UT-No. 3.3	UT on ferritic attachment welds (single, double bevel groove) $s_1 \leq 15$ mm and length > 100 mm				
							A1	H 100 S 25	DU AN[7] DU[7] –	E –
2.2.5	x	x	x	x	Section 9.3.6; Section 11, Table 11-11, UT-No. 4.1	UT on ferritic fillet welds $s_1 \geq 10$ mm or length > 100 mm				
							A1/A2	H 100 S 25	DU AN[7] DU[7] –	E –
							A3	H 25 S 25	DU AN[7] DU[7] –	E –
2.2.6	x	x	x	x	Section 9.3.6; Section 11	UT on shaping ferritic and austenitic build-up welds, weld claddings and butterings				
							A1/A2	H 100 S 25	DU AN[7] DU[7] –	E –
							A3	H 25 S 10	DU AN[7] DU[7] –	E –
2.2.7	x	x	x	x	Section 9.3.6; Section 11	UT on weld claddings and hardsurfaces for bonding (where practicable)		H 100 S 25	DU AN[7] DU[7] –	E –

Table 9-4: Inspection sheet for final inspection for components and piping systems (continued)

Test No.	B	Ar	P	R	Requirements in accordance with	Description of the tests	Test by, scope in %	Test activity, furnishing of certificates	Document file
2.2.8	x	x	x	x	Section 9.3.6; Section 11	Ultrasonic testing of austenitic butt welds and nozzle welds ≥ DN 125 [8)] This test shall only be performed if the surface inspection to test no. 2.1.2 cannot be conducted.			
						A1/A2	H 100 S 25	DU AN [7)] DU [7)] –	E –
						A3	H 25 S 25	DU AN [7)] DU [7)] –	E –
2.3						Radiographic testing (RT) [8)]			
2.3.1	x	x	x	x	Section 9.3.6; Section 11	RT on ferritic and austenitic butt welds (LW, CW). When determining the test technique it shall be considered whether a surface inspection as per test no. 2.1.2 can be conducted. This test shall be waived in the case of ferritic butt welds of Test Group A3 where 8 ≤ s ≤ 20 mm, if the UT has already been conducted in accordance with test no. 2.2.1. [6)]			
						A1/A2	H 100	DU AN	E
						A3	H 25	DU AN	E
2.3.2	x	x	x	x	Section 9.3.6; Section 11	RT on austenitic nozzle welds ≥ DN 125, RT on ferritic nozzle welds ≥ DN 125 as well as s and s_1 ≤ 15 mm			
						A1/A2	H 100	DU AN	E
						A3	H 25	DU AN	E
2.4	x	x	x	x	Section 11	Evaluation of the radiographs for test numbers 2.3.1 and 2.3.2	H 100 S 100	DU AN DU [9)]	E –
3.						**Tests Conducted After Fabrication**			
3.1	x	x	x	x	Section 8	Inspection of the required production control tests in accordance with **Table 8-11** including checking of the allocation of the production control tests to the welds [16)]	H S	DU ST DU ST	– –
3.2	x	x	x	x	Section 4	Documentation of the part-based production control tests [16)] ; Final test report	H S	DU AN DU AN	E E
3.3	x				Drawing	Inspection of the rolling on/in of all tubes, random inspection of the final tube expansion and the expanded length of the rolled-in tubes for 10 % of the tubes of heat exchangers [10)]	H	DU ST	–
3.4	x				Section 9	Early final inspection for parts of the pressure-retaining wall which are no longer accessible after assembly	S	DU AN	E
3.5						Early leakage and pressure test without internals *Note:* *Tests shall be waived if these are conducted in accordance with test numbers 4.2, 4.4, 4.5 and 4.6.*			
3.5.1		x	x		Drawing; Materials list	Inspection of the stamping of the parts loaded in the pressure test	H S	DU ST DU ST	– –
3.5.2		x	x		Section 4.1.1.3.3 (4); Drawing; Dimensional check sheet	Dimensional check before the pressure test	H S	DU AN [11)] DU –	E –
3.5.3		x	x		Section 9.3.9; ADB (Design Data Sheet)	Leak test of castings	H S	DU ST TE ST	– –
3.5.4		x	x		Section 9.3.9; ADB (Design Data Sheet)	Pressure test	H S	DU AN TE [9)] –	E –
3.6				x	Section 9.1.3.4; Drawing or fabrication isometric	Dimensional check of parts fabricated at the manufacturer's works or pre-fabricated pipe parts (spools) including an inspection of the markings [17)]	H S	DU ST DU ST	– –
4.						**Final Tests Conducted on Components and Piping Systems or Sections of Systems**			
4.1	x	x	x	x	Design approval document; Welding procedure specification; heat treatment plan; Section 7	Check of the heat treatment certificate (waived if already effected in accordance with test number 1.9)	H S	DU AN DU [9)] –	E [4)] –

Table 9-4: Inspection sheet for final inspection for components and piping systems (continued)

Test No.	B	Ar	P	R	Requirements in accordance with	Description of the tests	Test by, scope in %	Test activity, furnishing of certificates	Document file
4.2						Dimensional check			
4.2.1	x	x	x		Section 4.1.1.3.3(4); Dimensional check sheet or drawing	Checking of actual dimensions of the component (main connecting and installation dimensions)	H	DU AN [11]	E
4.2.2	x	x	x		Drawing	Dimensional check within the scope of the final inspection on the basis of the design-approved drawings (may be waived in the case of valves and pumps if conducted in test number 3.5.2)	H S	DU ST DU ST	– –
4.2.3				x	Calculation isometry; Section 9.3.8; KTA 3205.2; KTA 3205.3	Checking of the actual main dimensions of the finished and assembled system, in particular, position of the pipe hangers and supports in the system *Note:* *Adjustment data for hangers: test steps in accordance with KTA 3205.2 and KTA 3205.3*	H S	DU ST DU ST	– –
4.3				x	Fabrication isometric drawing; Isometric item list; Section 9.1; RBA (Pipe loading specifications)	Review of the markings and confirmation in the isometric item list, Inspection of the execution of the pipes, e.g.: - installation of the correct parts, - marking and position of the welds, entry into the fabrication isometric drawing [13] If possible, these tests shall be conducted as in-process tests.	H S	DU ST DU ST	– –
4.4				x	Section 9.3.9	Release of pressure test	H S	DU AN DU [9] –	E –
	x	x	x	x		Review of the documentation of the tests in accordance with test numbers 1 to 3	H S	DU ST DU ST	– –
4.5						Leak test			
4.5.1	x	x	x	x	Section 9.3.9 Design Data Sheets (ADB), Pipe Loading Specifications (RBA)	Leak test of detachable connection for external leakage (for cast valves the complete valve) provided it has not already been conducted in test number 3.5	H	DU ST	
4.5.2		x			Section 9.3.9	Backseat testing	H	DU ST	
4.6	x	x	x	x	Section 9.3.9; Design Data Sheets (ADB), Pipe Loading Specifications (RBA)	Pressure test of the complete component; in the case of pipes, test of the system or section of the system (may be waived in the case of valves and pumps if test number 3.5.4 has already been conducted)	H S	DU AN TE –	E –
4.7						Tests conducted after the pressure test			
4.7.1		x			Section 9.3.9	Seat leak test	H S	DU ST TE ST	– –
4.7.2		x			Section 9.3.12	Test of the safety valves including the adjustment of the set pressure, measurement of the closing pressure and safety device to prevent displacement	H S	DU ST TE AN	– E
					AD 2000-Merkblatt A 2	Test of set pressure adjustment			
4.7.3		x			Section 9.3.11	Test of freedom of movement and ease of operation of all movable functional parts	H	DU ST	–
4.7.4			x		Section 9.3.13; Design approval document; measuring report	Acceptance inspection	H S, random tests	DU AN ÜW –	E –
4.7.5			x		Manufacturer's specifications	Inspection of the running and bearing parts after the acceptance inspection	H S	DU ST DU ST	– –
4.7.6			x		Materials list	Inspection of the markings before assembly	H S	DU ST DU ST	–
4.7.7		x			Section 11	Surface inspection of all surfaces which have been subsequently machined (e.g. pressure test rings)			
						A1/A2	H 100 S 10	DU AN TE [9] ST [3]	E –
						A3	H 10	DU AN	E

Table 9-4: Inspection sheet for final inspection for components and piping systems (continued)

Test No.	B	Ar	P	R	Requirements in accordance with	Description of the tests	Test by, scope in %	Test activity, furnishing of certificates	Document file
4.7.8					Section 11; Section 9.3.14	NDE on highly-loaded areas upon pressure test; determination of extent of testing and test procedures in design approval VPU 1			
	x	x	x	x		Surface inspection (MT/PT)	H S	DU AN TE [9] ST [3]	E –
	x	x	x	x		Ultrasonic testing	H S	DU AN [7] DU [7] –	E –
	x	x	x	x		Radiographic testing	H	DU AN	E
						Evaluation of radiographs	H S	DU AN DU [9] –	E –
4.8	x			x	Section 9.3.15	Preparation of a general list of welds with recordable UT indications for A1 and A2 [16]	H S	DU AN ÜW –	E –
4.9		x			Clause 4.1.1.3.3(4); Dimensional check sheet or drawing	Recording of the actual main connecting and installation dimensions, if machining is still effected after test number 4.2.1.	H	DU AN [11]	E
4.10	x	x	x	x	Section 4.1.1.3.15	Check of the given tightening parameters of mechanical fasteners	H 100 S 10	DU AN TE [9]	E
5					Section 9.2.3	**Confirmation of fabrication supervision which has been effected** [16]	H S	DU ST DU ST	–
6						**Review of the Documentation Before Delivery** [14] [16]			
6.1	x	x	x	x	Design approval document: Materials list; Isometric item list; Section 4	Documentation of the materials tests	H S	DU ST DU ST	–
6.2						Documentation of the final inspection			
6.2.1	x	x	x	x	Design approval document; Test and inspection sequence plan	for the total component; in the case of pipes, for prefabricated pipe parts (spools).	H S	DU ST DU ST	–
6.2.2	x	x	x	x	Design approval document	Check of the documentation for the internal coating	H S	DU ST DU ST	– –
6.2.3	x		x		Design approval document	Check of the documentation for the non-integral supports in accordance with KTA 3205.2	H S	DU ST DU ST	– –
6.3	x	x	x	x	Section 4	Issuing the Final Inspection Report [15]	S	DU AN	E
7	x	x	x	x	Section 4.2.1.9	**Review of the final documentation before or after delivery of the component or review of final documentation for the finished and assembled piping system, including issuing of the Final Inspection Report** [15]	H S	DU AN DU ST [9]	E –
8	x				Section 9.5	**Inspection prior to first putting into operation**	S	DU AN	E

1) After availability of the documentation for product forms reviewed by the authorized inspector, the following points shall be verified for vessels, valves and pumps:
   a) allocation to the test groups,
   b) test requirements with regard to the maximum allowable operating temperature (TB),
   c) comparison of the lowest loading temperature with the results of the notched bar impact test,
   d) performance of the required tests when the product forms are subjected to stress perpendicular to the major surface,
   e) comparison of the simulated annealing with the performance of the part annealing.

2) After availability of the documentation for product forms reviewed by the authorized inspector, parts fabricated at the manufacturer's works and prefabricated pipe parts (spools), the following points shall be verified for pipes:
   a) Product form documentation
      aa) allocation to the test groups,
      ab) test requirements with regard to the maximum allowable operating temperature (TB),
      ac) comparison of the lowest loading temperature with the results of the notched bar impact test,
      ad) performance of the required tests when the product forms are subjected to stress perpendicular to the major surface,
      ae) comparison of the simulated annealing with the performance of the part annealing.
      af) Dimensional check for observance of requirements laid down in the design-approved documents.
   b) Documentation of parts fabricated at the manufacturer's works or pre-fabricated pipe parts (spools)
      ba) allocation to the test groups,
      bb) test requirements with regard to the maximum allowable operating temperature (TB),
      bc) comparison of the lowest loading temperature with the results of the notched bar impact test,

3) The test report shall clearly indicate the respective extent of testing and examination area (e.g. location, test lengths, test sections, etc.).

4) The heat treatment certificate becomes part of final file E, the heat treatment diagrams are allocated to interim file Z.

5) If, on account of proven experience, use is made of a reduced test scope in accordance with Table 9-5, this shall be specified in the test and inspection sequence plan.

Table 9-4: Inspection sheet for final inspection for components and piping systems (continued)

6) In the case of components and pipes of Test Group A 3 with a wall thickness of 8 mm to 20 mm, UT or RT is permitted as alternative, in which case the radiographed wall thickness shall not exceed 20 mm when subjected to double-wall radiographic testing. Where the inner surface is inaccessible to MT/PT, ultrasonic testing shall be performed.

7) See Section 11.9.2 regarding the documentation of manual ultrasonic testing.

8) Connections between ferritic and austenitic steels shall be treated in the same way as austenitic welds.

9) Countersigning on the manufacturer's demonstration sheet (in the case of radiographic testing, deviating evaluations shall be entered into the evaluation columns).

10) If rolled-in tubes are discovered whose final tube expansion and expanded length do not meet the requirements, an additional 20 % of the tubes shall be measured. If deviations are found, all tubes of the tube bundle shall be measured.

11) In the case of vessels, valves and pumps:
The actual dimensions shall be entered into the drawing or the dimensional check sheet in the column "Specified dimensions".

12) In the case of pipes:
The actual dimensions to be recorded shall be specified in the fabrication isometric drawing (design approval step VPU 1). The actual dimensions shall be entered into a copy of the calculation isometry (design approval step VPU 2).
For the assessment and treatment of deviations, corresponding tolerances and procedure steps shall be specified and discussed and agreed upon with the authorized inspector; see Section 9.3.8.

13) In the case of pipes, the actual condition shall be documented in the fabrication isometric drawing.

14) The material certificates and records shall be assigned to the final file (E). The inspection by the authorized inspector of internals and accessories is not covered by this safety standard.

15) The Final Inspection Report may be replaced by a quality certificate if the pre-conditions in accordance with Section 4 are fulfilled.
In the case of pipes, this refers to factory-fabricated parts.

16) In the case of pipes for factory fabrication and site fabrication.

17) Refers to factory fabrication.

18) Where the manufacturer performs surface inspection (MT/PT) as per test no. 2.1 with an extent of less than 100 %, all accessible weld surfaces shall be subjected to a visual inspection by the authorized inspector.

19) If the inner surface is inaccessible, the procedure of cl. 9.3.6.2.2 shall be performed.

Table 9-4: Inspection sheet for final inspection for components and piping systems (continued)

Test object		Scope of tests and inspections in % [1]								
		Volumetric testing						Surface inspection (MT/PT) [2]		
		UT			RT					
		Test Group			Test Group			Test Group		
		A 1	A 2	A 3	A 1	A 2	A 3	A 1	A 2	A 3
Tests by the manufacturer										
Butt welds (LW, CW) [3]	austenitic [4] s < 8 mm	–	–	–	100	100 [5]	25 [6]	100	100	25
	austenitic [4] s ≥ 8 mm	–	–	–	100	100 [5]	25 [6]			
	ferritic s < 8 mm	–	–	–	100	100 [5]	25 [6]	100	100 [5]	25 [6]
	ferritic s ≥ 8 mm	100	100 [5]	25 [6] [7]	–	–	[7]	100	100 [5]	25 [6]
	interface buttering/ ferritic base metal in the case of dissimilar welds s < 8 mm	–	–	–	100	100	25	–	–	–
	interface buttering/ ferritic base metal in the case of dissimilar welds s ≥ 8 mm	100	100	25	–	–	–	–	–	–
Nozzle welds ≥ DN 125 [3]	austenitic [4]	–	–	–	100	100	25	100	100	100
	ferritic s and $s_1 \leq 15$ mm	–	–	–				100	100	100
	ferritic s or $s_1 > 15$ mm	100	100	25	–					
Nozzle welds < DN 125 [3]	austenitic [4] or ferritic	–	–	–	–			100	100	100
Attachment welds (single, double bevel groove) [3]	austenitic $s_1 > 15$ mm	[10]	[10]	[10]	–			100	100	100
	austenitic [4] $s_1 \leq 15$ mm and $l > 100$ mm	[10]	–	–						
	ferritic $s_1 > 15$ mm	100	100	25						
	ferritic $s_1 \leq 15$ mm and $l > 100$ mm	100	–	–						
	ferritic $s_1 \leq 15$ mm and $l \leq 100$ mm	–	–	–						
Attachment welds (Fillet welds)	ferritic $s_1 \geq 10$ mm or $l > 100$ mm	100	100	25	–					
	austenitic, ferritic $s_1 \leq 10$ mm and $l \leq 100$ mm	–	–	–						
Build-up welds (see **Table 9-6**)		100	100	25 [8]	–			100	100	100
Tube-to-tube-sheet welds of heat exchangers		–			–			100	100	25
Areas of removed welds		–			–			100	100	100
Tests by the authorized inspector S [9]		25	25	25 [6]	100	100	25	25	25	25 [6]

Remarks:

In the case of test extents below 100 % see also Section 9.3.2.

All accessible weld surfaces shall be inspected to 100 % by the manufacturer and to 10 % the authorized inspector. Where the manufacturer performs surface inspection (MT/PT) as per test no. 2.1 with an extent of less than 100 %, all accessible weld surfaces shall be subjected to a visual inspection by the authorized inspector.

1) At the latest prior to commissioning, baseline testing shall be determined and performed in consideration of clauses 9.3.15 and 11.4.2.1 so that in-service test and examinations on the inner surface of welds are possible.

2) If the inner surface is inaccessible, the procedure of cl. 9.3.6.2.2 shall be performed.

3) Including buttering.

4) Including the welded joints between ferritic and austenitic steels, Section 11.5 shall be considered additionally.

5) 25 % in the case of circumferential pipe welds on account of demonstrated experience.

6) 10 % in the case of circumferential pipe welds on account of demonstrated experience.

7) UT or RT may be performed alternatively in the case of wall thicknesses $8 \leq s \leq 20$ (in mm), in which case the radiographed wall thickness shall not exceed 20 mm when subjected to double-wall radiographic testing.

8) For hardsurfaces in the area of valve seatings also in the test group A3 100 % testing.

9) Regarding the tests and examinations performed by the authorized inspector Section 9.3.6.4 applies.

10) In the case of austenitic attachment welds subject to force application (fixed points and partial fixed points) an examination for detecting lack of side wall fusion shall me made in addition to the surface inspection. The test method and the procedural requirements shall be laid down in the test instruction as per cl. 11.2.1.

Table 9-5: Non-destructive tests and inspections conducted on weldings

Test object	Volumetric testing	Testing for bonding	Surface inspection
Shaping build-up welds ferritic	UT	UT	MT (PT [1])
Shaping build-up welds austenitic	RT [2] or UT [2]	UT	PT
Claddings, austenitic or made of nickel alloys	—	UT	PT
Butterings for hard surface overlays	—	UT [3]	PT
Butterings for seam welds, austenitic or made of nickel alloys	RT [4]	UT	PT
Hard surface overlays	—	UT	PT

[1] In the case of limited accessibility or insufficient magnetizability.

[2] The method of testing and the procedural requirements shall be specified in the test instruction to Section 11.2.1.

[3] The test may be performed in conjunction with the test of the hard surface overlay.

[4] The test is effected in conjunction with the test of the seam weld.

Table 9-6: Test methods for testing of build-upwelds

Procedure	Test Performance	Demonstration Limit in mbar × dm^3 × s^{-1}
Leak test with gas [1], pressure method	1. With foaming agents a) pressure: max. 2 bar, recommended 0.5 bar b) time: at least 2 mins after admission of pressure	10^{-3}
	2. Submerging in water a) test pressure: 0.1 × PB, max. 2 bar b) test time: ≥ 2 mins	10^{-3}
Leak test with helium [1]	1. Vacuum method a) spraying of the part (seal) or b) integral measurement	10^{-11}
	2. Pressure method a) direct sniffing leak test on the part (seal) or b) integral measurement	10^{-8}

[1] The leak test for external leakage shall be conducted before the hydrostatic pressure test.

Table 9-7: Demonstration procedures and test performance for leak tests

Test Group	Areas to be tested	Test procedure
A1 or A2/WI	Highly loaded areas [1] (e.g. highly loaded welds, nozzle adjacent areas, transitions to bottom heads)	The test and examination procedures as per Section 11 suitable to detect defects on the inner and outer surfaces shall preferably be used.

[1] If the primary stress exceeds 80 % of the stress permitted in the pressure test, i.e. if P_l or $P_l + P_b \geq 0.8 \times 1.35\ R_{p0.2RT}$.

Table 9-8: Non-destructive tests and inspections after the pressure test conducted on highly loaded areas

10 Requirements for the Manufacture of PG 1 Small Items

(1) PG 1 small items in accordance with **Table 2-1** are understood to be casing parts (e.g. nozzles, covers), flanges, bolts, nuts, isolating elements and closure plugs. The specifications laid down in **Table 2-3** shall apply to the choice of materials. However, seam welds which connect components shall be tested in accordance with Sections 9.2 and 9.3.

(2) The design approval, fabrication supervision, final inspection and documentation shall be effected together with the component.

(3) The confirmation of fabrication supervision and final inspection shall be effected by means of a stamp in the test and inspection sequence plan for the component.

11 Non-destructive tests and examinations

11.1 Layout suitable for testing purposes

11.1.1 General

(1) The design of welded connections which is suitable for testing depends on the test procedure to be employed.

(2) If deviations from the prescribed shapes of weld interfaces are mandatory for urgent reasons, e.g. even if standard items are used, the testability shall be demonstrated within the scope of the design approval.

11.1.2 Ultrasonic testing

11.1.2.1 Ferritic circumferential and longitudinal welds

Note:
***Figures 11-1** and **11-2** show examples of permissible wall thickness transitions.*

(1) For ultrasonic testing, scan paths in accordance with **Table 11-1** shall normally be provided. The inclination of the scanning and opposite surfaces shall not exceed 10 degrees.

(2) Where, in exceptional cases, it is not possible to adhere to the scan paths as per **Table 11-1** reduced scan paths are acceptable upon agreement with the authorized inspector; substitute test measures shall be specified (e.g. additional angles of incidence, performance of radiographic testing).

11.1.2.2 Ferritic nozzle welds

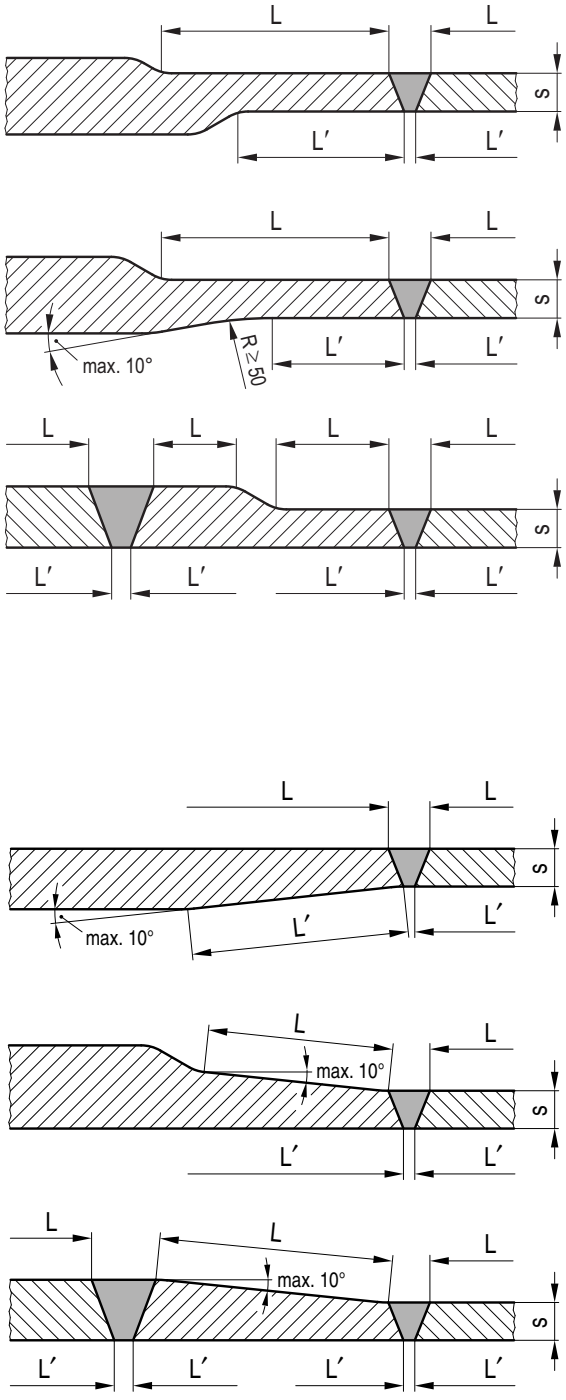
Note:
***Figure 11-3** illustrates examples of permissible wall thickness transitions.*

The required scan paths L and L' are specified in **Table 11-1**. These scan paths shall be provided for the nozzle side in the case of set-on nozzles and for the run pipe or vessel side in the case of set-through nozzles, provided that the nozzle welds are accessible from the inside and that the radii of the nozzle inner edges are equal to or smaller than $0.2 \cdot s$. If this is not the case, the scan paths L and L' shall be adhered to for both the run pipe or vessel side and the nozzle side.

11.1.2.3 Ferritic attachment welds

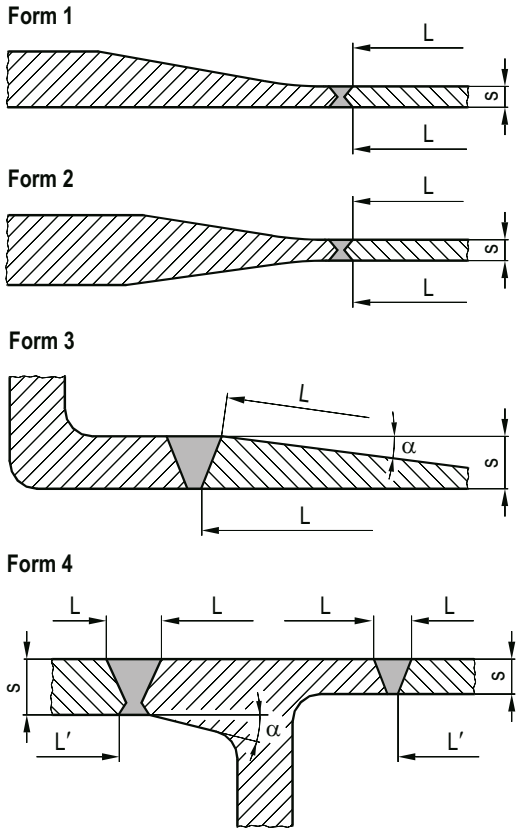
(1) In the case of single and double bevel groove welds, scan paths L and L' in **Figure 11-4** shall be adhered to in accordance with **Table 11-1** for web thicknesses s_1 equal to or greater than 15 mm. If both web surfaces are accessible for the test, scan paths L and L' may be reduced to $2 \cdot s_1 + 30$ mm in the case of web thicknesses s_1 equal to or smaller than 40 mm, or to $2 \cdot s_1 + 50$ mm in the case of web thicknesses which are greater than 40 mm. In Test Group A1, scan paths L_K equal to or greater than 50 mm in accordance with **Figure 11-4** shall be provided additionally on both sides of the web. In the case of web thicknesses s_1 smaller than 15 mm and weld lengths greater than 100 mm in Test Group A1, only these scan paths L_K shall be adhered to.

(2) In the case of fillet welds where s_1 is greater than 10 mm or weld lengths greater than 100 mm scan paths L_K equal to or greater than 50 mm in accordance with **Figure 11-4** shall be provided.



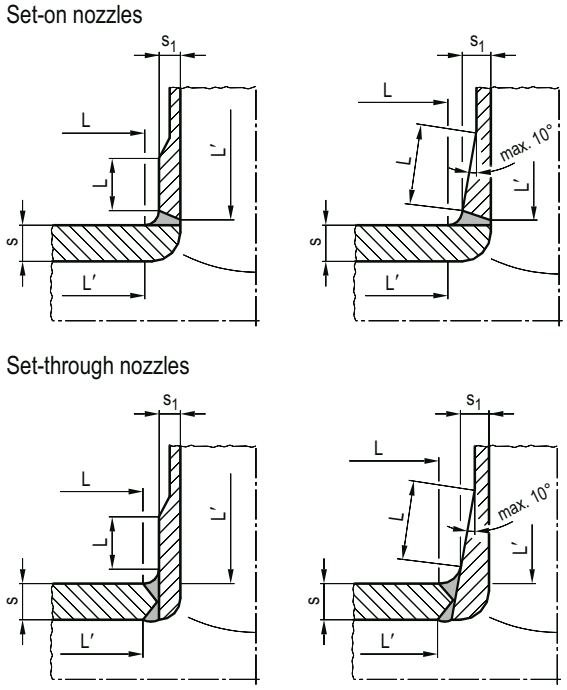
L, L′: Scan paths
R : Radius (if machined)
s : Wall thickness

Figure 11-1: Examples of structural design of wall thickness transitions in consideration of the scan paths required for ultrasonic testing of butt welds ≥ DN 80 and s ≥ 8 mm



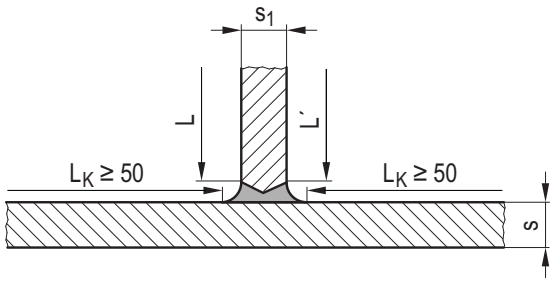
L, L′ : Scan paths
s : Wall thickness
α = max. 10 degrees

Figure 11-2: Examples of structural design of wall thickness transitions in consideration of the scan paths required for ultrasonic testing of flush butt welds ≥ DN 80 and s ≥ 8 mm (restricted scanning from opposite directions)



L, L′: Scan paths
s : Wall thickness of the part
s_1: Nozzle wall thickness

Figure 11-3: Examples of structural design of wall thickness transitions in consideration of the scan paths required for ultrasonic testing of nozzle welds if s or s_1 > 15 mm



L, L′: Scan paths
L_K: Scan path for creeping wave technique
s : Wall thickness of the part
s_1: Wall thickness of the welded attachment

Figure 11-4: Scan paths for ultrasonic testing of ferritic attachment welds (single, double bevel groove or fillet welds)

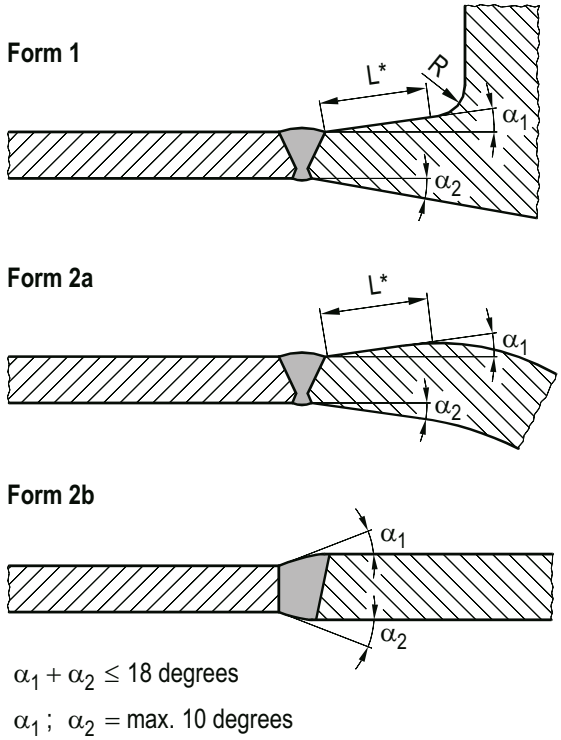
11.1.2.4 Longitudinal, circumferential and nozzle welds on austenitic steels or between ferritic and austenitic steels

(1) In the case of welded joints on austenitic steels or between ferritic and austenitic steels the scan paths as per **Table 11-1** shall basically be adhered to for nominal wall thicknesses equal to or greater than 8 mm. The wall thickness transitions shall be designed to **Figure 11-1**.

(2) Where, in exceptional cases, it is not possible to adhere to the scan paths as per **Table 11-1** reduced scan paths are acceptable upon agreement with the authorized inspector; substitute test measures shall be specified (e.g. additional angles of incidence, performance of radiographic testing).

11.1.3 Radiographic testing

(1) **Figure 11-5** illustrates an example of the conditions to be fulfilled by the layout of circumferential and longitudinal welds which are suitable for testing purposes.



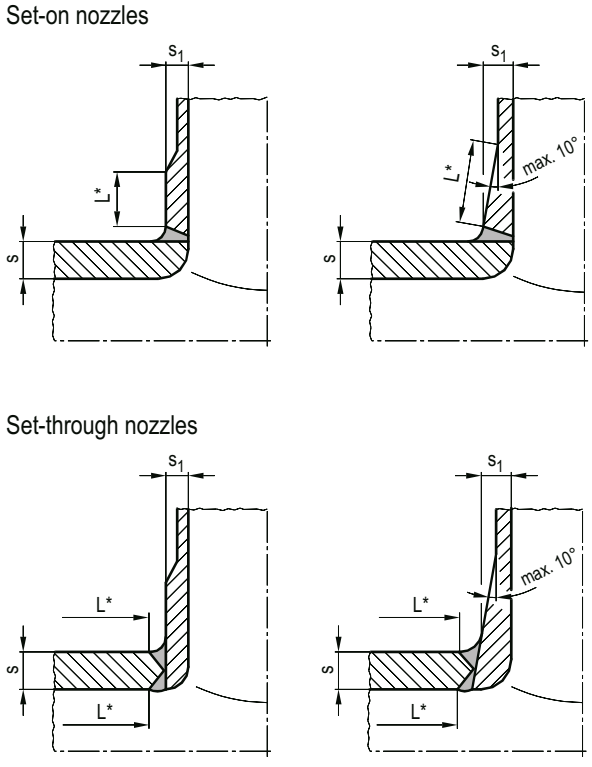
$\alpha_1 + \alpha_2 \leq 18$ degrees

α_1 ; α_2 = max. 10 degrees

Figure 11-5: Examples of a design of circumferential and longitudinal welds which is suitable for radiographic testing

(2) **Figure 11-6** illustrates examples of permissible shapes of nozzle welds.

(3) The paths L* as per **Table 11-2** shall be adhered to.



s : Wall thickness of the part
s_1: Nozzle wall thickness
L* : Scan path for radiographic testing

Figure 11-6: Examples of structural design of wall thickness transitions in consideration of the scan paths required for radiographic testing of nozzle welds if s or $s_1 \leq 15$ mm

11.2 General requirements

11.2.1 Test instructions

(1) Test instructions shall be established by the manufacturers for non-destructive tests and examinations.

(2) These instructions may be established for identical test objects (e.g. welds of same shape and dimensions) in standardized form.

(3) For surface inspection instructions established by the manufacturer and being independent of the project and test object may be used in lieu of test instructions.

(3) The test instructions shall contain detailed information on:

a) Assignment to the individual test objects,

b) time of testing in accordance with the test and inspection sequence plan,

c) test requirements, test methods and test facilities/equipment to be used, type of testing level adjustment,

d) if required, additional explanations regarding the performance of the test (e.g. drawing to scale),

e) intended substitute measures to be taken if the applicability of the requirements of this Section is restricted,

f) reference system and counting direction for a description of indications or irregularities assigned to a test object,

g) recording, evaluating and documentation of indications irregularities.

11.2.2 System of coordinates

For the examination areas, a co-ordinate system shall be fixed being capable of clearly assigning the position of indications and irregularities during the fabrication process and the entire lifetime of the components.

11.2.3 Requirements for surfaces

11.2.3.1 General requirements

(1) The surfaces shall be in a condition appropriate to the purpose of the test.

(2) In addition to the weld requirements as per Section 5.7, the surfaces of the test objects shall meet the requirements given hereinafter.

11.2.3.2 Radiographic testing

For radiographic testing, the weld surfaces shall be such that the evaluation is in no way impaired. If necessary, the surfaces shall be smoothed by grinding.

11.2.3.3 Surface inspection by magnetic particle and penetrant testing

(1) For the surface inspection by magnetic particle and penetrant testing, the surfaces shall be free from scale, weld splatters or any other contaminants. Any grooves or notches affecting the test result shall be eliminated.

(2) The arithmetical mean deviation of the assessed profile (average roughness) Ra to DIN EN ISO 4287 shall not exceed 10 µm on the areas to be examined. Requirements for the surfaces of hard-surfacings outside functional surfaces shall be laid down in each individual case.

11.2.3.4 Ultrasonic testing

(1) The requirements of Section D 3 apply.

(2) In addition to the requirements specified in Section D 3 the following shall apply:

a) Residual notches and deviations from the specified contour due to processing or fabrication are only permitted if the detection sensitivity of ultrasonic testing, including periodic (in-service) inspections, is not impaired.

b) On welds between ferritic and austenitic steels (dissimilar welds) with nominal wall thicknesses equal to or exceeding 8 mm the inner surface including buttering and hard-surfacing (if any) shall be ground flush without any notches.

11.2.3.5 Proof of required surface condition

(1) It shall be proved by a combination of visual inspection and a representative number of quantitative measurements that the component-specific requirements for the surface condition have been met.

(2) For these measurements instructions shall be established to contain the following:

a) requirements,

b) extent of checks and measurements,

c) measuring instruments,

d) documentation.

11.2.4 Requirements for testing techniques

11.2.4.1 Suitability of test procedures and techniques

The suitability of test procedures and techniques the application of which for the respective testing task is not sufficiently

described in standards shall be verified. The type and extent of verification shall be laid down with respect to each component. In the case of materials or complex geometries that are difficult to examine, the suitability of the test procedures shall basically be demonstrated to the methodology of VGB Guideline R 516 (VGB-ENIQ-Guideline) on reference blocks. Where test procedures or techniques are to be applied for which a qualified test technique is available and the applicability of which has been ascertained by the authorized inspector, no further proof of suitability is required.

11.2.4.2 Manual testing

(1) The general specifications laid down in **Annexes D** and **E**

a) Annex D Performance of manual ultrasonic testing,

b) Annex E Performance of surface inspection by magnetic particle and penetrant testing,

as well as the additional specifications resulting from the Sections hereinafter shall apply to ultrasonic testing and surface inspection by magnetic particle and penetrant testing.

(2) The magnetic particle method shall be used when examining the surfaces of sufficiently magnetizable materials, unless specified otherwise in Sections 9.3.6.2 or 11.3.

(3) For radiographic testing the following applies:

The test shall be performed to DIN EN ISO 17636-1 or DIN EN ISO 17636-2 where the requirements of clause 7.2.2 of DIN 25435-7 are to be satisfied if digital radiography is applied. In addition, the following requirements shall be met:

a) The requirements of class B to DIN EN ISO 17636-1 for film radiography or DIN EN ISO 17636-2 for digital radiography shall be met. The substitute solution of Section 5 of DIN EN ISO 17636-1 and of Section 5.1 of DIN EN ISO 17636-2 shall not be applied in this case.

b) The image quality values of image quality class B to DIN EN ISO 19232-3 shall be adhered to in which case the image quality indicators to DIN EN ISO 19232-1 be used.

c) Where clause 9.3.6.2.2 specifies radiographic testing since the inner surface is neither accessible for magnetic particle nor penetrant testing, the perpendicular technique is required for radiographic testing. In this case, the requirements of DIN 25435-7 shall be met.

   Where, in the case of wall thicknesses less than 8 mm, the test results are unclear due to overlapping radiographs of the weld,

   ca) the cover pass shall be ground, or

   cb) the test be performed from both sides of the weld by radiographing the weld at an oblique angle.

   Where radiography is performed at oblique angles, the angle shall be as little as possible and be directed such that overlapping of two welded joints is avoided.

d) In the case of wall thicknesses less than 8 mm the volumetric radiographic test is covered by the test performed as to c).

11.2.4.3 Mechanized testing

(1) Mechanized testing is required

a) if an evaluation is not possible without extensive recordings and representation of measured data (e.g. in the case of spurious echoes on austenitic welds, flaws due to external contour in the case of root notches, complex geometries of nozzle welds),

b) if extreme radiation exposure is to be expected in the areas to be tested, and

c) for testing welds between austenitic steels or welds between ferritic and austenitic steels (dissimilar welds).

(2) Where ultrasonic testing requirements are applied to automated and mechanized non-destructive testing and where other testing techniques are applied, test instructions shall be established on the basis of an evaluation of the test systems in due consideration of DIN 25435-1 to ensure that the requirements described hereafter are met or be satisfied to an equivalent extent. The test instructions shall be submitted to the authorized inspector along with the design approval documents.

11.2.5 Extent and times of the tests

The extent and times of the tests are specified in Sections 6 and 9.

11.2.6 Evaluation of the test results

(1) For the evaluation of the test results obtained by the various test methods the criteria as per Sections 11.3 to 11.8 apply.

(2) The evaluation of the test results shall normally always take into consideration the measuring tolerances of the test procedure as well as the properties of the tested material or material area.

(3) If several test procedures are employed in order to detect internal or external irregularities, the final evaluation of the test object shall be effected on the basis of the test results of all test procedures.

(4) If the evalution criteria specified in Sections 11.3 to 11.8 are not adhered to, it may be demonstrated by further examinations (e.g. by using methods for a more exact determination of reflector size) that the use of the component is permitted (see also Section 13 and **Annex B**). Here a decision shall be made in accordance with Section 13 on whether to repair the defect or leave it as it is. This decision may also consider an analysis concerning the loading resistance of the component.

(5) However, it shall be ensured that safety-relevant defects as well as systematic irregularities characterized by repeated occurrence and large extension are covered by this evaluation. Where such defects or systematic irregularities are detected this shall be the cause for rejection of the test object.

11.3 Welded connections on ferritic steels

11.3.1 Testing prior to welding

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) For the surface inspection on fusion faces the magnetic particle method shall normally be used if the geometry permits. On product forms with a wall thickness less than 20 mm the penetrant method may be used instead of the magnetic particle method.

(3) Tests performed by the penetrant method shall be evaluated in accordance with **Table 11-3** and tests performed by the magnetic particle method shall be evaluated in accordance with **Table 11-4**. In both cases the criteria given hereinafter shall be taken into account.

11.3.2 Additional evaluation criteria for fusion faces

(1) When evaluating the results obtained from the surface inspection on fusion faces, possible effects by defects, if any, on the weld quality shall be taken into account in dependence of the product form and welding procedure.

(2) The results obtained from ultrasonic testing of the weld areas to be performed in accordance with KTA 3211.1 shall be covered by the evaluation.

11.3.3 Surface inspection upon welding

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) The requirements of **Table 11-5** are considered acceptance standards for magnetic particle and penetrant testing.

11.3.4 Ultrasonic testing upon welding

11.3.4.1 General

(1) The extent and times of the tests are specified in Section 9.3.6. All welds with a nominal wall thickness equal to or greater than 8 mm shall be subjected to ultrasonic testing for longitudinal and transverse defects.

(2) The ultrasonic test shall cover the entire weld metal. In addition, in the case of wall thicknesses or connecting cross-sections up to 30 mm, an adjacent base metal width of at least 10 mm, and in the case of greater wall thicknesses or connecting cross-sections, a base metal width of at least 20 mm shall be examined on both sides of the welded joint.

(3) In the case of differing nominal wall thicknesses on butt welds the greater nominal wall thickness shall govern the determination of the number of beam angles and the smaller nominal wall thickness shall govern the determination of the recording level.

(4) In the case of set-on nozzles, the wall thickness s_1 of the nozzle in accordance with **Figure 11-3** shall govern the number of beam angles and the recording level.

(5) In the case of set-through nozzles, the wall thickness s of the part in accordance with **Figure 11-3** shall govern the number of beam angles and the recording level.

(6) In the case of welds of permanent welded attachments, the wall thickness s_1 of the welded attachment in accordance with **Figure 11-4** shall govern the choice of the beam angles and the specification of the recording level, provided testing is effected from the welded attachment.

(7) If the connection welds of welded attachments are tested through the pressure-retaining wall, the wall thickness s of the pressure-retaining wall in accordance with **Figure 11-4** shall constitute the criterion for the recording level and evaluation.

11.3.4.2 Procedural requirements

11.3.4.2.1 Scanning surfaces

The scanning surfaces for the test for longitudinal defects shall be wide enough to ensure that the areas to be evaluated are covered for all scanning directions and beam angles. This is generally the case if the scan paths specified in **Figures. 11-1** to **11-4** and **Table 11-1** are adhered to. If these requirements are met, the conditions as regards testing for transverse defects are also covered.

11.3.4.2.2 Test frequencies and transducer dimensions

(1) Basically probes with such transducer dimensions and nominal frequencies of 2 MH to 6 MHz shall be used as to ensure the required testing level in the area to be examined. When selecting the probes care shall be taken to ensure that interference zones close to the probe are minimised.

(2) In the case of a wall thickness s equal to or less than 40 mm a nominal frequency of 4 MHz shall normally be used. In the case of a wall thickness exceeding 40 mm a nominal frequency of 2 MHz may be applied.

(3) Where an austenitic weld cladding is provided, the test may be performed in accordance with clause 11.3.4.3 or 11.3.4.4 if the testing level required by clause 11.3.4.5 can be adhered to, e.g. by the use of probes with adapted test frequencies or transducer dimensions.

11.3.4.2.3 Adjustment of the testing level

(1) The testing systems shall be adjusted in accordance with Section D 6.

(2) The testing level adjustment may be effected in accordance with the DGS method as well as using the reference block method or DAC method.

(3) In addition to the stipulations of **Annex D** the following applies:

a) The wall thickness of the reference block as per **Figure D-2** may deviate from the test object wall thickness by a maximum of 10 %.
b) Where notches and side-drilled holes are used simultaneously as reference reflectors according to **Figure D-2**, the lesser reference reflector amplitude applies to the entire wall thickness. If the respective surface is subjected to a surface inspection by magnetic particle or penetrant testing, the notch as reference reflector may be omitted.

(4) In the case of reflectors in layers near the surface, the testing level adjusted in accordance with the DGS method may be corrected using reference reflectors near the surface in accordance with **Figure D-2**.

11.3.4.2.4 Determination of the indication length

(1) Where the echo amplitudes reach or exceed the respective recording levels specified, the lengths of the pertinent reflectors shall be measured in accordance with clause D 11.2.2. The displacement is limited by the amplitude of the indication falling

a) below the recording level in the case of nominal wall thicknesses equal to or less than 10 mm,
b) 6 dB below the recording level in the case of nominal wall thicknesses greater than 10 mm to $\leq$ 40 mm,
c) 12 dB below the recording level in the case of nominal wall thicknesses exceeding 40 mm.

(2) If the recording level is lowered, the size of reflectors whose maximum echo aplitude is smaller than the original recording level, shall be determined in accordance with clause D 11.2.3 (half-amplitude method).

(3) If the echo amplitudes exceed the original recording level, the size of the reflector shall be determined as per (1). The original recording level shall be decisive with regard to measuring.

(4) Where a more exact determination of the size of reflectors is required, the specifications of clause D 11.2.4 shall be satisfied.

(5) Reflectors with an indication length less than 10 mm are to be recorded as point-type indications.

11.3.4.3 Testing of butt welds

11.3.4.3.1 Beam angles

(1) **Table 11-6** contains recommendations for the choice of beam angles. In the case of welds in accordance with **Figure 11-2** Form 4, the test may also be effected from the tubesheet side (see **Table 11-7** item No. 1.6) using beam angles smaller than those recommended in **Table 11-6**, if, for geometric reasons, it is impossible to use the beam angle in accordance with **Table 11-6**. For the test of transverse defects, the beam angle shall normally be selected such that the orientation of

the main beam is as perpendicular as possible to defects which are perpendicular to the surface.

(2) Care shall be taken to ensure that the incident angle on the opposite surface does not exceed 70 degrees. In the case of wall thicknesses greater than 40 mm, the incident angle on the opposite surface shall normally be between 35 degrees and 55 degrees for the smaller beam angle. The orientation of the greater beam angle shall normally be as perpendicular as possible to defects which are perpendicular to the surface. These specifications shall also apply to testing of curved parts and wall thickness transitions.

(3) In the case of welds with bevel angles smaller than 5 degrees and wall thicknesses greater than 40 mm, additional tests shall be performed to detect defects which are perpendicular to the surface. If these defects cannot be detected using the beam angles in accordance with **Table 11-6**, other suitable beam angles shall be selected or lower test frequencies or other test techniques (e.g. LLT technique in accordance with Section D 9) shall be provided. These additional tests may be waived if the geometry makes it possible to detect defects perpendicular to the surface using incident angles below 10 degrees.

11.3.4.3.2 Scanning surfaces and positions for angle beam scanning

Table 11-7 contains the necessary test conditions.

11.3.4.4 Testing of nozzle welds and attachment welds

Table 11-8 contains the necessary test conditions for ultrasonic testing of the nozzle welds, **Tables 11-9** to **11-11** for those of the attachment welds. The specifications laid down in clauses 11.3.4.3.1 (1) and (2) shall apply by analogy.

11.3.4.5 Recording levels

(1) All indications reaching or exceeding the recording level shall be recorded.

(2) Indications due to geometric discontinuities which have been demonstrated as such in accordance with Section D 11.3 - shall also be recorded in the test reports with indication of location, position and size.

(3) In dependence of the method used to calibrate the sensitivity the following recording levels apply:

a) For the adjustment of the testing level to the DGS method for disc shaped reflectors the echo amplitudes of the disc shaped reflectors given in **Table 11-12** in dependence of the nominal wall thickness shall be considered as the recording level.

b) Where during straight beam scanning of double-bevel groove welds (sound entry position 4 in **Table 11-9** UT-no. 3.2) sound path travel distances exceeding 300 mm occur, a recording level shall be fixed to correspond to an echo amplitude of a side-drilled hole with 3 mm diameter plus a sensitivity allowance of 6 dB.

c) For the adjustment of the testing level to the reference block method or DAC method according to clause 11.3.4.2 the reference reflectors specified in **Figure D-2** shall be used for adjusting the testing level. The recording level corresponds to the echo height of the reference reflector plus a sensitivity allowance of 6 dB.

(4) It shall be ensured that the testing level given by the recording level is maintained in the entire volume of material to be tested. This may be achieved, if required, by additional sound entry positions, beam angles, test frequencies or methods (e.g. use of dual-element probe technique).

(5) The testing level shall be selected such that during the test for longitudinal defects reflector indications with echo amplitudes of 6 dB and during the test for transverse defects reflector indications with echo amplitudes of 12 dB below the recording level as per (3) can be detected.

(6) When testing for longitudinal defects, indications below the recording level, but not more than 6 dB below this level, shall be recorded with their half-amplitude length as per clause D 11.2.3 as follows:

a) in the total testing area if their length exceeds twice the acceptable length of individual reflectors as specified in **Table 11-13**,

or

b) in the area under consideration of at least one meter of weld length if indications are found the echo heights of which reach or exceed the recording level and the lengths of which exceed the acceptance criteria of **Table 11-13**.

(7) If during the test for transverse defects several indications of reflectors (indication clusters) appear which are indistinguishable from each other when moving the search unit, or if only one of several indications reaches the recording level, indications up to 12 dB below the recording level shall be recorded as per subpara (3).

(8) If the signal-to-noise ratio is less than 6 dB, this shall be specified in the test report, and any further action to be taken shall be fixed jointly with the authorized inspector.

(9) When testing with creeping wave probes, the recording level corresponds to the echo height of a flat-bottom hole or the DAC curve of the flat-bottom holes as per **Figure D-10** in consideration of the transfer losses determined. All indications reaching or exceeding the recording level shall be recorded. The indication length is obtained from the probe displacement to a decrease of the echo amplitude of 6 dB below the recording level.

11.3.4.6 Acceptance standards

11.3.4.6.1 General requirements

(1) On accessible locations surface imperfections causing indications shall be removed by machining.

(2) Indications from inaccessible root areas are only permissible if they are caused by excess penetration and if they can be ascertained as indications due to external contour as per Section D 11.3.

(3) Where radiographs cover the area with ultrasonic indications such that an evaluation is possible they shall be included in the evaluation.

(4) If indications are detected in claddings during angle beam scanning of clad test objects from the base metal side they shall not be included in the evaluation if they are proved to be due to structural discontinuities. This demonstration shall be made on a reference block.

(5) Where recordable indications are detected in the test using LLT technique to Section D 9 or in the test with creeping wave probes, they shall be thoroughly examined in accordance with clause 11.3.4.6.5.

11.3.4.6.2 Indications detected in testing for longitudinal defects

(1) When using the single probe technique, the evaluation of indications depends on their echo height, length, distance and frequency. Here, the frequency is determined as accumulated length (sum of indication lengths) per reference length. Where accumulated indications are found on large weld lengths (exceeding the reference length as per **Table 11-13**),

these accumulated indications are considered systematic weld defects and are inacceptable.

(2) The acceptance limits for indication lengths of individual reflectors and the allowable accumulated length of reflectors referred to a reference length are shown in **Table 11-13** in dependence of the wall thickness. The requirements of clauses (3) to (8) shall be met.

(3) Indications of point-type reflectors are permitted in the volume, i.e. outside the subsurface area to clause (4) up to an echo height not exceeding the recording level as per Section 11.3.4.5 by more than 12 dB. Where the echo height exceeds the recording level by 6 dB or more, the number of such reflectors shall be limited to one per metre of weld length. To verify such indications, a control check (e.g. by radiographic testing) shall be made.

(4) In subsurface areas (areas of 5 mm below the final surface) only point-type reflector indications the echo height of which does not exceed the recording level by more than 6 dB, are permitted as single indication (one reflector per reference length as per **Table 11-13** where in the case of nominal wall thickness exceeding 60 mm the reference length is to be limited to 360 mm).

(5) The location of reflectors to each other, their position and orientation in the weld as well as their reflectivity from differing scanning directions shall be considered in the evaluation as follows:

The combination is based on the length of and distance between two admissible indications the echo heights of which exceed the recording level. The length of one group of indications shall not be used for further combinations. For evaluation purposes one group of indications shall be considered a single indication, if:

a) the distance d_x is less than twice the length of the longest indication (see **Figure 11-7**),

b) the distance d_y is less than half the wall thickness, but nor greater than 10 mm,

c) the distance d_z is less than half the wall thickness, but nor greater than 10 mm.

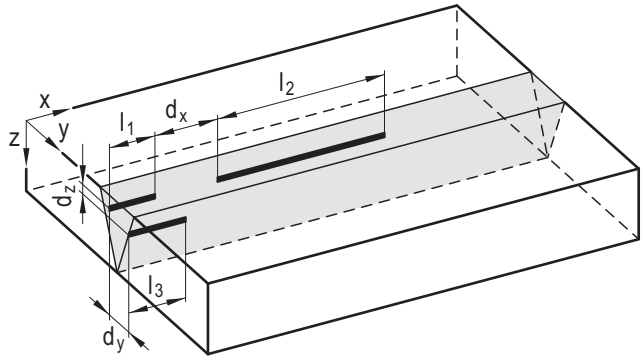


Figure 11-7: Geometric arrangement of accumulated indications during testing for longitudinal defects

(6) Indications recorded as per clause 11.3.4.5 (6), the echo height of which is less than the recording level, shall be covered by the evaluation.

(7) Indications are permitted up to an echo height not exceeding the recording level as per Section 11.3.4.5 by more than 6 dB. Where indications are found the echo height of which exceeds the recording level as per Section 11.3.4.5 by more than 6 dB,

a) their reflectivity shall be examined in dependence of all prescribed scanning directions,

b) a manual double probe technique for the purpose of LLT technique in accordance with Section D 9 shall be performed.

The echo heights determined shall be compared to the echo heights determined before and be included in the evaluation. The reflectors may be left as they are if no planar reflectors are suspected and the aforementioned conditions regarding length, frequency and distances are satisfied.

(8) When determining the accumulated length of reflectors, indications of point-type reflectors with an echo height below the recording level shall not be taken into account. Indications of point-type reflectors the echo height of which does not exceed the recording level by more than 6 dB shall be considered in the determination of the accumulated length with an indication length of 10 mm.

11.3.4.6.3 Indications detected in the test for transverse defects

(1) The evaluation of indications detected during the test for transverse defects which are clearly assignable to a reflector detected when testing for longitudinal defect, shall satisfy the evaluation criteria for longitudinal defects. The following acceptance standards shall only apply to indications, for which it cannot be unambiguously demonstrated that they originate from a reflector in the test for longitudinal defects. The evaluation shall be based on the indication amplitude and frequency.

(2) Recordable indications of reflectors as per Section 11.3.4.5 are only permitted without further check as per clause 11.3.4.6.5 if they are isolated (not more than 3 per metre of weld) and point-type reflectors and if they are not accompanied by frequent indications up to 12 dB below the recording level.

(3) If in the test for transverse defects several indications indistinguishable from each other in the event of probe movement appear on the screen (indication clusters), all indications up to 12 dB below the recording level as per Section 11.3.4.5 are permitted if it can be demonstrated that they are no cracks. This may be demonstrated by means of random tests.

11.3.4.6.4 Indications detected by tests using the creeping wave technique

Recordable indications are permitted if it can be demonstrated that they are no cracks.

11.3.4.6.5 Measures to be taken if limit values are exceeded

(1) Where the limit values set by the above-mentioned acceptance criteria are exceeded, test results obtained by testing in accordance with the aforementioned requirements may be determined more exactly by additional examinations, and may be additionally used for the evaluation. Additional examinations can be, e.g.:

a) the determination of the reflector locations in the welded joint (weld metal, heat affected zone, base metal, root area) and the possible causes for indication that can be derived herefrom,

b) the use of other ultrasonic techniques, e.g. the use of focussing probes for a more exact determination of the size of the reflectors,

c) the performance of selective radiographic testing.

(2) In the case of reflectors located in the subsurface area, the testing level set by means of the DGS method may be corrected by using subsurface reference reflectors as per **Figure D-2**.

11.3.5 Radiographic testing upon welding

11.3.5.1 General

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) Where ultrasonic testing is used for examining the inner surfaces of butt welds, the requirements of cl. 11.2.4.2 (3) c) shall be met.

11.3.5.2 Performance of testing

(1) The specifications laid down in Section 11.2.4 apply.

(2) The adjacent base metal areas on both sides of the weld shall be radiographed on a width equal to or graeter than 10 mm.

(3) In the case of circumferential welds a central radiograph shall be made provided the welds are accessible and the requirements of (1) and (2) are met.

(4) In the test X-ray tubes shall be used unless an at least equivalent evaluation is possible by the use of other radiation sources. Film/screen combinations with an as high as possible resolution and preferably vacuum cassettes shall be used.

11.3.5.3 Acceptance standards

(1) The requirements of acceptance limit 1 to DIN EN ISO 10675-1 apply and are supplemented by the following stipulations.

(2) If the acceptability of a defect detected by radiographic testing is not clear, a decision on whether the defect is acceptable or not shall be taken on the basis of a verification test (e.g. optimized radiographic testing or ultrasonic testing).

(3) In the case of undressed roots of single-side welds, linear irregularities at the root-to-base metal transition are only permitted if the are subject to flat contractions and a clear statement as to evaluation is possible when performing periodic non-destructive tests and examinations.

(4) Where the distance between adjacent inclusions, wormholes or gas pores in weld direction is less than twice the length of the longer inclusion, wormhole or gas pore, both inclusions shall be considered to form one irregularity. The length of this irregularity is the sum of the individual lengths plus the distance between the inclusions, wormholes or gas pores.

(5) Where several inclusions, pores (porosity), gas pores or wormholes lying one after the other or adjacent to each other occur on weld lengths exceeding six times the nominal wall thickness s, they are considered systematic defects and are not permitted.

(6) The allowable individual and cumulated lengths of solid inclusions shall be taken from **Table 11-14**.

(7) For wormholes and gas pores the following applies:

a) wormholes and gas pores are not permitted in single-layer welds or in the case of a wall thickness less than 10 mm.

b) Apart from that the requirements are the same as for solid inclusions as per (6).

(8) Local accumulations of pores (porosity, clustered porosity, linear porosity) are only permitted as isolated accumulations, i.e. not more than three accumulations per metre of weld length.

11.4 Welded joints on austenitic steels

11.4.1 Tests and examinations prior to welding

The requirements of Sections 11.3.1 and 11.3.2 apply in which case the surface inspection shall be made to the penetrant method.

11.4.2 Tests and examinations after welding

11.4.2.1 Surface inspection

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) The specifications laid down in **Table 11-15** shall constitute the acceptance standards for penetrant testing.

11.4.2.2 Radiographic testing

The requirements of Section 11.3.5 apply to radiographic testing.

11.4.2.3 Ultrasonic testing of the of the inner surface after welding

11.4.2.3.1 General requirements

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) Welds with a nominal wall thickness equal to or exceeding 8 mm shall be subject to ultrasonic testing for longitudinal defects. The test shall be performed as mechanized test from two opposite directions on both sides of single-side welds.

(3) By this test the weld root and the adjacent base metal (weld-adjacent area) shall be covered. The width of the weld-adjacent area to be covered shall be 10 mm in the case of wall thicknesses less than or equal to 30 mm and 20 mm in the case of greater wall thicknesses.

(4) The procedural requirements for the test of nozzle welds shall be laid down in the test instruction.

11.4.2.3.2 Procedural requirements

11.4.2.3.2.1 Testing technique

(1) The testing technique to be used shall be determined on a similar reference block (e.g. from a production control test piece), i.e. the reference block must correspond to the test object as regards the test-relevant characteristics (material, weld design, shape, wall thickness, heat treatment).

(2) For the detection of planar discontinuities, a test technique or a combination of several test techniques shall be applied with which the testing level as per clause 11.4.2.3.2.2 is attained. When selecting a technique, the acoustic properties (absorption, scatter, refraction, diffraction) shall be considered. Where the geometry and acoustic properties of the test object permit, test techniques shall be preferred which admit an echo height evaluation as per clause 11.4.2.3.2.2 b).

(3) Depending on the task and test object, the following test techniques are e.g. possible:

a) vertically polarized transverse waves with an angle of incidence of the sound beam ranging from 35 to 55 degrees (corner effect),

b) vertically polarized transverse waves with an angle of incidence of the sound beam ranging from 65 to 70 degrees,

c) longitudinal waves,

d) wave conversion techniques as per **Annex D**, Sections D 7 and D 8.

Note:

The test techniques a) and b) generally permit an echo height evaluation on homogenous materials.

(4) Where due to the geometry of the test object or the structual properties (e.g. in case of clad surfaces, austenitic weld metal, dissimilar welds) no sufficient proof of the suitability can be obtained using the test techniques mentioned above, an optimized test technique or a combination of test techniques shall be used upon respective proof of suitability. Optimized test techniques are e.g.:

a) test frequencies less than or equal to 2 MHz,

b) probes with highly attenuated crystals,

c) dual-element probe techniques with overlap in half skip range,

d) horizontally polarized transverse waves.

11.4.2.3.2.2 Proof of suitability of the test technique and adjustment of the testing level

In addition to the requirements of **Annex D** the following applies:

a) A similar reference block with notches shall be used. The notches shall be located in the base metal at the transition from the base metal to weld metal as shown in **Figure 11-8**. The exact number, locations and dimensions of the notches to be provided on the reference block shall be fixed within the design approval procedure.

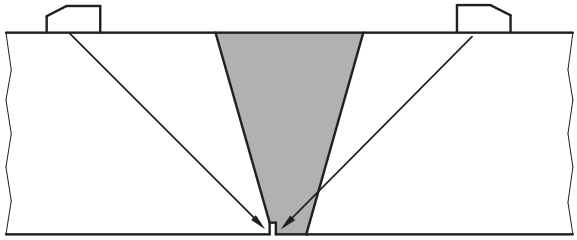


Figure 11-8 Location of notches and beam angles for testing of welded joints on austenitic steels

b) For the proof of suitability of the test technique at least three rectangular notches with varying depths shall be scanned from both sides of the weld as well as the edge of the reference block shall be scanned and the respective echo heights be determined. Here, one notch shall have a greater depth and one notch a lower depth than the notch used for adjusting the testing level as per **Table 11-17**.

Where, for geometric reasons, the edge of the reference block is not available with regard to the area to be tested, another notch may be used as a substitute which is deeper than the deepest of the aforementioned three notches. In each individual case, the notch depth referred to the test technique applied shall be fixed such that its reflection behaviour corresponds to that of an edge or a through-wall notch.

Acoustical differences when scanning from both sides of the weld shall be recorded.

The test technique is suited if

ba) the echo heights increase with the notch depth (**Table 11-18**, case 1),

bb) the echo height of the notch to be selected as per **Table 11-17** exceeds the noise level by 12 dB or more in the case of sound beam angles as shown in **Figure 11-8**,

bc) the edge simulating a through-wall crack or the echo height of the additional sufficently deep notch exceeds the echo height of the notch to be selected as per **Table 11-17** by at least 6 dB in the case of sound beam angles as shown in **Figure 11-8**.

Where, even upon optimization of the test technique, the criteria to ba) to bc) cannot be satisfied, the procedure as per d) shall be followed.

c) Testing level adjustment shall be made to the reference block method in due consideration of the recording level to be adjusted. For the testing area „area adjacent to the weld“ the reference reflector shall be scanned directly. For the testing area “weld root“ the reference reflector shall be scanned through the weld metal. The acoustical differences arising during scanning from both sides of the weld shall be taken into account. Differing acoustical properties between reference block and test object shall be considered by transfer measurements (V-transmission) in the base metal (area adjacent to weld). The measurements shall be made on 6 measuring points distributed over the circumference on each side of the weld. Where components have been fabricated from product forms which where tested to KTA 3211.1, local variations of sound attenuations which were determinated within the testing suitability determination as per KTA 3211.1 on a circumferential notch, shall be taken into account for the weld edge areas of such product forms.

d) Where the criteria of b) in parts of the testing area (e.g. in the case of dissimilar welds with buttering where the test is made for longitudinal defects at the buttering to weld metal transition) cannot be satisfied, the following procedure applies (see **Table 11-18** case 2):

On the basis of the results obtained from reference block measurements, the reference notch for testing level adjustment shall be selected to be a notch with an echo height of at least 6 dB above the noise level including a transfer correction, if any. If the suitability of detecting defects cannot be determined with the available notches, further depth-graduated notches or realistic reference flaws (cracks) shall be produced in the reference block. All notches having a greater depth than the reference notch shall show an echo height of at least 6 dB above the noise level including a transfer correction, if any.

A differentiation shall be given between the signal pattern of the reference notch and the noise signals as well as a clear distinction between the reference notch pattern and the edge pattern simulating a through-wall crack. The evaluation criteria for comparing the signal pattern shall be fixed in the test instruction on the basis of reference block measurements (e.g. display dynamics, correlation of indication patterns at varying beam angles and wave modes, crack-tip signal detection).

11.4.2.3.3 Determination of the indication length

Where the echo amplitudes reach or exceed the respective recording levels, the lengths of the pertinent reflectors shall be measured in accordance with clause D 11.2.3 (half-amplitude method).

11.4.2.3.4 Recording levels

(1) Where the test techniques to clause 11.4.2.3.2.2 b) are applied, the echo height of the reference reflector in dependence of the nominal wall thickness as per **Table 11-17** plus a sensitivity allowance of 6 dB shall be used as recording level. All echo indications shall be recorded where they reach or exceed the recording level.

(2) Where the test techniques to clause 11.4.2.3.2.2 d) are applied, all indications showing characteristic features of the indicated patterns determined on the reference reflectors shall be recorded and be evaluated.

(3) Indications due to geometric discontinuities which are obtained from root areas - when verified as such - shall be recorded in the test reports with indication of location, position and size.

11.4.2.3.5 Acceptance standards

(1) On accessible locations surface imperfections causing indications shall be removed by machining.

(2) Indications from inaccessible root areas are only permissible if they are caused by excess penetration and if they can be ascertained as indications due to external contour.

(3) Where radiographs cover the area with ultrasonic indications such that an evaluation is possible they shall be included in the evaluation.

(4) Where the test techniques to clause 11.4.2.3.2.2 b) are applied, those indications are permitted which, according to their number, echo height exceeding the recording level, and indication length, are within the limits shown in **Table 11-19**, and after verification, e.g. by means of the wave conversion method I, do not lead to indications suggesting planar flaws.

(5) Where the test techniques to clause 11.4.2.3.2.2 d) are applied, the acceptance level is considered to have been exceeded if indications show characteristic features of the indication patterns obtained on the reference reflectors.

(6) The distance between adjacent indications shall be at least 20 mm.

11.5 Welded joints between ferritic steels and austenitic steels

11.5.1 Tests and examinations prior to welding

The requirements of clauses 11.3.1, 11.3.2 and 11.4.1 apply.

11.5.2 Ultrasonic testing for bonding upon buttering

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) For adjusting the testing level, the indication of a side-drilled hole of 3 mm diameter being parallel to the scanning surface in the base metal at the interface to the buttering shall be used as reference echo. The reference block shall correspond to the test object as regards the test-relevant characteristics (material, weld design, shape, wall thickness, heat treatment).

(3) The size of reflectors shall be determined in accordance with Section D 11.2.3 (half-amplitude method). Reflectors from the buttering to base metal transition reaching or exceeding the echo height of the reference reflector plus a sensitivity allowance of 6 dB shall be recorded indicating the echo height. Where the distance of the recording level to the noise level is less than 6 dB, this shall be entered in the test report, and further steps shall be fixed jointly with the authorized inspector.

(4) The evaluation of reflectors shall be based on the lengths and frequency of indications unless their echo amplitudes exceed the recording level by more than 6 dB. **Table 11-13** contains acceptance criteria for the indication length of individual reflectors and frequencies as accumulated length (sum of indication lengths) per reference length. Reflectors which in depth orientation (in wall thickness direction, perpendicular to the scanning direction) are not more than 2.5 mm away from each other shall have a distance of at least one times the length of the longer indication in the direction of weld progression. Otherwise, the reflectors are considered to be interconnected. Where more than two reflectors are located closely one after the other, every two of them shall be compared and meet the above requirements.

11.5.3 Surface inspection upon buttering

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) The surface inspection shall be made to the penetrant method.

(3) The stipulations of **Table 11-15** apply to the acceptance standards.

11.5.4 Tests and examinations after welding

11.5.4.1 Examination of welds including buttering

(1) The requirements of clauses 11.4.2.1, 11.4.2.2 and 11.4.2.3 apply.

Note:

Additional requirements for baseline non-destructive tests are laid down in clause 9.3.15.

(2) Deviating from clause 11.4.2.3 the following applies:

For the purpose of proving the suitability of the test technique and the testing level adjustment of testing for longitudinal defects, the notches shall be milled into the reference block to clause 11.4.2.3.2.2 in direction of welding progress and be located in the weld metal/base metal transition, in the weld metal/buttering transition and in the buttering/base metal transition as per **Figure 11-9**.

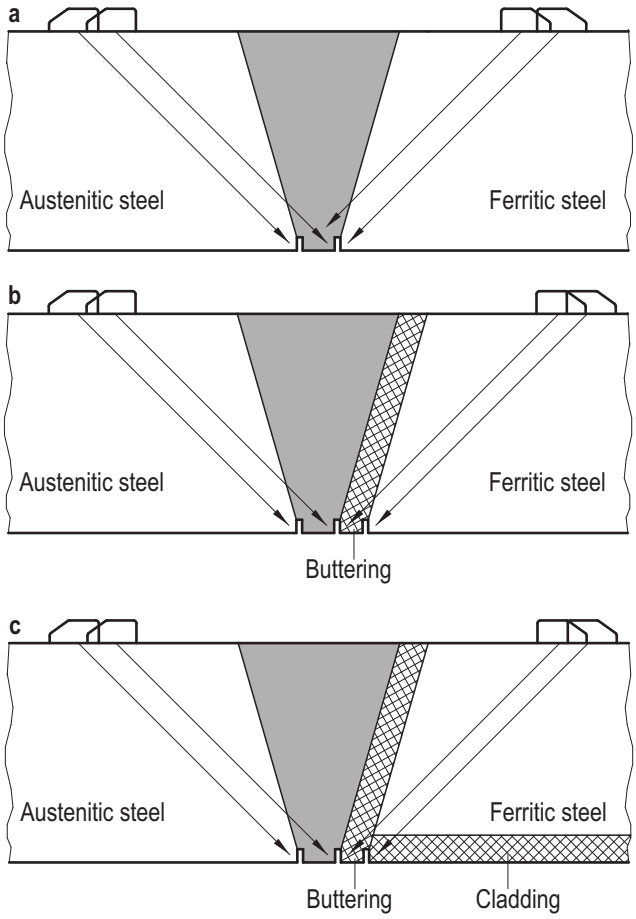


Figure 11-9: Location of notches and beam angles for testing for longitudinal defects of welded joints between ferritic and austenitic steels

As to the testing level adjustment the following applies:

a) For the testing area “adjacent to the weld” the reference reflectors shall be scanned directly.
b) For the testing area “weld root” in the case of unbuttered welds the reference reflectors shall be scanned through the weld metal.

c) For the testing area “weld root including buttering” the reference reflector in the weld metal/buttering transition shall be scanned from both the austenitic and ferritic base metal areas.

11.5.4.2 Testing for bonding at the interface to the ferritic base metal

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) Ultrasonic testing shall normally be performed from the ferritic side of the weld. The test techniques and angles of incidence shall be selected such that defects oriented in parallel to the interface of the ferritic base metal are covered. The size of the reflectors shall be determined as per Section D 11.2.3 (half-amplitude technique).

a) For testing of the subsurface areas to a depth of 10 mm the following techniques may be used

aa) the longitudinal wave dual-element probe technique or creeping wave technique for the interface below the scanning surface,

ab) the transverse wave single probe technique for the interface ahead of the opposite surface.

The testing level shall be adjusted on a reference block welded with similar metal, in the case of clad welds on a clad reference block in due consideration of the requirements of clauses 11.4.2.3.2.2 as well as 11.5.4.1 (2) b). In addition a further notch shall be provided on the cover pass side at the transition from buttering to ferritic base metal in parallel to the direction of weld progression as shown in **Figure 11-10a**. Where welds are not buttered, this notch shall be provided at the transition from weld metal to ferritic base metal. The notches at the buttering/base metal transition and at the weld metal/ferritic base metal transition shall be scanned from the ferritic base metal side. The depth of the notch shall be specified in dependence of the nominal wall thickness as per **Table 11-17**. In the case of clad ferritic base metal the flat-bottom hole to **Figure 11-10b** located directly above the cladding may be used alternatively for adjustment of the testing level.

For the determination of the recording level clause 11.4.2.3.4 applies, the evaluation shall be made to clause 11.4.2.3.5.

b) For testing of non-subsurface areas the following techniques may be used:

ba) the wave conversion technique (LLT technique in accordance with Section D 9),

bb) the single probe technique.

The testing level shall be adjusted on a reference block welded with similar metal, in the case of clad welds on a clad reference block, with 6 mm flat-bottom holes as shown in **Figure 11-10**. The number and distances (Δt) of the flat-bottom holes shall be specified such that the testing level can be determined over the entire range to be tested. The reference reflectors (flat-bottom) shall be oriented in parallel to the interface and be provided at the transition from buttering to base metal. In the case of welds without buttering the reference reflectors shall be provided at the weld metal/ferritic base metal transition. The reference reflectors at the buttering/base metal transition or at the weld metal/ferritic base metal transition shall be scanned from the ferritic base metal side.

Table 11-12 applies to the determination of the recording level, the evaluation shall be made to clause 11.5.2 (4).

Where beam angles are used to hit the interface vertically, the requirements of para. (2), (3) and (4) of clause 11.5.2 apply.

(3) In radiographic testing the incident beam shall be directed towards the interface. The direction of beam incidence shall not deviate from the interface by more than 5 degrees. Basically, single-wall radiographic testing shall be performed. Where single-wall radiographic testing is not practicable, further procedural steps shall be laid down in the test instruction. In addition, the requirements of clause 11.3.5 apply.

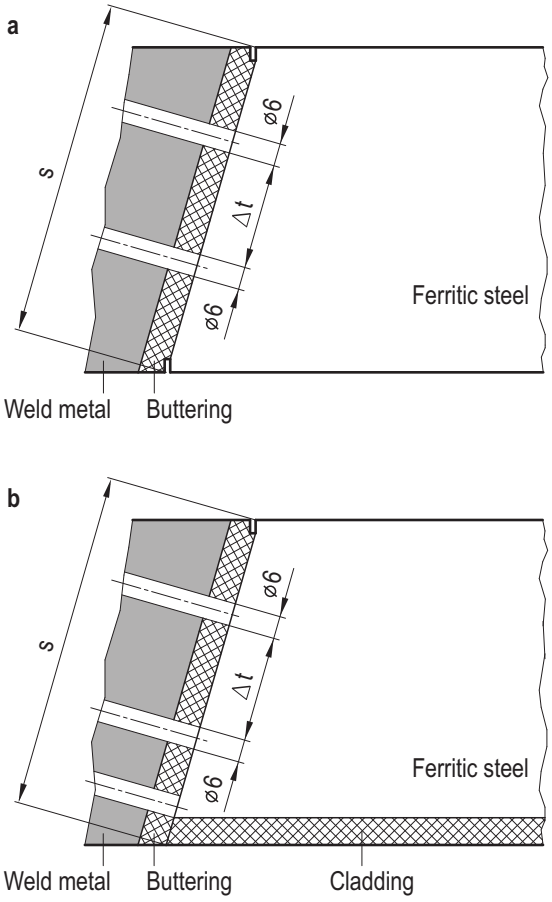


Figure 11-10: Location of flat bottom holes and notches for testing of bonding at the interface to the ferritic base metal

11.6 Build-up welds

11.6.1 Tests and examinations prior to welding

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) For surfaces of product forms the respective requirements of KTA 3211.1 and for weld surfaces the requirements of **Table 11-5** shall apply with regard to the evaluation of test results.

11.6.2 Tests and examinations upon welding

11.6.2.1 Claddings

This Section shall also apply to areas consisting of claddings and a shaping weld on the cladding.

11.6.2.1.1 Surface inspection by penetrant method

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) The specifications laid down in **Table 11-16** shall constitute the acceptance standards for the surface inspection.

11.6.2.1.2 Ultrasonic testing

11.6.2.1.2.1 Procedural requirements

11.6.2.1.2.1.1 Performance of testing

The test shall be effected for bonding by means of straight beam scanning from the base metal side or from the side of the build-up weld.

11.6.2.1.2.1.2 Adjustment of the testing level

(1) For the adjustment of the testing level the indication of a side-drilled hole of 3 mm diameter being parallel to the surface in the base metal at the interface to the cladding shall be used as reference echo.

(2) The reference block shall correspond to the test object as regards the test-relevant characteristics (material, type of cladding, heat treatment, shape, wall thickness). If there are different sound path travel distances in the reference block and in the part, formula D-10 (Section D 2.3) may be used for correcting the testing level of single transducer probes if the examination is performed from the base metal side.

11.6.2.1.2.1.3 Recording levels

(1) For indications from the transition between cladding and base metal the recording level corresponds to the echo height of the reference reflector plus a sensitivity allowance of 6 dB. All indications reaching or exceeding the recording level shall be recorded.

(2) If the distance between recording level and noise level is less than 6 dB, this shall be stated in the test report, and any further action to be taken shall be fixed jointly with the authorized inspector.

11.6.2.1.2.1.4 Determination of the size of reflectors

The size of reflectors shall be determined using the half-amplitude method in accordance with Section D 11.2.3.

11.6.2.1.2.1.5 Acceptance standards

(1) Individual reflectors with an indictaion length equal to or less than 10 mm shall be considered as disbonding areas with a cross-sectional area of 100 mm^2 when determining the total bonding area.

(2) Referred to a scan path length of one metre linear reflectors are permitted up to a length of 250 mm in which case individual reflectors shall not exceed 100 mm in length. When determining the total bonding area, linear reflectors shall be considered as disbonding areas with a width of 10 mm.

(3) Plane reflectors are permitted up to a maximum cross-sectional area of 1000 mm^2.

(4) Referred to the total area the portion of the bonding area shall be 98 %, where it is permitted that locally, i.e. referred to a cross-sectional area of 1 m · 1 m, the portion of the bonding area is only 95 %.

11.6.2.2 Hard surface overlays and butterings for hard surface overlays

11.6.2.2.1 Surface inspection

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) The surface inspection shall be made to the penetrant method.

(3) The following acceptance standards apply:

a) Linear indications are not permitted.

b) Valve seating surfaces:

Seating surfaces (e.g. contact faces of ball-type seatings) shall be free from indications on 1 mm each on the right and left side of the functional area, the i.e. tangent line.

On seating surfaces with a width exceeding 2 mm and smaller than or equal to 6 mm isolated rounded indications are permitted if their extensions does not exceed half the width of the seating surface.

On seating surfaces with a width exceeding 6 mm rounded indications with an extension of smaller than or equal to 3 mm are permitted as isolated indications.

The number of allowable indications shall not exceed 10 per square decimetre of seating surface.

c) Other surfaces:

In the case of other surfaces pores with a bleedout of smaller than or equal to 6 mm and an effective extension smaller than or equal to 1.5 mm are permitted as isolated indication, with the number of indications not exceeding 10 per square decimetre and a minimum distance between edges of indication of 3 mm.

11.6.2.2.2 Ultrasonic testing

11.6.2.2.2.1 Performance of testing

(1) The hard surface overlays and the adjacent buttering, if any, shall be scanned vertically to the bond zone.

(2) The test shall be performed from the side of hard surfave overlay.

(3) A test instruction shall be established.

11.6.2.2.2.2 Adjustment of the testing level

(1) For the testing level adjustment the indication of a side-drilled hole of 3 mm diameter shall be used as reference echo, with the bore being parallel to the scanning surface in the base metal at the interface to the buttering or hard surface overlay at the interface to the hard surface overlay in a similar reference block. Here, the weldment shall correspond to the test object.

(2) Where a buttering or hard surface overlay is provided, an additional bore shall be made at the interface to the hard surface overlay.

11.6.2.2.2.3 Determination of reflector size

All recordable indications shall be measured as to length and width. The size of the reflectors shall be given as the probe displacement path at the beginning and end of which the echo amplitudes have fallen by 6 dB below the recording level (see clause D 11.2.2). In this case, the sound beam diameter at the location of indication may be considered in accordance with clause D 11.2.4.3.

11.6.2.2.2.4 Recording level

The recording level corresponds to the echo height of the respective reference reflector as per clause 11.6.2.2.2.2 plus a sensitivity allowance of 6 dB. All indications reaching or exceeding the recording level shall be recorded.

11.6.2.2.2.5 Acceptance standards

(1) For sealing face areas no recordable indications are permitted.

(2) For bearing and guiding surface areas recordable indications which exceed the recording level by not more than 6 dB are permitted if they are individual indications.

(3) For the other areas the portion of the bonded area shall be at least 98 %. Isolated lack of bond is permitted on an area of not more than 250 mm^2.

11.6.2.3 Ferritic shaping welds (e.g compensating welds, welds for cutout reinforcements)

Note:

KTA 3211.1 shall apply to parts which are manufactured entirely by means of shaping welds.

11.6.2.3.1 Surface inspection

(1) The extent and times of the tests are specified in Section 9.3.6.

(2) The specifications laid down in **Table 11-5** shall constitute the acceptance standards.

11.6.2.3.2 Ultrasonic testing

11.6.2.3.2.1 Performance of testing

(1) Shaping welds shall normally be tested from one of the surfaces by means of angle-beam and straight-beam scanning.

(2) For angle-beam scanning one beam angle will suffice. Angle-beam scanning - as far as practicable - shall be performed from two directions vertical to each other in due consideration of the direction of weld progression as well as from opposite direction.

(3) It shall be ensured that the entire weld volume including an adjacent base metal area of at least 10 mm is covered and evaluated.

11.6.2.3.2.2 Adjustment of the testing level

The specifications laid down in Section 11.3.4.2.3 apply.

11.6.2.3.2.3 Recording levels

The specifications laid down in **Table 11-12** shall apply to the recording levels. The thickness of the pressure-retaining wall is decisive as regards the application of **Table 11-12**.

11.6.2.3.2.4 Determination of the indication length

(1) The specifications laid down in Section 11.3.4.2.4 apply.

(2) If the test is conducted from the surface of the shaping weld, the determination of the indication length shall be based on the height of the shaping weld instead of the wall thickness.

11.6.2.3.2.5 Acceptance standards

The evaluation of shaping welds shall be effected in accordance with Section 11.3.4.6. **Table 11-13** shall be applied so that the evaluation is based on the height of the build-up weld instead of the wall thickness. If the height of the build-up weld is smaller than its width, the width shall be decisive. For this purpose, the build-up weld may be divided into strips 60 mm in width and, with regard to the reflectors, each strip may be individually evaluated.

11.6.2.4 Butterings for seam welds

(1) Butterings for seam welds shall normally be tested together with the weld and shall be subject to the same evaluation requirements.

(2) For the test of butterings for welded joints between ferritic and austenitic steels the requirements of Section 11.5 apply.

11.6.2.5 Austenitic shaping welds

11.6.2.5.1 Surface inspection

(1) Shaping welds shall be tested in their finished condition by penetrant method.

(2) The specifications laid down in **Table 11-15** shall constitute the acceptance standards.

(3) Indications are not permitted in functional areas of sealing surfaces.

11.6.2.5.2 Ultrasonic testing

The specifications of Section 11.6.2.1.2 apply to ultrasonic testing.

11.7 Weld-in welds of heat exchanger tubes

(1) The welds shall be subjected to penetrant testing.

(2) Indications are not permitted in ferritic and austenitic welds. Isolated indications are permitted in welds of titanium pipes.

(3) Indications in the area adjacent to the weld shall be evaluated in accordance with KTA 3211.1 in the case of unclad surfaces and in accordance with Section 11.6.2.1 in the case of clad surfaces.

11.8 Areas of removed welds

(1) Areas where welded attachments or build-up welds were temporarily attached shall be subjected to a surface inspection; in the case of ferritic steels, this shall preferably be effected by the magnetic particle method.

(2) Crack-like surface defects are not permitted.

11.9 Recording of test results

11.9.1 General

Where **Table 9-4** requires the establishment of a certification, the performance of the test and the test results obtained shall be recorded in a test report (test record).

11.9.2 Manual ultrasonic testing

(1) Recording shall be performed by means of individual test reports of the parties involved. The results obtained by several participants shall be evaluated (e.g. on a common cover sheet).

(2) Test results obtained from similar test objects for which identical test instructions have been established, may be comprised in overall records.

11.9.3 Mechanised ultrasonic testing

The manufacturer shall establish test reports. As regards the control of the performance of the test and the test results obtained the other participants in the test shall countersign the manufacturer's report.

11.9.4 Surface inspection

The manufacturer shall establish test reports. As regards their attendance and the test results obtained the other participants in the examination shall countersign the manufacturer's report.

11.9.5 Radiographic testing

The manufacturer shall establish test reports. As regards the random checking that the test is performed and the test

results obtained the other participants in the test shall countersign the manufacturer's report. Deviating evaluation columns shall be entered and be marked by the authorized inspector.

11.9.6 Overview on the results obtained by non-destructive tests and examinations (NDE)

Recordable indications detected by ultrasonic testing and recorded imperfections detected by radiographic testing shall be listed by the manufacturer

a) for vessels, valves and pumps with specific reference to the component,

b) for pipework with reference to specific piping systems

in overview lists indicating the sequence of welds tested with the pertinent test report number and be added to the final file. This also applies to tolerated deviations from NDE requirements.

11.9.7 Forms for test records

The use of **forms A-14** to **A-20** is recommended. The use of other forms is permitted if they contain comparable information as to the examinations performed and permit to reproduce such examinations.

Accessibility, scanning conditions		Testing at	Scan path L (scanning surface) [1], mm		
			$s \leq 20$ mm	$20 \text{ mm} < s \leq 40$ mm	$s > 40$ mm
Welds on ferritic steels	Accessibility from both surfaces and scanning from one side of the weld or acessibility from one surface and scanning from both sides of the weld	p	$\geq 5.5 \cdot s + 30$	$\geq 3.5 \cdot s + 30$	$\geq 3.5 \cdot s + 50$
	Accessibility from both surfaces and scanning from both sides of the weld	p/2	$\geq 3 \cdot s + 30$	$\geq 2 \cdot s + 30$	$\geq 2 \cdot s + 50$
	Accessibility from one surface and scanning from one side of the weld	3/2 p	$\geq 5.5 \cdot s + 30$	$\geq 5.5 \cdot s + 30$	$\geq 3.5 \cdot s + 50$
Welds on austenitic steels or between ferritic and austenitic steels		p/2	$\geq 3 \cdot s + 30$	$\geq 2 \cdot s + 30$ [2]	$\geq 2 \cdot s + 50$ [3]

[1] The scan path L' (opposite surface) shall be $\geq 0.7 \cdot L$ (mm) in any case.

[2] For the scan path L on the ferritic side of buttered welds between ferritic and austenitic steels the following applies: $L \geq 3 \cdot s + 30$ mm

[3] For the scan path L on the ferritic side of buttered welds between ferritic and austenitic steels the following applies: $L \geq 3 \cdot s + 50$ mm

p : Skip distance

Table 11-1: Scan paths L and L' for ultrasonic testing

Wall thickness s in mm	$s \leq 30$	$30 < s \leq 60$	$s > 60$
Scan paths L* in mm	≥ 20	$\geq 1/3 \cdot s + 10$	≥ 30

Table 11-2: Scan paths L* for radiographic testing (see Figures 11-5 and 11-6)

Indications ≤ 3 mm individual	Indications ≤ 3 mm clustered	Rounded indications > 3 mm up to ≤ 6 mm individual	Linear indications [1] > 3 mm up to ≤ 6 mm individual non-metallic inclusions parallel to part surface	Indications > 3 mm clustered	Linear indications [1] > 3 mm crack-like	Indications > 6 mm [2]
Acceptable	Acceptable up to and incl. 10 indications per metre of fusion face			Not acceptable		

[1] A penetrant indication will have an extension in length if its dimension in the direction of maximum extension is at least three times its smallest dimension transverse to this direction.

[2] Difffering from these stipulations and by agreement with the authorized inspector, indication lengths > 6 mm caused by linear carbonitride indications may be permitted for Ti-stabilized austenitic materials.

Table 11-3: Acceptance standards for penetrant testing of fusion faces

Indications ≤ 1.5 mm individual	Indications ≤ 1.5 mm clustered	Indications > 1.5 mm up to ≤ 10 mm individual non-metallic inclusions parallel to part surface	Indications > 1.5 mm clustered	Indications > 1.5 mm crack-like	Indications > 10 mm
Acceptable	Acceptable up to and incl. 10 indications per metre of fusion face		Not acceptable		

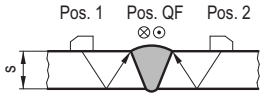
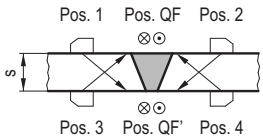
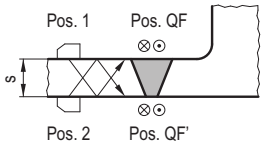
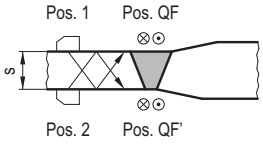
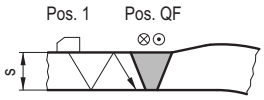
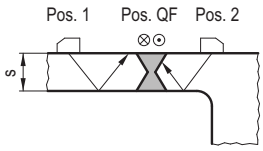
Table 11-4: Acceptance standards for magnetic particle testing of fusion faces

(1) Magnetic particle testing			
Indications outside the fusion line or HAZ			Indications in the fusion line or heat affected zone
Indications ≤ 1.5 mm	Indications > 1.5 mm up to ≤ 6 mm caused by non-metallic inclusions	Other indications > 1.5 mm	
Acceptable not to be included in the evaluation	Acceptable to be included in frequency	Not acceptable	Cause of indication to be clarified Cracks and incomplete fusions not acceptable
Locally there shall not be more than 10 indications per square decimetre. The cause of indications appearing systematically shall be investigated even if their maximum extensions are less than 1.5 mm. Indications are not acceptable in the case of single-pass sealing welds.			
(2) Penetrant testing			
Indications outside the fusion line or HAZ			Indications in the fusion line or heat affected zone
Indications ≤ 3 mm	Indications > 1.5 mm up to ≤ 6 mm caused by non-metallic inclusions	Other indications > 3 mm	
Acceptable not to be included in the evaluation	Acceptable to be included in frequency	Not acceptable	Cause of indication to be clarified Cracks and incomplete fusions not acceptable
Locally there shall not be more than 10 indications per square decimetre. The cause of indications appearing systematically shall be investigated even if their maximum extensions are less than 3 mm. Indications are not acceptable in the case of single-pass sealing welds.			

Table 11-5: Acceptance standards for magnetic particle and penetrant testing on ferritic seam and build-up welds

Nominal wall thickness s in mm	s ≤ 20	20 < s ≤ 40	s > 40
Beam angle, general	70 degrees	60 Grad	45 Grad und 60 Grad
Beam angle in direction of curvature or in the case of wall thickness transitions	45 degrees up to 60 degrees	45 degrees up to 60 degrees	35 degrees up to 45 degrees and 60 degrees up to 70 degrees
Angles of incidence for detecting reflectors oriented perpendicular to the inner surface insofar as the inner surface is neither accessible for magnetic particle nor penetrant testing.	70 degrees	35 degrees up to 55 degrees	35 degrees up to 55 degrees

Table 11-6: Recommended beam angles and angles of incidence for ultrasonic testing of ferritic butt and nozzle welds

UT-No.	Accessibility Scanning	Surface condition of the weld	Scanning conditions	
1.1	From both sides of the weld and from one surface at one skip distance	a) Outside and inside machined flat b) Outside machined flat, inside unmachined. [1]		**Test for longitudinal defects:** Positions 1 and 2 at p [2]
1.2	From both sides of the weld and from both surfaces at 1/2 skip distance	Outside and inside machined flat		**Test for longitudinal defects:** Positions 1 up to 4 at p/2
1.3	From one side of the weld and from both surfaces at one skip distance	Outside and inside machined flat		**Test for longitudinal defects:** Positions 1 and 2 at p
1.4				
1.5	From one side of the weld and from one surface at 1 ½ skip distances If s > 40 mm, second beam angle at one skip distance	Outside and inside machined flat		**Test for longitudinal defects:** Position 1 at 3/2 p If s ≤ 20 mm position 1 using 60 degrees permitted If s > 40 mm position 1 with second angle at P
1.6	From both sides of the weld and from one surface at one skip distance and at 1/2 skip distance	Outside and inside machined flat		**Test for longitudinal defects:** Position 1 at p Position 2 at least at P/2

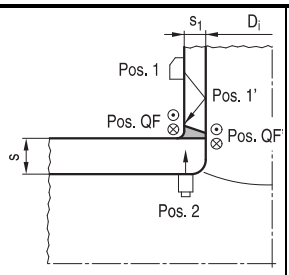
Test for transverse defects: QF at P or QF and QF′ at P/2, each in the two opposing weld directions.

p : skip distance

[1] In due consideration of the requirements of clause 5.1 (3).

[2] In the case of wall thicknesses > 40 mm, this shall only apply to the smaller beam angle, the evaluation up to p/2 shall be sufficient for the large beam angle.

Table 11-7: Test conditions for ultrasonic testing of ferritic circumferential and longitudinal welds

<table>
<tr><th>UT-No.</th><th>Accessibility Scanning</th><th>Surface condition of the weld</th><th colspan="2">Scanning conditions</th></tr>
<tr><td>2.1</td><td>From the nozzle side for angle beam scanning and from the run pipe or vessel side for straight beam scanning</td><td rowspan="4">Shaped outside.
Inside machined flat, where accessible.</td><td> 
</td><td rowspan="4">Test for longitudinal defects:
a) Angle beam scanning:
Position 1 at p or positions 1 and 1' at p/2.
Position 3 at p or position 3' at p/2 with the smallest possible beam angle, however, covering the total cross section over the total circumference.
In the case of s > 40 mm, the second beam angle is waived, if the total weld cross section is covered using position 2.
b) Straight beam scanning using position 2

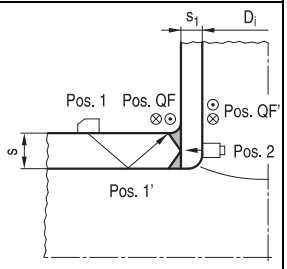
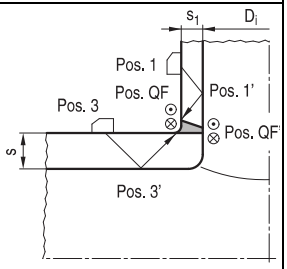
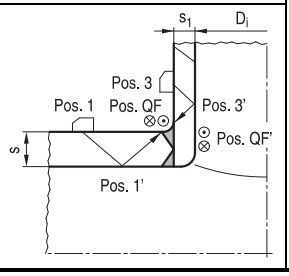
Test for transverse defects:
Position QF, alternatively position QF' in the two opposing weld directions without reflection.
The scanning direction shall be selected such that the incident angle on possible transverse defects is as small as possible.
If s > 40 mm, a second beam angle shall be used.</td></tr>
<tr><td>2.2</td><td>From the run pipe or vessel side for angle beam scanning and from the nozzle inner side for straight beam scanning</td><td> 
</td></tr>
<tr><td>2.3</td><td>Inside not accessible or straight beam scanning impeded due to the nozzle inside edge</td><td> 
</td></tr>
<tr><td>2.4</td><td>Accessible from the run pipe or vessel side as well as from the nozzle side for angle beam scanning</td><td> 
</td></tr>
<tr><td colspan="5">p : skip distance</td></tr>
</table>

Table 11-8: Test conditions for ultrasonic testing of ferritic nozzle welds ≥ DN 125 and s or s_1 > 15 mm

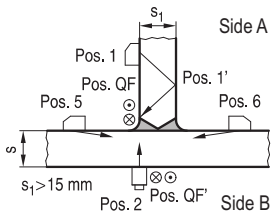
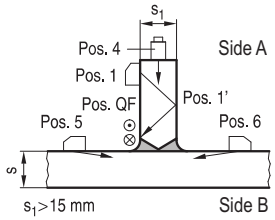
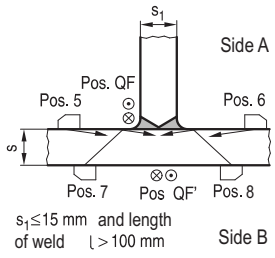
UT-No.	Accessibility Scanning	Surface condition of the weld	Scanning conditions	
3.1	Side B accessible for straight beam scanning. Side A accessible for angle beam scanning from the web side; for the creeping wave technique, from both sides of the weld.	Shaped		**Test for longitudinal defects:** a) Angle beam scanning: Position 1 or 1' at p or positions 1 and 1' at P/2 using a beam angle whose impact on the weld edge shall normally be as vertical as possible. b) Creeping wave technique: Positions 5 and 6 on incipient cracks below the weld in the base metal. c) Straight beam scanning: Position 2; scanning from Side B Position 4; scanning from the web, if this is possible with regard to the dimensions (height, width). If Position 4 is not possible, positions 1 and 1' with a flat beam angle (60 degrees or 70 degrees) at p/2. d) Wave conversion technique: Positions 7 and 8 on incipient cracks below the weld in the base metal. **Test for transverse defects:** Position QF, alternatively QF', in the two opposing weld directions. When scanning from side A, the test shall preferably be performed from both sides of the welded attachment at p/2. The scanning direction shall be selected such that the incident angle on possible transverse defects is as small as possible. If s_1 > 40 mm, a second beam angle shall be used.
3.2	Side B not accessible. Side A accessible for angle beam scanning from the web side; for the creeping wave technique from both sides of the weld; for straight beam scanning from the web.			
3.3	Side A or side B accessible. Side A accessible for the creeping wave technique from both sides of the weld or side B accessible for the wave conversion technique from both sides of the weld.			
p : skip distance				

Table 11-9: Test conditions for ultrasonic testing of ferritic attachment welds (single, double bevel groove) belonging to Test Group A 1

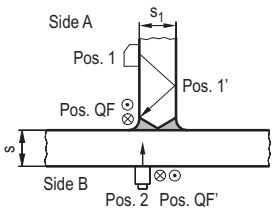
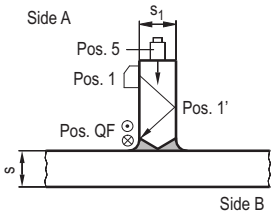
<table>
<tr><th>UT-No.</th><th>Accessibility Scanning</th><th>Surface condition of the weld</th><th colspan="2">Scanning conditions</th></tr>
<tr><td>3.4</td><td>Side A accessible for angle beam scanning from the web side and Side B accessible for straight beam scanning</td><td rowspan="2">Shaped</td><td> 
</td><td rowspan="2">Test for longitudinal defects:
a) Angle beam scanning:
Position 1 or 1' at p or positions 1 and 1' at p/2 using a beam angle whose impact on the weld edge shall normally be as vertical as possible.
b) Straight beam scanning:
Position 2; scanning from Side B.
Position 5; scanning from the web, if this is possible with regard to the dimensions (height, width).
if Position 5 is not possible, positions 1 and 1' with a flat beam angle (60 degrees or 70 degrees) at p/2.
Test for transverse defects:
Position QF, alternatively QF', in the two opposing weld directions. When scanning from side A, the test shall preferably be performed from both sides of the welded attachment at p/2.
The scanning direction shall be selected such that the incident angle on possible transverse defects is as small as possible.
If s_1 > 40 mm, a second beam angle shall be used.</td></tr>
<tr><td>3.5</td><td>Side B not accessible.
Side A accessible for angle beam scanning from the web side and for straight beam scanning from the web</td><td> 
</td></tr>
<tr><td colspan="5">p : skip distance</td></tr>
</table>

Table 11-10: Test conditions for ultrasonic testing of ferritic attachment welds (single, double bevel groove) belonging to Test Groups A 2, A 3 if s_1 > 15 mm

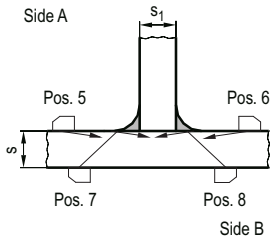
<table>
<tr><th>UT-No.</th><th>Accessibility Scanning</th><th>Surface condition of the weld</th><th colspan="2">Scanning conditions</th></tr>
<tr><td>4.1</td><td>Side A or side B accessible.
Side A accessible for the creeping wave technique from both sides of the weld or side B accessible for the wave conversion technique from both sides of the weld.</td><td>Shaped</td><td> 
</td><td>Test for longitudinal defects from positions 5 and 6 by means of the creeping wave technique or from positions 7 and 8 by means of the wave conversion technique for incipient cracks below the weld in the base metal.</td></tr>
</table>

Table 11-11: Test conditions for ultrasonic testing of ferritic attachment welds (fillet welds) if s_1 > 10 mm or the weld length > 100 mm

Nominal wall thickness [1] s in mm	Diameter of the respective disc shaped reflector in mm		
	Straight beam scanning	Angle beam scanning	LLT-technique
8 ≤ s ≤ 15	2.0	1.0	—
15 < s ≤ 20	2.0	1.5	—
20 < s ≤ 40	2.0	2.0; 6.0 [2]	6.0 [2]
s > 40	3.0	3.0; 6.0 [2]	6.0 [2] [3]

[1] For butt welds with differing nominal wall thicknesses clause 11.3.4.1 (3) shall govern.
[2] Applies to the test for bonding at the interface to the ferritic base metal in accordance with Section 11.5.4.2.
[3] Applies only to the test of narrow gap welds in accordance with clause 11.3.4.3 (3).

Table 11-12: Recording levels as a function of nominal wall thicknesses

Nominal wall thickness s [1], mm	Recording length of individual reflectors for ultrasonic testing	Accumulated length (sum of indication lengths for ultrasonic testing) per reference length [2]
$8 \le s \le 25$	$\le s$	$\le 1.5 \cdot s$
$25 < s \le 40$	≤ 25	$\le 1.5 \cdot s$
$s > 40$	≤ 30	$\le 1.5 \cdot s$

[1] s_1 for welds on set-on nozzles and attachment welds (single bevel and double bevel groove welds)

[2] The reference length is $6 \cdot s$, for welds on set-on nozzles and welded attachments (single bevel and double bevel groove welds) $6 \cdot s_1$

Table 11-13: Acceptance standards for indications detected by ultrasonic testing for longitudinal defects

Nominal wall thickness s [1] of the seam weld, mm	Allowable width, mm	Allowable individual length l, mm	Allowable accumulated length $\sum l$ per reference length $L = 6 \cdot s$ [1], mm
$s < 10$	$< 0.2 \cdot s$	$l \le s$	$\sum l \le s$
$10 \le s \le 25$	≤ 2	$l \le s$	$\sum l \le 1.5 \cdot s$
$25 < s \le 40$		$l \le 25$	
$40 < s$		$l \le 30$	

[1] s_1 for welds on set-on nozzles and attachment welds (single bevel and double bevel groove welds)

Table 11-14: Acceptance standards for the evaluation of metallic and non-metallic inclusions detected by radiographic testing

Type of welded connection	Indications ≤ 1.5 mm	Indications > 1.5 mm up to ≤ 3 mm	Indications > 3 mm
Welded connections $s > 3$ mm and multiple-pass sealing welds	Not to be included in the evaluation	Acceptable up to 10 indications per meter of weld length	Not permitted
Welded connections $s \le 3$ mm and single-pass sealing welds	No indications permitted		
The last evaluation time in accordance with **Annex F** is decisive for the evaluation of the size of the indication.			

Table 11-15: Acceptance standards for penetrant testing of welded connections on austenitic steels as well as between ferritic and austenitic steels, on build-up welds and sealing welds made of austenitic or nickel weld metal

Type of the weld cladding	Indications ≤ 1.5 mm	Indications > 1.5 mm up to ≤ 3 mm	Indications > 3 mm up to ≤ 6 mm caused by slag inclusions	Indications > 6 mm
Weld claddings (except tubesheets) with a thickness ≥ 3 mm	Not to be included in the evaluation	Locally up to 10 indications on an area of 100 mm x 100 mm, however, referred to the entire component surface to be tested not more than 20 indications (on an average) per m^2	Up to 10 indications per m^2 permitted	Not permitted
Weld claddings with a thickness < 3 mm	No indications acceptable			
Weld claddings for tubesheets	A maximum of 100 indications in the area of the tube-to-tubesheet weld permitted		Not permitted	
Sealing surface functional area	No indications acceptable			
The last evaluation time in accordance with **Annex F** is decisive for the evaluation of the size of the indication. **Table 11-5** shall apply to ferritic claddings.				

Table 11-16: Acceptance standards for penetrant testing of weld claddings made of austenitic or nickel weld metal

Nominal wall thickness s in mm	$8 < s \le 20$	$20 < s \le 40$	$s > 40$
Notch depth in mm	1.5	2	3

Table 11-17: Depth of reference reflector for testing level adjustment in ultrasonic testing of inner surface of welded joints between austenitic steels as well as between ferritic and austenitic steels

	Case 1	Case 2
Evaluation method	Echo height evaluation to clause 11.4.2.3.2.2 b)	Pattern recognition to clause 11.4.2.3.2.2 e)
Reference notch	Notch to be selected to Table 11-17	Notch to be selected to Table 11-17
Echo height difference between reference notch and noise level	≥ 12 dB	≥ 6 dB
Echo height difference between edge simulating a through-wall crack and reference notch	≥ 6 dB	≥ 0 dB
Recording level	Reference notch plus a sensitivity allowance of 6 dB	Noise level
Recording	All indications the echo heights of which reach or exceed the recording level	All indication patterns starting at noise level
Evaluation	As per 11.4.2.3.5 (4)	As per 11.4.2.3.5 (5)

Table 11-18: Criteria to be satisfied when proving the suitability of test techniques for ultrasonic testing of butt welds and unclad base metal areas

Maximum number of indications per meter of weld	Maximum indication length in mm	Maximum echo amplitude above the recording level specified in dB
10	10	6

Table 11-19: Acceptance standards for ultrasonic testing of the inner surface of welded joints between austenitic steels as well as between ferritic and austenitic steels

12 Surface Cleanliness and Surface Protection

(1) Measures which serve the attainment and preservation of the cleanliness of the surfaces of parts, components and piping systems shall be specified on the basis of DIN 25410 in order to exclude possible malfunctions and damage to materials.

(2) Such measures may become necessary in the course of planning, fabrication, packaging, storage, assembly and commissioning. In particular, they include

a) fabrication and assembly of the plant parts under special conditions of cleanliness,
b) pressure and leak test,
c) cleaning, drying and conservation of the surfaces,
d) packaging.

(3) The cleanliness categories required in accordance with DIN 25410 shall be specified for each component and for each system, depending on materials and functions, and adherence to these categories shall be verified. There may be deviations in the case of assembly at the plant provided that the system or component is cleaned at a later time.

(4) Were reqirements beyond DIN 25410 exist dealing with the cleanliness of individual plant parts in order to exclude the possibility of impurities in piping systems, these shall be specified by agreement with the authorized inspector.

(5) Specifications dealing with the execution and testing of internal coatings, where required in accordance with the Design Data Sheet or the Pipe Loading Specifications, shall be fixed jointly with the authorized inspector in each individual case.

(6) External coatings, where required in accordance with the Design Data Sheet or the Pipe Loading Specifications, shall be performed in accordance with the manufacturer's specifications. They shall not interfere with the feasability of necessary periodic inspections. Insofar as required, it shall be possible to decontaminate external coatings.

13 Remedial Work, Repairs and Tolerances

(1) If deviations from the requirements or the design approval documents are found, in particular, deviations from specified

a) quality characteristics,
b) quality demonstrations,
c) fabrication requirements,

special measures serving their elimination shall be taken.

Note:
Revisions of the design approval documents do not constitute deviations.

(2) The deviations are divided into 3 categories in accordance with **Table 13-1**. **Annex B** contains detailed explanations dealing with the type and treatment of these deviations.

(3) All remedial work and repairs shall adhere to the quality assurance measures required for the base metal of the part.

(4) Before any repair is conducted, it shall be checked whether leaving the defect would be disadvantageous in terms of safety.

14 Additional Requirements for the Exclusion of the Concept of Postulated Breaks in Circumferential Pipe Welds

(1) In the case of pipes of nominal diameters greater than DN 50 and operating at a pressure equal to or greater than 2 MPa (20 bar) or operating at a temperature equal to or greater than 100 °C, the additional requirements in accordance with **Table 14-1** shall be met with respect to circumferential pipe welds if the exclusion of the concept of postulated breaks is relied upon for these pipes and the stress usage and usage period in accordance with (2) are exceeded.

(2) If, in the case of circumferential pipe welds, the exclusion of the circumferential rupture is to be attained by adherence to the criterion P_{mNB} equal to or smaller than 50 N/mm^2 or a usage period equal to or smaller than 2 %, the welds shall be categorized into Test Groups A 1 or A 2; in this connection, the scheduled facilitations in accordance with **Table 9-5**, footnote 5 shall not be relied upon.

Note:

Requirements to be met by circumferential welds between valves (e.g. main steam safety valves) shall be dealt with separately.

Category 1 Back-up tests Remedial work	Category 2 Repairs in accordance with standard documents	Category 3 Repairs in accordance with individual repair plans or tolerances
(1) Minor deviations which can be carried back to the range of acceptability by means of a) back-up tests or b) remedial work. (2) Minor deviations which occur occasionally and which may be left as they are if their effect can be assessed to be negligible due to experience or demonstrations.	Local defects of known cause which are eliminated before the final heat treatment and the pressure test in accordance with the standard repair plan.	(1) Deviations which cannot be allocated to either Category 1 or Category 2 and which, with the authorized inspector's agreement, are eliminated in accordance with individual repair plans, provided the required quality demonstrations are available. (2) Deviations which may be tolerated.

Table 13-1: Deviations - Classification into categories

No.	Basic requirement	Additional requirements
1	Table 2-3	Classification shall always be into Test Group A 1.
2	Section 4	As a deviation from the specifications laid down in Section 4, the design approval of the fabrication isometric drawing and the isometric item list shall be effected before the start of manufacture or a section of manufacture. The design approval documents shall be supplemented in accordance with the specifications laid down in this Table and provided with special references to the concept of postulated breaks.
3	Section 5.7.1.3; Table 5-4	Surface condition machined flat shall be required for outer surfaces of circumferential pipe welds. For the inner surfaces clause 5.1 (3) applies. Grinding of the inner surfaces may be waived only if no indications due to geometric discontinuities from the root area are obtained. Deviations from this, e.g. in the case of closure welds, are permitted by agreement with the authorized inspector.
4	Section 5.3	The requirements of KTA 3201.3 shall apply to welding filler metals and welding consumables (welding material test required).
5	Section 6.4	As a deviation from **Table 6-1**, the lot size for mechanical tests of hot and cold bends is specified at a maximum of 10 for all materials.
6	Section 7.2.2; Table 7-1	A stress relief heat treatment shall be conducted on of single-side welds between ferritic steels.
7	Section 8.2	Examinations shall be conducted in the course of the production control tests on materials belonging to material sub-groups 4.1 and 4.2 in accordance with **Table 8-1**, insofar as this is scheduled in accordance with Annex A of KTA 3201.3.
8	Section 8.2	If a second production control test is required in accordance with **Table 8-11**, welding for this test shall take place on the site.
9	Section 9.2.3	The density of the supervisory activity by the manufacturer and the authorized inspector shall be adapted to the significance of the component.
10	Section 9.3.6; Table 9-5 Section 9.3.14; Table 9-8	The following shall apply to non-destructive tests of welds: a) extent of ultrasonic testing and surface inspection conducted by the authorized inspector: 100 % The test and examination methods as per KTA 3201.3 shall apply. b) ultrasonic testing conducted by the manufacturer and authorized inspector after the pressure test: 5 % (in the case of 15 MnNi 6 3), 10 % (in the case of 20 MnMoNi 5 5) of the welds.
11	Section 11	Section 12 of KTA 3201.3 shall apply to the non-destructive tests. In the case of pipe elbows or bends, cylindrical ends shall be required if they are needed for the performance of the non-destructive tests (if applicable, adhering to the requirements for the in-service tests and inspections).
12	KTA 3211.2 Section 5.2	With the exception of sealing welds, welds which are not penetration-welded and fillet welds are not permitted.

Table 14-1: Additional requirements for the exclusion of the concept of postulated breaks of circumferential pipe welds

Annex A

Samples of Forms

The forms apply to K1 and K2. The spaces which are not applicable to K2 are indicated on the respective forms.

Forms relating to Sections 4, 5 and 7

A-1a - Cover Sheet
A-1b - Cover Sheet
A-1c - Cover Sheet
A-2 - List of materials
A-3a - Test and inspection sequence plan
A-3b - Test and inspection sequence plan
A-4a - Welding procedure specification
A-4b - Welding procedure specification
A-5 - Heat treatment plan
A-6 - Heat treatment record
A-7 - Materials testing and specimen-taking plan
A-8 - Annex
A-9 - Contents final file
A-10 - Isometric parts list
A-11 - Fabrication isometric drawing
A-12a - Welding record
A-12b - Welding record (continued)
A-13a - Welding Record / Overall certificate (cover sheet)
A-13b - Welding Record / Overall certificate (review sheet)

Forms relating to Section 11

A-14a - Ultrasonic testing report
A-14b - Ultrasonic testing report
A-14c - Ultrasonic testing report
A-15 - Surface examination report
A-16a - Radiographic testing report (film radiography) - page 1
A-16b - Radiographic testing report (film radiography)- last page
A-17a - Radiographic testing report (digital radiography) - page 1
A-17b - Radiographic testing report (digital radiography) - last page
A-18 - Eddy current testing report
A-19 - Non-conformance report
A-20 - Annnex to documents as per forms A-13 to A-18

Hersteller: *manufacturer:*	Auftrags-Nr.: *contract no.*	Bestell-Nr.: *order no.*	
Anlage/Projekt: *power plant / project:*	**Deckblatt** *cover sheet* DBL-Nr.: *DBL no.*		Seite: *page:* von: *of:*

1	
Komponente *component:*	Komp.-Spezifikation *component specification:*
Gegenstand *item:*	Klasse *classification:*
KKS/AKZ *NPP identification system:*	Prüfgruppe PG *testing group:*
Typ, Antrieb, DN *type, drive, DN:*	Einzelteilgruppe EG *parts group:*
Identnummer *identification no.:*	

2 Inhaltsverzeichnis für Vorprüfunterlagen
table of contents of design review documents

3 Revisionstabelle der Unterlagen der Rubrik 2
table of revisions of documents class 2

	Vorprüfunterlagen Nr. *design review document no.*	Seite: von - bis *page: from - to*	Rev. 01/a Seite Nr. *page no.*	Rev. 02/b Seite Nr. *page no.*	Rev. 03/c Seite Nr. *page no*	Rev. 04/d Seite Nr. *page no.*
☐	Deckblatt DBL *cover sheet*					
☐	Zeichnung ZG *technical drawing*					
☐	Werkstoffliste WL *list of materials*					
☐	Schweißstellenliste STL *weld location list*					
☐	Prüffolgeplan PFP *test and inspection sequence plan*					
☐	Schweißplan SP *welding procedure sheet*					
☐	Wärmebehandlungsplan WBP *heat treatment plan*					
☐	Werkstoffprüf- und Proben-entnahmeplan WPP *materials testing and specimen-taking plan*					
☐						
☐						
☐						
☐						
☐						
☐	Auslegungsberechnung *design calculation*					
☐	Spannungsanalyse *stress analysis*					

4 Hersteller: *manufacturer:*

Rev. *revision*	Datum *date*	Geprüft *checked* Erstellt von *prepared by*	QST *quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*
00						
01						
02						
03						
04						

Form A-1a: Cover sheet

Hersteller: *manufacturer:*	Auftrags-Nr.: *contract no.*	Bestell-Nr.: *order no.*	
Anlage/Projekt: *power plant / project:*	**Deckblatt** *cover sheet* DBL-Nr.: *DBL no.*		Seite: *page:* von: *of:*

5

Spezifikationen, Vorschriften:
specifications, instructions:

Rev. *revision*	Hersteller: *manufacturer:* Datum *date*	Geprüft *checked* Erstellt von *prepared by*	QST *quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*
00						
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Form A-1b: Cover sheet

Hersteller: *manufacturer:*	Auftrags-Nr.: *contract no.*	Bestell-Nr.: *order no.*	
Anlage/Projekt: *power plant / project:*	**Deckblatt** *cover sheet* DBL-Nr.: *DBL no.*		Seite: *page:* von: *of:*

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7

Rev. *revision*	Datum *date*	Hersteller: *manufacturer:* Geprüft *checked* Erstellt von: *prepared by*	QST: *quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*
00						
01						
02						
03						
04						

Form A-1c: Cover sheet

1	2	3	4	5	6	7		8	9	10	11	12	13			14	15
Pos.-Nr. *item No.*	Stück-zahl *quan-tity*	Stück-gewicht *unit weight*	Bezeichnung *designation*	Abmessungen *dimensions*	Werkstoff *material*	Anforderungen nach *requirements in acc. with* Vorschrift *code*	Rev. *rev.*	EG *part group*	VPU-Nr. Sonstiges *design review doc. no. others*	Schmelzen-Nr. Proben-Nr. *heat no. specimen no.*	Kenn-zeichnung *identifica-tion marking*	Nachweis-Kenn-zeichnung *certification identification*	Prüfvermerk Nachweiskontrolle *certification mark* H		S	Bemerkungen *remarks*	Hersteller: *manufacturer:*
																	Anlage/Projekt: *power plant / project:*
																	Komponente: *component:*
																	KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ/ type, drive, DN:*
																	Spezifikation: *specification:*
																	Klasse: *classification:*
																	Prüfgruppe: *test group:*
																	Auftrags-Nr.: *contract no.:*
																	Bestell-Nr.: *order no.:*
																	Werk-Nr./Index-Nr.: *plant no. / index no.:*
																	STL-Nr.: *STL no.:*
																	Zeichnungs-Nr.: *technical drawing no.:*
																	PFP-Nr.: *PFP no.:*
																	SP-Nr.: *SP no.*

Rev. *revision*	Hersteller: *manufacturer:* Datum *date*	Erstellt von *prepared by*	Geprüft QST *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*	Dokumentationsfreigabe *release certification of documents* Hersteller *manufacturer*
00							
01							Sachverständiger *authorized inspector*
02							
03							
04							

Werkstoffliste
list of materials

WL-Nr.:
list of materials no.:

Seite:
page:

von:
of:

Form A-2: List of materials

1	2	3	4	5	6	7		8	9	10	11	12
Prüf-Nr. *test no.*	Anforderungen nach *requirements in accordance with*	Beschreibung *description*	Prüfzeitpunkt *date of test*	Prüfart. *type of test*	Prüfung durch: *test performed by*	Nachweisschlüssel *certification key*		Doku.-Ablage *document file*	Durchführungsvermerk *mark, when examination was performed*	Nachweise *certification of examinations*	Bemerkungen *remarks*	Hersteller: *manufactorer:*
												Anlage/Projekt: *power plant / project:*
												Komponente: *component:*
												KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ/type, drive, DN:*
												Spezifikation: *specification:*
												Klasse: *classification:*
												Prüfgruppe:: *test group:*
												Auftrags-Nr. *contract no.:*
												Bestell-Nr.: *order no.:*
												Werk-Nr./Index-Nr. 1): *plant no. / index no.:*
												Zeichnungs-Nr.: *technical drawing no.:*
												WL-Nr.: / *WL no.:* STL-Nr.: / *STL no.:* SP-Nr. 1): / *SP no. 1):*

Rev. *revision*	Hersteller: *manufacturer:* Datum *date*	Erstellt von *prepared by*	Geprüft QST *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*
00						
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03						
04						

Dokumentationsfreigabe *release certification of documents*

Hersteller *manufacturer*

Sachverständiger *authorized inspector*

1) nur für Rohrleitungen, Armaturen und Pumpen *only for pipes, valves and pumps*

Prüffolgeplan
test and inspection sequence plan

PFP-Nr.: *test and inspection sequence plan no:.*

Seite: / *page:*

Von: / *of:*

Form A-3a: Test and inspection sequence plan

1	2	3	4	5	6	7		8	9							10
Prüf-Nr. *test no.*	Anforderungen nach *requirements in accordance with*	Beschreibung *description*	Prüfzeitpunkt *date of test*	Prüfart *type of test*	Prüfung durch: *test performed by*	Nachweisschlüssel *certification key*		Doku-Ablage *document file*	Naht/Teil-Nr. *weld/part no.* H S Protokoll-Nr. *record no.*	Naht/Teil-Nr. *weld/part no.* H S Protokoll-Nr. *record no.*	Naht/Teil-Nr. *weld/part no.* H S Protokoll-Nr. *record no.*	Naht/Teil-Nr. *weld/part no.* H S Protokoll-Nr. *record no.*	Naht/Teil-Nr. *weld/part no.* H S Protokoll-Nr. *record no.*	Naht/Teil-Nr. *weld/part no.* H S Protokoll-Nr. *record no.*	Naht/Teil-Nr. *weld/part no.* H S Protokoll-Nr. *record no.*	Hersteller: *manufacturer:*
																Anlage/Projekt: *power plant/project:*
																Komponente: *component:*
																Spezifikation: *specification:* Klasse: *classification:* Prüfgruppe: *test group:*
																KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ/type, drive, DN*
																Zeichnungs-Nr.: *drawing no.:*
																Auftrags-Nr.: *contract no.:*
																Bestell-Nr.: *order no.:*
																Werk-Nr./Index-Nr.: *plant no. / index no.:*
																WL-Nr.: *list of materials no.:* STL-Nr.: *weld location list no.:* SP-Nr.: *welding procedure specification no.:*

[11] Rev. *revision*	Hersteller: *manufacturer:* Datum *date*	Erstellt von *prepared by*	Geprüft QST *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*	Dokumentationsfreigabe *release certification of documents*
00							Hersteller *manufacturer*
01							
02							Sachverständiger *authorized inspector*
03							
04							

Prüffolgeplan
test and inspection sequence plan

PFP-Nr.: *test and inspection sequence plan no:.*

Seite: / *page:*

Von: / *of:*

Form A-3b: Test and inspection sequence plan

Skizze/Schweißfolge/Aufbau der Schweißung/Abmessungen *sketch/welding sequence/build-up of weld/dimensions*	Bemerkungen *remarks* SAMPLE COPY	(15) Grundwerkstoff / Werkstoffuntergruppe nach DIN CEN ISO/TR 15608 *base metal / material subgroup according to DIN CEN ISO/TR 15608* Pos. *pos.* / Normbezeichnung *standard designation*	(16) Hersteller: *manufacturer:*
			Anlage/Projekt: *power plant / project:*
			Komponente: *component:*
		Nachfolg. Wärmebehandlung *subsequent heat treatment*	Spezifikation: *specification:*
		Arbeitsprüfung *associated production control test*	Klasse, Prüfgruppe: *classification, test group:*
		Schweißerprüfung *welder's qualification test*	EG: *part group:*

Schweißfolge *welding sequence*	Schweißverfahren *welding process*	Schweißposition *welding position*	Schweißzusätze u. Hilfsstoffe / *filler metals and consumables*: Hersteller und Bezeichnung *manufacturer and designation*	Abmessungen *dimension* [mm]	Pulver Hersteller und Bezeichnung *flux manufacturer and designation*	Schutzgas *shield gas* [l/min] DIN EN ISO 14175	Schweißdaten / *welding data*: Stromart *type of current*	Stromstärke Grundstrom/Pulsstrom *amperage base current / pulse current* [A]	Geschwindigkeit *travel speed* [mm/min]	Pendelbreite *oscillation width* [mm]	Drahtgeschwindigkeit Heißdraht *wire speed hot wire* [mm/min]	Vorwärm-/Haltetemperatur *preheat /holding temp.* [°C]	Lagenzahl *no. of passes*	Schweißnahtart *type of weld*	KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ/ type, drive, DN:*
	Verfahrensprüf-Nr. *welding proc. qualification no.*					Formiergas *purging gas* [l/min] DIN EN ISO 14175	Polung der Elektrode *electrode polarity*	Spannung *voltage* [V]	Auszieh-länge *run-out length* [mm] / Puls-frequenz *pulse frequency* (10) [Hz]	Pendelfrequenz *oscillation frequency* [1/min]	Kaltdraht *cold wire* [m/min]	Zwischenlagentemperatur *interpass temperature* [°C]		Schweißstellenliste *weld location list*	Zeichnungs-Nr.: *technical drawing no.:*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)		
														Schweißstellenkennzeichnung *weld identification*	Auftrags-Nr.: *contract no.*
														Schweißnahtvorbereitung *weld preparation*	Bestell-Nr.: *order no.:*
														Ausarbeiten der Wurzel *grooving out of root*	Werk-Nr./Index-Nr. [1]: *plant no. / index no.:*
														Trocknung Elektroden/Pulver (Temp., Zeit) *drying electrodes/flux (temp., time)*	PFP-Nr.: / *PFP no.:*
															WL-Nr.: / *WL no.:*

(17) Rev. *revision*	Hersteller: *manufacturer:* Datum *date*	Erstellt von *prepared by*	Geprüft QST *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*	**Schweißplan** *welding procedure specification*
00							SP-Nr.: *SP no:.*
01							
02							
03							Seite: *page:*
04						[1] Nur für Rohrleitungen, Armaturen und Pumpen *only for pipes, valves and pumps*	Von: *of:*

Form A-4a: Welding procedure specification

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Schweiß-stellen-Nr. *weld location no.* Lfd.Nr. *ser. no.*	Skizze der Schweißnaht *sketch of weld*	Schweißfolge zum Nahtaufbau *layer sequence for weld build-up*	Position nach Zeichnung *pos. as to drawing* Pos. m. Pos. *pos. with no.*	Grund-werkstoff *base metal*	Schweiß-verfahren *welding procedure*	Ausnutzung der zuläss. Berech-nungs-spannung *usage of all. design stress*	Schweiß-position *welding pos.*	Schweißzusätze u. –hilfstoffe Hersteller Bezeichnung Abmessung *welding filler metals and consumables; manufacturer, designation, dimension*	Trock-nungs-temperatur und Zeit *drying temp. and time*	Schweiß-daten *welding data*	Vorwärm-/ Haltetemperatur *preheating/holding temp.* [°C]	Zwischen-lagen-temperatur *interpass temperature* [°C]	Nachfolgende Wärme-behandlung *subsequent heat treatment*	Verfahrensprüfungs-Nr. Schweißerprüfung *welding procedure qualification no.; welder's performance qualification test* Arbeitsprüfungs-Nr. *production control test no.*	Hersteller: *manufacturer:* Anlage/Projekt: *power plant/project:* Komponente: *component:* Spezifikation: *specification:* Klasse: *classification:* Prüfgruppe: *test group:* KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ/type, drive, DN* Zeichnungs-Nr.: *drawing no.:* Auftrags-Nr.: *contract no.:* Bestell-Nr.: *order no.:* Werk-Nr./Index-Nr.: 1) *plant no. / index no.: 1)* PFP-Nr.: *test and inspection sequence plan no.:* WL-Nr.: *list of materials no.:*

[17] Hersteller: *manufacturer:*						
Rev. *revision*	Datum *date*	Erstellt von *prepared by*	Geprüft QST *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*
00						
01						
02						
03						1) nur für Rohrleitungen, Armaturen, Pumpen *1) only for pipes, valves, pumps*
04						

Schweißplan *Welding procedure specification*

SP-Nr.: *welding procedure specification no.:*

Seite: *page:* von: *of:*

Form A-4b: Welding procedure specification

Skizze *sketch*	Prüf-Nr. *test no.*	Wärmebehandlungsdiagramm *heat treatment diagram*	Mitlaufende Grundwerkstoff- und Arbeitsprüfstücke *accompanying test coupons of base material and production welds*	5
1	2	3	4	Hersteller: *manufacturer:* Anlage/Projekt: *power plant / project:* Komponente: *component:* KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ/ type, drive, DN:* Spezifikation: *specification:* Klasse: *classification:* Prüfgruppe: *test group:* Auftrags-Nr.: *contract no.:* Bestell-Nr.: *order no.:* Zeichnungs-Nr.: *technical drawing no.:* Werk-Nr./Index-Nr. [1]: *plant no. / index no.:* PFP/WPP-Nr. [1]: *test and inspection sequence plan no. /materials testing and specimen-taking plan no.:* SP-Nr. [1]: *welding procedure specification no.:* WL-Nr.: *list of materials no.:*

Rev. *revision*	Hersteller: *manufacturer:* Datum *date*	Erstellt von *prepared by*	Geprüft QST *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*	
00							
01							
02							
03							
04							[1] nur für Rohrleitungen, Armaturen und Pumpen *only for pipes, valves and pumps*

Wärmebehandlungsplan
heat treatment plan

WBP-Nr.:
heat treatment plan no:.

Seite:
page:

von:
of:

Form A-5: Heat treatment plan

1 Hersteller: *manufacturer:*	**Protokoll über Wärmebehandlung** *heat treatment record*	Nachweis-Nr.: *certificationt no.:* **WBK-** Seite: von: *page: of:*
Anlage/Projekt: *power plant/project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/part group:*
KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ / type, drive, DN:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr.: *test no.:*
Hersteller-Auftr.-Nr.: *manufacturer's order no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr.: *plant no./index no.:*
Spezifikation: Rev.: *specification: revision:*	Werkstoff: *material:*	Prüfgegenstand einschließlich Angabe der mitlaufenden Prüfstücke: *test object incl. accompanying test pieces:*

2 Art der Wärmebehandlung:
type of heat tretament:

Datum der Wärmebehandlung:
date of heat treatment:

Art, Anzahl und Lage der Temperaturmessstellen:
type, number and location of temperature measuring points:

Wärmebehandlungsplan-Nr.:
heat tretament plan no.:

Bei Wärmebehandlung im Ofen *in case of furnace heat treatment*	Bei örtlicher Wärmebehandlung *in case of local treatment*
Ofen-Nr.: *furnace no:*	Verfahren: *method:*
Art der Beheizung/Ofenatmosphäre: *type of heating/atmosphere:*	Wärmeeinbringbereich: *heat input area:*
	Breite der Isolierung: *width of insulation:*

3

Temperatur (°C)
temperature

Diagramm
diagram

Aufheiz- und Abgeschwindigkeit (°C/h), Haltezeit (min)
heating and cooling speed (°C/h), time at temperature (min)

Zeit (h)
time (h)

4 Die Lage der Teile, der mitlaufenden Prüfstücke und der Temperaturmessstellen sind, soweit gefordert, im Ofenbelegungsplan dargestellt.
The location of parts, accompanying test pieces and temperature measuring points shall be shown in the furnace charging plan where required.

Die Anforderungen gemäß Wärmebehandlungsplan sind: erfüllt/nicht erfüllt
The requirements of the heat treatment plan have been met / not been met

5 Bemerkungen:
remarks:

6 Unterschrift (H): *signature (manufacturer):* Ort: *place:* Datum: *date:*	Unterschrift (S): *signature (authorized inspector):* Ort: *place:* Datum: *date:*	Unterschrift: *signature:* Ort: *place:* Datum: *date:*

Form A-6: Heat treatment record

1	2	3	4	5	6	7	8	9	10		11	12	13	14	15
Prüf-Nr. *test no.*	Anforderungen nach *requirements in accordance with*	Beschreibung *description*	Anzahl je Prüfeinheit *number per test lot*	Proben-abmessungen *dimensions of test specimens*	Prüftem-peratur *test temperature* in °C	Probenlage *location of test specimens*	Proben-kennzeichnung *identification marking of test specimens*	Prüfung durch *test performed by*	Nachweis-schlüssel *certification key*		Doku-ablage *document file*	Durchführungs-vermerk *mark, when examination was performed*	Nachweise *certification of examinations*	Bemerkungen *remarks*	Hersteller: *manufacturer:*
															Anlage/Projekt: *power plant / project:*
															Komponente: *component:*
															Spezifikation: *specification:* Klasse: *classification:* Prüfgruppe: *test group:*
															KKS/AKZ/Typ, Antrieb, DN: *code KKS or AKZ / type, drive, DN:*
															Zeichnungs-Nr.: *technical drawing no.:*
															WL-Nr.: *list of materials no.:*
															Auftrags-Nr.: *contract no.:*
															Bestell-Nr.: *order no.::*
															Werk-Nr./Index-Nr. 1): *plant no. / index no.:*
															PFP-Nr. 1): *test and inspection sequence plan no.:* SP-Nr.: *welding procedure specification no.:*

(16) Hersteller: *manufacturer:*							Dokumentationsfreigabe *release certification of documents*	**Werkstoffprüf- und Probenentnahmeplan** *materials testing and specimen-taking plan*
Rev. *revision*	Datum *Date*	Erstellt von *prepared by*	Geprüft QST *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*	Hersteller *manufacturer:*	
00								WPP-Nr.: *materials testing and specimen-taking plan no.*
01							Sachverständiger *authorized inspector*	
02								
03								Seite: / *page:*
04							1) nur für Rohrleitungen, Armaturen und Pumpen *only for pipes, valves and pumps*	von: / *of:*

Form A-7: Materials testing and specimen-taking plan

1

SAMPLE COPY

2 Hersteller:
manufacturer:

Rev. *revision*	Datum: *date*	Erstellt von: *prepared by*	Geprüft QST: *checked by quality dept.*	Grund der Revision *reason for revision*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*
00						
01						
02						
03						
04						

Anlage/Projekt:
power plant / project:

Komponente:
component:

Anhang zu:
annex of:

Seite:
page:

Von:
of:

Form A-8: Annex

1 Anlage/Projekt: *power plant / project*	**Inhaltsverzeichnis Endablage** *Contents (IVZ) Final file*	Nachweis-Nr.: *certificationt no.:* **IVZ-** Seite: *page:* von: *of:*
Hersteller: *manufacturer:*		
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form / part / sub-unit:*
Hersteller-Auftr.-Nr.: *manufacturer's contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnungs-Nr.: *plant no. / index no.:*

2 Dokumentationsunterlage *document*	3 Seitenzahl *number of pages*	4 Dokumentenart 1) *document type:*	5 Ordner- Nr. *file no.*

6 Unterschrift (H): *signature (H):* Ort: *place:* Datum: *date:*	Unterschrift (S: *signature (S):* Ort: *place:* Datum: *date:*	Unterschrift: *signature:* Ort: *place:* Datum: *date:*

1) z.B. Vorprüfunterlagen, Nachweise (Art)
e.g. design approval documents, certificates (type)

Form A-9: Contents final file

1	2	3	4	5		6	7	8	9	10		
Pos.-Nr. *pos. no:*	Bezeichnung *designation*	Abmessungen *dimension*	Werkstoff *material*	Anforderungen nach *requirements to*	Rev. *revision*	Schmelzen-Nr., Proben-Nr., Rohr-Nr. *heat no, specimen no, pipe no.*	Schlüssel-Nummer *key no.*	Werk-Nr. oder Fabrik-Nr. *plant no. or works no.*	Nachweiskennzeichnung *certification of identification marking*	Prüfvermerke *check notes*		
										H		S

11	Rev. *revision*	Datum *date*	Erstellt von *prepared by*	Geprüft (H) *checked (H)*	Freigabe *release certification*	Prüfvermerk des Sachverständigen gemäß § 20 AtG *certification mark of authorized inspector to § 20 AtG*
Vor-prüfung *design review*						

12 Anlage/Projekt: *power plant / project:*	Spezifikation: *specification:*	Rev.: *revision*
Bestell-Nr.: *order no.:*	Hersteller: *manufactorer:*	
Auftrags-Nr.: *contract no:*	Klasse: *classification:*	Prüfgruppe: *test group:*

Bau-prüfung *final inspection*	Unterschrift (H): *signature (H):* Datum: *date:*	Unterschrift (S): *signature (S):* Datum: *date:*	Unterschrift: *signature:* Datum: *date:*	**Isometriestückliste** *isometric parts list* ISO-SL.-Nr.: *isometric parts list no.*	Seite: *page:* Von: *of:*

Form A-10: Isometric parts list

SAMPLE COPY

Hersteller:
manufactorer:

Auftrags-Nr.:
contract no.:

Bestell-Nr.:
order no:.

ISO-SL-Nr.: Rev.:
isometric parts list no. *revision:*

PFP (allgem.) Rev.:
PFP (general) *revision:*

PFP (Schweißnähte) Rev.:
PFP (welds) *revision:*

Schweißplan-Nr.: Rev.:
weld procedure sheet no.: *revision:*

Auslegungsdruck:
design pressure:
(MPa)

Auslegungstemperatur:
design temperature:
(°C)

Spezfikation:
specification:

Klasse: Prüfgruppe:
classification: *test group:*

Vorprüfung *design review*						Bauprüfung *final inspection*			Plangruppe: *planning group:*	Anlage/Projekt: *power plant / project:*
Rev. *revision*	Datum *date*	Erstellt von *prepared by*	Geprüft H *checked by manuf.*	Prüfvermerk *certification mark*	S-Prüfvermerk *certification mark of auth. inspector*	Unterschrift (H), Datum *signature manufacturer, date*	Unterschrift (S), Datum *signature auth. inspector, date*	Unterschrift, Datum *signature, date*		
									Raum: *room:*	
									Fertigungsisometrie *isometric fabrication drawing*	
									ISO-Nr.: *isometric fabrication drawing no.*	

Form A-11: Isometric fabrication drawing

1 Hersteller: *manufacturer:*	**Schweißprotokoll** *welding record (SPK)*	Nachweis-Nr.: *certification no.* **SPK-** Seite: *pages:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form / part / sub-unit:*
Zeichnung Nr.: *technical drawing no.:*	Naht-Nr./Schweißstellen-Nr. [1]: *weld no. / weld location no· [1]:*	SP-Nr.: *welding procedure sheet no.:* Rev.: *revision:*
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	PFP/WPP: *test and inspection sequence plan no. /materials testing and specimen-taking plan no.*	Prüf-Nr.: *test / examination no.:*
Hersteller-Auftr.-Nr.: *manufacturer's contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnungs-Nr.: *plant no. / index no.:*
Maschinentyp und Maschinennummer: *equipment type and no.:*	Besondere Vorrichtungen: *special equipment:*	

SAMPLE COPY

Schweißfolge *welding sequence*	Schweißverfahren *welding process*	Lagen-Nr. *layer no.*	Schweißzusätze und Hilfsstoffe / *welding filler metals and consumables*: Handelbezeichnung der Schweißzusätze u. -hilfsstoffe *trademark of filler metals and consumables*	Schmelze-Nr. und Fertigungs-Nr. *heat no. and fabrication no.*	Schutzgas nach DIN EN ISO 14175 *shield gas to DIN EN ISO 14175* in l/min	Pulver Handelsbezeichnung *flux trademark*	Schweißdaten / *welding data*: Stromstärke Stromart Polung *amperage type of current polarity* in A	Geschwindigkeit *travel speed* in mm/min	Pendelbreite *oscillation width* in mm	Drahtgeschwindigkeit Heißdraht *wire speed hot wire* in mm/min	Vorwärm-/Haltetemperatur *preheat / holding temp.* in °C	Pulsfrequenz *pulse frequency* [Hz] bei UP: Düsen-Nr. *for submerged arc: nozzle no.*	Schweißer-Name oder Kenn-Nummer *welder's name or indentification no.*	Datum *date*	Unterschrift *signature*
	Schweißposition *welding position*	Raupen-Nr. *bead no.*	Abmessungen *dimensions*		Formiergas nach DIN EN ISO 14175 *purging gas to DIN EN ISO 14175* in l/min	Chargen-Nr. *batch no.*	Spannung *voltage* in V	Auszieh-länge *run-out length* in mm	Pendelfrequenz *oscillation frequency* in 1/min	Kaltdraht *cold wire* in m/min	Zwischenlagentemperatur *interpass temperature* in °C	Pulsstrom/ Grundstrom *pulse current/ background current* in A	Bemerkung *remarks*	Uhrzeit *time*	H Schweißaufsicht *welding supervision* / H Qualitätsstelle *quality departm.* / S *authorized inspector*

[1] Nicht zutreffendes streichen
[1] *Delete where not applicable*

Form A-12a: Welding record

	Schweißprotokoll (Folgeseite) *welding record (SPK)*	Nachweis-Nr.: *certification no.* ***SPK-*** Seite: *pages:* von: *of:*	1	Hersteller: *manufacturer:*	Komponente: *component:*	Schweißplan-Nr.: *weld procedure sheet no.:*
				Anlage/Projekt: *power plant / project:*		
				PFP/WPP: *test and inspection sequence plan no. /materials testing and specimen-taking plan no.*	Prüf-Nr.: *test / examination no.:*	Schweißstellen-Nr.: *weld location no.:*

			Schweißzusätze und Hilfsstoffe / *welding filler metals and consumables*				Schweißdaten / *welding data*											
Schweiß-folge *welding sequence*	Schweiß-verfahren *welding process*	Lagen-Nr. *layer no.*	Handelbezeichnung der Schweißzusätze u. -hilfsstoffe *trademark of filler metals and consumables*	Schmelze-Nr. und Fer-tigungs-Nr. *heat no. and fabrication no.*	Schutzgas nach DIN EN ISO 14175 *shield gas to DIN EN ISO 14175* in l/min	Pulver Handels-bezeichnung *flux trademark*	Stromstärke Stromart Polung *amperage type of current polarity* in A	Geschwin-digkeit *travel speed* in mm/min	Pendel-breite *oscillation width* in mm	Draht-geschwindig-keit Heißdraht *wire speed hot wire* in mm/min	Vorwärm-/ Halte-temperatur *preheat / holding temp.* in °C	Pulsfrequenz *pulse frequency* [Hz] bei UP: Düsen-Nr. *for submerged arc: nozzle no.*	Schweißer-Name oder Kenn-Nummer *welder's name or indentification no.*	Datum *date*	Unterschrift *signature*			
	Schweiß-position *welding position*	Raupen-Nr. *bead no.*	Abmessungen *dimensions*		Formiergas nach DIN EN ISO 14175 *purging gas to DIN EN ISO 14175* in l/min	Chargen-Nr. *batch no.*	Spannung *voltage* in V	Ausziehlänge *run-out length* in mm	Pendel-frequenz *oscillation frequency* in 1/min	Kaltdraht *cold wire* in m/min	Zwischen-lagentempe-ratur *interpass temperature* in °C	Pulsstrom/ Grundstrom *pulse current/ background current* in A	Bemerkung *remarks*	Uhrzeit *time*	H Schweiß-aufsicht *welding supervision*	H Qualitäts-stelle *quality departm.*	S *authorized inspector*	

SAMPLE COPY

Form A-12b: Welding record (continued)

1 Hersteller: *manufacturer*	**Schweißprotokoll Sammelbescheinigung (Deckblatt)** *welding record / overall certificate (cover sheet)*	Nachweis-Nr.: *record No.:* **SPS-** Seite: *page:* von: *of:*
Anlage/Projekt: *power plant/project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly*
KKS/AKZ: *code acc. to KKS or AKZ identification system:*	PFP/WPP/Schritt-Nr.: *test and inspection sequence plan no. / materials testing and specimen-taking plan no. / step no.:*	Prüf-Nr./Lfd.-Nr.: *test no. / serial no.:.*
Hersteller-Auftr.-Nr.: *manufacturer´s contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr. 1): *fabrication no./ idenification marking 1):*

2 Schweißprotokoll-Nr.: *weld record no.*	befindet sich in der Dokumentation des Herstellers *filed in manufacturer's documentation*	
Dauer der Schweißung von *duration of welding*	bis *from*	
Schweißnahtart: *type of weld*		
Schweißstellen-Nr./Naht-Nr.: *weld location no. / weld no.:*	SP-Nr.: *welding procedure specification no.:*	Rev.: *revision:*
Grundwerkstoff: *base metal:*	AP-Nr.: *production control test no.:*	
Gültige Verfahrensprüfungs-Nr.: *valid welding procedure qualification no.:*		

3 Verwendete Schweißgeräte: *welding equipment used:*

Verfahren *process*	Masch.-Typ *equipment type*	Masch.-Nr.: *equipment no.*	Besondere Vorrichtungen *special equipment*

4 Verwendete Schweißzusätze und -hilfsstoffe: *filler metals and consumables used*

Schweißfolge *welding sequence*	Verfahren *process*	Bezeichnung *designation*	Abmessung *dimension*	Los.-Nr. *lot no.*	Chargen-Prüfung *weld material test no.*

5 Ausarbeiten der Wurzel durch: *root gouged by:*

1) z. B. Schmelze-Nr. oder Coupon-Nr., nicht zutreffend in Verbindung mit PFP/WPP
e.g., melt no. or coupon no, not applicable in connection with test and inspection sequence plan / materials testing and specimen-taking plan

Dieses Formblatt ist nur in Verbindung mit Formblatt A-13b anzuwenden.
This form shall be used together with form A-13b only.

Form A-13a: Welding Record / Overall certificate (cover sheet)

	Schweißprotokoll Sammelbescheinigung **(Kontrollblatt)** *welding record / overall certificate* *(review sheet)*	Nachweis-Nr.: *record no.:* **SPS-** Seite: *page:* von: *of:*

6 Protokollierte Parameter:
recorded parameter:

Drahtgeschwindigkeit:
wire speed:

Raupenüberdeckung:
bead overlap:

Pendelbreite:
oscillation width:

Wurzelausarbeitung:
root dressing:

Schweißfolge *welding sequence*	Schweißposition *welding position*	Lagenzahl Raupenzahl *number of layers / number of beads*	I in A U in V min/max	Stromart und Polung *type of current and polarity*	Vorwärm-/ Haltetemp. in °C *preheat/holding temp.* Zwischenlagentemp. *interpass temp.* min/max in °C	Ausziehlänge *run-out length* in mm Schweißgeschwindigkeit *welding speed* in mm/min	Gasart *type of gas* DIN EN ISO 14175 Gasmenge *gas consumption* in l/min	Düsendurchmesser *nozzle diameter* in mm	Schweißer-Nr. *welder's ident. no.*
a	b	c	d	e	f	g	h	j	k

7 Soaking:
soaking:

8 Besonderheiten:
special remarks:

9 Ergänzende Angaben zum Schweißen, siehe Anlage
supplementary data regarding welding, see annex

10 Zulässige Abweichungen mit Begründung, siehe Anlage
allowable deviations with reason, see annex

11 Skizze:
sketch:

12 Die Bedingungen des Schweißplanes wurden - soweit nicht unter „Besonderheiten" (Rubrik 8) anders vermerkt - eingehalten.
Requirements of welding procedure specification are complied with unless described under „special remarks".

13 Unterschrift (H): *signature (manufacturer):* Ort: *place:* Datum: *date:*	Unterschrift (S): *signature (authorized inspector):* Ort: *place:* Datum: *date:*	Unterschrift: *signature:* Ort: *place:* Datum: *date:*

Form A-13b: Welding Record / Overall certificate (review sheet)

1 Hersteller: *manufacturer:*	**Prüfbericht über Ultraschallprüfung** *Ultrasonic testing report*	Nachweis-Nr.: *record no.:* **UT-** Seite: *page:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly:*
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr. aus PFP: *test no. to test and inspection sequence plan:*
		Prüfzeitpunkt: *time of testing:*
Hersteller-Auftr.-Nr.: *manufacturer´s contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr.: *plant no./index no.:*
Spezifikation: *specification:* Rev.: *revision:*	Prüfvorschrift: *process spec.:* Rev.: *revision:*	Prüfanweisung: *test instruction:* Rev.: *revision:*
Zeichnungs-Nr.: *technical drawing no.:* Rev.: *revision:*	Werkstoff: *material:*	Prüfgegenstand: *test object:*
	Abmessung: *dimension:*	Prüfumfang: *extent of testing:*

2 Oberflächenzustand Prüffläche: *condition of scanning surface:* Gegenflächen: *condition of opposite surface:*

Prüfgerätetyp/Hersteller: *type of equipment and manufacturer:* Koppelmittel: *couplant:*

Ident.-Nr.: *identification no.:*

Kontrolle des kompletten Prüfsystems nach DIN EN 12668-3 durchgeführt: ☐ Anforderungen erfüllt
check of the complete test system to DIN EN 12668-3 performed *requirements have been met*

3

Einschallposition *scanning position*	Prüfkopfbezeichnung *designation of probe*	Angepasst: j = ja; n = nein *adapted: y = yes; n = no*	Entfernungs-justierung *Range adjustment*		Empfindlichkeitsjustierung *calibration of sensitivity*				Registrierverstärkung für max. auszuwertenden Schallweg S_{max} *Increase in gain for recording at max. sound path travel distance S_{max}*									Zuschlag für Beobachtungsschwelle *evaluation level allowance*	Schallschwächung *sound attenuation*
			Prüfbereich *scanning range* mm	Art (S, PA, vPA) *method (BP, PD, SPD)*	Bewertungsmethode (AVG, DAC, VK) *evaluation method (DGS, DAC, RB)*	Kalibrier-, Vergleichskörper *calibration / reference block*	Bezugsreflektor *reference reflector*	Schallweg zum Bezugsreflektor *Beam path to reference reflector* mm	Registrierschwelle (KSR, %DAC, %BH) *Recording level (CRR, %DAC, %RE)*	Schallweg S_{max} *Beam path S_{max}* mm	A V aus AVG-Diagramm bzw. Prüfvorschrift (DAC/VK) *ΔV from DGS diagram or process specification (DAC, RB)* dB	B Korrekturfaktor für K1 und K2 *corrective value for K1 and K2* dB	C Transferkorrektur [1] *transfer correction [1]* dB	D Grundverstärkung *basic gain* dB	Summe A bis D *total of A to D* dB	dB	dB/m

4 Bemerkungen: *remarks:*

Die Anforderungen sind: *the requirements have*
- ☐ Erfüllt, keine registrierpflichtigen Anzeigen *been met / no recordable indications*
- ☐ Erfüllt, mit registrierpflichtigen Anzeigen *been met / recordable indications*
- ☐ Nicht erfüllt *not been met*

5 Firma (☐ H oder ☐ S): *firm manufacturer or authorized inspector*

Name Prüfer/UT Stufe 2 [2]: *name of operator/UT level 2 [2]*
Zertifikat Nr.: *certificate no.*
Unterschrift: *signature*
Ort: *place*
Datum: *date*

Name Prüfaufsicht/UT Stufe 3 [2]: *name of supervisor/UT level 3 [2]*
Zertifikat Nr.: *certificate no.*
Unterschrift: *signature*
Ort: *place*
Datum: *date*

Firma (B): *firm (plant owner)*
Name: *name*
Unterschrift: *signature*
Ort: *place*
Datum: *date*

1) Ankopplungs- und Schallschwächungsunterschiede für S_{max}. *(coupling and sound attenuation differencies for S_{max})*
2) Zertifizierungsstufe nach DIN EN ISO 9712. (*level of certificate in acc. with DIN EN EN 9712)*

Form A-14a: Ultrasonic testing report

1 Hersteller: *manufacturer:*	**Prüfbericht über Ultraschallprüfung** *Ultrasonic testing report*	Nachweis-Nr.: *record no.:* **UT-** Seite: *page:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly:*
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr. aus PFP: *test no. to test and inspection sequence plan:* / Prüfzeitpunkt: *time of testing:*

2

Schweißnaht Nr. /Bauteil Nr. *weld or part no.*	Reflektor Nr. *reflector no.*	Einschallposition *scanning position*	Prüfkopfbezeichnung *designation of probe*	Lage und Orientierung von Reflektoren *location and orientation of reflectors*							Ergebnis *result*			Bewertung *evaluation*		Bemerkungen *remarks*
				Schallweg S, PA, vPA *sound path lenght S, PD, SPD* mm	Abstand vom Bezugspunkt *distance from reference point* x mm	y mm	Tiefe von *depth from* Innen *inside* mm	Außen *outside* mm	in Längsrichtung [1] *in longitudinal direction [1]*	in Querrichtung [1] *in transverse direction [1]*	Überschreitung der Registrierschwelle *above recording level* dB	Anzeigenlänge *length of indication* mm	Registrierfläche *recording area* mm^2	Die Anforderungen sind: *The requirements have* Erfüllt *been met*	Nicht erfüllt *not been met*	

3 Bemerkungen: *remarks:*

4 Firma (☐ H oder ☐ S): *firm manufacturer or authorized inspector*		Firma (B): *firm (plant owner)*
Name Prüfer/UT Stufe 2 [2]: *name of examiner/UT level 2 [2]*	Name Prüfaufsicht/UT Stufe 3 [2]: *name of supervisor/UT level 3 [2]*	Name: *name*
Zertifikat Nr.: *certificate no.*	Zertifikat Nr.: *certificate no.*	
Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*
Ort: *place*	Ort: *place*	Ort: *place*
Datum: *date*	Datum: *date*	Datum: *date*

1) Nur für Schweißnähte
for welds only

2) Zertifizierungsstufe nach DIN EN ISO 9712.
level of certificate in acc. with DIN EN EN 9712

Form A-14b: Ultrasonic testing report

1 Hersteller: *manufacturer:*	**Prüfbericht** *Test report*	Nachweis-Nr.: *record no.:* Seite: *page:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly:*
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr. aus PFP: *test no. to test and inspection sequence plan:* Prüfzeitpunkt: *time of testing:*

2 Skizze:
sketch:

3 Bemerkungen:
remarks:

4 Firma (☐ H oder ☐ S): *firm manufacturer or authorized inspector*		Firma (B): *firm (plant owner)*	
Name Prüfer/UT Stufe 2 [1]: *name of examiner/UT level 2 [1]* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*	Name Prüfaufsicht/UT Stufe 3 [1]: *name of supervisor/UT level 3 [1]* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*	Name: *name* Unterschrift: *signature* Ort: *place* Datum: *date*	

[1] Zertifizierungsstufe nach DIN EN ISO 9712.
level of certificate in acc. with DIN EN EN 9712

Form A-14c: Ultrasonic testing report

1 Hersteller: *manufacturer:*	**Prüfbericht über Oberflächenprüfung** *Surface examination report*	Nachweis-Nr.: *record no.:* **MT/PT-** Seite: *page:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly:*
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr. aus PFP: *test no. to test and inspection sequence plan:* / Prüfzeitpunkt: *time of testing:*
Hersteller-Auftr.-Nr.: *manufacturer´s contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr.: *plant no./index no.:*
Spezifikation: *specification:* Rev.: *revision:*	Prüfvorschrift: *process spec.:* Rev.: *revision:*	Prüfanweisung: *test instruction:* Rev.: *revision:*
Zeichnungs-Nr.: *technical drawing no.:* Rev.: *revision:*	Werkstoff: *material:*	Prüfgegenstand: *test object:*

2 Oberflächenzustand *(surface condition)*: Beleuchtungsstärke *(illuminance)*: lx Bestrahlungsstärke *(light intensity)*: W/m^2	Prüftemperatur T: *testing temperature*	T < 10 °C ☐ 10 °C ≤ T ≤ 50 °C ☐ T > 50 °C ☐
3 **MT** Magnetisierungsart nach 1): *method of magnetisation to 1)*	Prüfgeräte-Typ/Hersteller: *type of equipment and manufacturer:* Ident.-Nr.: *identification no.:*	
Magnetpulverbezeichnung/Charge Nr.: *magnetic particle powder trade name / batch no.:*	Bezeichnung Trägerflüssigkeit und Zusätze/Charge Nr.: *carrier fluid and additives trade name / batch no.:*	
Bezeichnung Kontrastmittel/Charge Nr.: *contrast medium trade name / batch no.:*	UV-Prüflampe/Typ/Hersteller: *UV lamp trade name and manufacturer:* Ident.-Nr.: *identification no.:*	

Elektroden-/Polabstand bei SS/JE: *prod spacing / pole spacing for SS/JE:*	Anzahl der Windungen bei LK: *number of wrappings for LK*	Stromstärke (A) bei LK/SS: A *current for LK/SS:* Spannung (V) bei LK/SS: V *voltage for LK/SS:*
Tangent. Feldstärke: kA/m *tangential field strength (kA/m):* Messgerät: *measuring tool:* Ident.-Nr.: *identification no.:*	Entmagnetisierung: *demagnetisation* ja *yes* ☐ nein *no* ☐	Elektrodenmaterial bei SS: *prod tip material for SS:*

4 **PT** Prüfmittelsystem nach 1): *testing equipment to 1)* : Empfindlichkeitsklasse nach 1): *sensitivity class to 1)* :		Hersteller: *manufacturer:*
Bezeichnung Eindringmittel/Charge Nr.: *penetrant trade name / batch no.:*	Bezeichnung Zwischenreiniger/Charge Nr.: *remover trade name / batch no.:*	Bezeichnung Entwickler/Charge Nr.: *developer trade name / batch no.:*
Vorreinigung: *precleaning:*	Trocknung nach Vorreinigung: *drying after precleaning:*	Auftragart Eindringmittel: *penetrant application:* / Eindringdauer (min): *penetration time (min):*
Zwischenreinigung: *surface penetrant removal:*	Trocknung nach Zwischenreinigung: *drying after excess penetrant removal:*	Auftragart Entwickler: *developer application:*

Inspektionszeitpunkte *inspection times*	nach dem Antrocknen des Entwicklers *after drying of developer*	nach 30 Min. *after 30 min.*		
Wesentliche Änderungen *major changes:* ja/*yes*				
nein/*no*				

5 Bewertung: *evaluation:* Die Anforderungen sind: *The requirements have*

☐ Erfüllt, keine Anzeigen *been met, no indications*

☐ Erfüllt, keine unzulässigen Anzeigen *been met, no unacceptable indications*

☐ Nicht erfüllt, unzulässige Anzeigen siehe Ergebnisblatt *not been met, unacceptable indications as given in sheet of results*

6 Prüfumfang: *extent of testing:*	Bemerkungen: *remarks:*

7 Prüfer, MT/PT Stufe 1 2)(H): *examiner, MT/PT level 1 2) (manufacturer)*	Prüfaufsicht, MT/PT Stufe 2 2) *supervisor, MT/PT level 2 2) (manufacturer)*	(B): *(plant owner)*	Prüfer, MT/PT Stufe 1 2)(S): *examiner, MT/PT level 1 2) (auth. insp.)*	Prüfaufsicht, MT/PT Stufe 2 2)(S): *supervisor, MT/PT level 2 2) (authorized insp.)*
Name: *name*	Name: *name*	Name: *name*	Name: *name*	Name: *name*
Zertifikat Nr.: *certificate no.*	Zertifikat Nr.: *certificate no.*		Zertifikat Nr.: *certificate no.*	Zertifikat Nr.: *certificate no.*
Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*
Ort: *place*	Ort: *place*	Ort: *place*	Ort: *place*	Ort: *place*
Datum: *date*	Datum: *date*	Datum: *date*	Datum: *date*	Datum: *date*

1) Die angewandte Norm ist anzugeben. *(The standard applied shall be indicated).*

2) Zertifizierungsstufe nach DIN EN ISO 9712. (*level of certificate in acc. with DIN EN ISO 9712)*

Form A-15: Surface examination report

1 Hersteller: *manufacturer:*	**Prüfbericht über Durchstrahlungsprüfung (Filmradiografie)** *Radiographic testing report (film radiography)*	Nachweis-Nr.: *record no.:* **RT-** Seite: *page:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly:*
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr. aus PFP: *test no. to test and inspection sequence plan:*
		Prüfzeitpunkt: *time of testing:*
Hersteller-Auftr.-Nr.: *manufacturer´s contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr.: *plant no./index no.:*
Spezifikation: *specification:* Rev.: *revision:*	Prüfvorschrift: *process spec.:* Rev.: *revision:*	Prüfanweisung: *test instruction:* Rev.: *revision:*
Zeichnungs-Nr.: *technical drawing no.:* Rev.: *revision:*	Werkstoff: *material:*	Prüfgegenstand: *test object:*
Prüfumfang: *extent of testing:*		

2 Oberflächenzustand Außenseite: *surface condition outside:* Innenseite: *surface condition inside:*

Filmlageplan Nr.: *film location plan no.*	Gerätehersteller und -typ: *equipment manufacturer and type:* Ident.-Nr.: *identification no.:*
Strahlenquelle: *radiation source:*	Abmessungen des Brennflecks/Strahlenquelle: mm x mm *focal spot size / source* nach Zertifikat-Nr.: *as per certificate no.:*
Geforderte Klasse nach DIN EN ISO 17636-1: *required class as per DIN EN ISO 17636-1:*	Filmhersteller und -typ: *film brand and type:* Filmsystemklasse nach DIN EN ISO 11699-1: *film system type as per DIN EN ISO 11699-1:*
Aufnahmeanordnung nach DIN EN ISO 17636-1, Bild: *exposure arrangement as per DIN EN ISO 17636-1, picture:*	Folienart und -dicke: *screen material and thickness* vorn: *front:* hinten: *back:*

3

Schweißnaht-Nr./ Bauteil-Nr. *weld no. / part no.*	Prüfabschnitt/ Filmbezeichnung *weld section / film identification*	Werkstückdicke *part thickness* mm	Außendurchmesser *outer diameter* mm	Röhrenspannung *plate voltage* kV	Röhrenstrom *plate current* mA	Aktivität *activity* GBq	Belichtungszeit *exposure time* min	Abstand (f) Strahlenquelle-Prüfgegenstand *distance (f) between source and test object* mm	Bildgüteprüfkörper nach DIN EN ISO 19232-1 *image quality indicator to DIN EN ISO 19232-1*	Lage *position* Filmnah *close to film*	Lage *position* Filmfern *remote from film*	Bemerkungen *remarks:*

4 Bemerkungen: *remarks:*

Form A-16a: Radiographic testing report (film radiography) - page 1

	Prüfbericht über Durchstrahlungsprüfung (Filmradiografie) *Radiographic testing report (film radiography)*	Nachweis-Nr.: *record no.:* **RT-** Seite: *page:* von: *of:*

5 Schweißnaht-Nr./ Bauteil-Nr. *weld no. / part no.*	Prüfabschnitt/ Filmbezeichnung *section to be tested/ film identification*	Schwärzung *density* Minimum *maximum*	Schwärzung *density* Maximum *minimum*	Bildgütezahl nach DIN EN ISO 17636-1 [1] *image quality index as per DIN EN ISO 17636-1* [1] Gefordert *required value*	Bildgütezahl nach DIN EN ISO 17636-1 [1] Erreicht *actual value*	Beschreibung von Unregelmäßigkeiten [1] *characterization of imperfections* Referenz-Nr. nach DIN EN ISO 6520-1 [2] *reference no. as per DIN EN ISO 6520-1* [1]	Filmfehler *film defect*	Ohne Unregelmäßigkeiten *without imperfections*	Die Anforderungen sind: *The requirements have* Erfüllt *been met*	Nicht erfüllt *not been met*	Bemerkungen *remarks* z. B. Lage der Unregelmäßigkeit mit Längenausdehnung *i.e. location of the irregularities and extension in length*

6 Bemerkungen: *remarks:*	Die Anforderungen sind: *The requirements have* ☐ Erfüllt *been met* ☐ Nicht erfüllt *not been met*

7 Prüfer/RT-F Stufe 2 [3] (H): *examiner/RT-F level 2* [3] *(manufacturer)*	Prüfaufsicht/RT Stufe 3 [3] (H): *supervisor/RT level 3* [3] *(manufacturer)*	(B): *(plant owner)*	Prüfer/RT-F Stufe 2 [3] (S): *examiner/RT-F level 2* [3] *(auth. insp.)*	Prüfaufsicht/RT Stufe 3 [3] (S): *supervisor/RT level 3* [3] *(authorized insp.)*
Name: *name*	Name: *name*	Name: *name*	Name: *name*	Name: *name*
Zertifikat Nr.: *certificate no.*	Zertifikat Nr.: *certificate no.*		Zertifikat Nr.: *certificate no.*	Zertifikat Nr.: *certificate no.*
Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*	Unterschrift: *signature*
Ort: *place*	Ort: *place*	Ort: *place*	Ort: *place*	Ort: *place*
Datum: *date*	Datum: *date*	Datum: *date*	Datum: *date*	Datum: *date*

1) Ggf. Hinweis auf Vergleichsaufnahme in Spalte „Bemerkungen“.
Comparison with reference radiograph, if required, in „remarks“ column.

2) Zu verwendende Referenznummern (Beispiele) und deren Bedeutung:
Reference numbers (examples) to be used and their meaning:

- 101 Längsriss *(logitudinal crack)*
- 102 Querriss *(transverse crack)*
- 104 Endkraterriss *(crater crack)*
- 106 Verästelte Risse *(branching cracks)*
- 2011 Pore *(pore)*
- 2013 Porennest *(clustered (localized) porosity)*
- 2015 Gaskanal *(elongated cavity)*
- 2016 Schlauchpore *(wormhole)*
- 202 Lunker *(cavity)*
- 301 Schlackeneinschluss *(slag inclusion)*
- 304 Metallischer Einschluss *(metallic inclusion)*
- 401 Bindefehler *(lack of fusion)*
- 402 Ungenügende Durchschweißung *(lack of penetration)*
- 5011 Kerbe *(concavity)*
- 5013 Wurzelkerbe *(root contraction)*
- 515 Wurzelrückfall *(root concavity)*

3) Zertifizierungsstufe nach DIN EN ISO 9712.
level of certificate in acc. with DIN EN ISO 9712

Form A-16b: Radiographic testing report (film radiography) - last page

1 Hersteller: *manufacturer:*	**Prüfbericht über Durchstrahlungsprüfung (Digitale Radiografie)** *Radiographic testing report (digital radiography)*	Nachweis-Nr.: *record no.:* **DR-** Seite: *page:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly:*
KKS/AKZ/Typ, Antrieb, DN: *code acc. to KKS or AKZ identification system / type, drive, DN:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr. aus PFP: *test no. to test and inspection sequence plan:*
		Prüfzeitpunkt: *time of testing:*
Hersteller-Auftr.-Nr.: *manufacturer´s contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr.: *plant no./index no.:*
Spezifikation: *specification:* Rev.: *revision:*	Prüfvorschrift: *process spec.:* Rev.: *revision:*	Prüfanweisung: *test instruction:* Rev.: *revision:*
Zeichnungs-Nr.: *technical drawing no.:* Rev.: *revision:*	Werkstoff: *material:*	Prüfgegenstand: *test object:*
Prüfumfang: *extent of testing:*		

2 Oberflächenzustand Außenseite: *surface condition outside:* Innenseite: *surface condition inside:*

Strahlenquelle: *radiation source:* Gerätehersteller und -typ: *equipment manufacturer and type:* Ident.-Nr.: *identification no.:* Größe der Strahlenquelle (Brennfleck) d: mm *radiation source size (focal spot) d:* nach Zertifikat-Nr.: *as per certificate no.:*	Geforderte Klasse nach DIN EN ISO 17636-2: *required class as per DIN EN ISO 17636-2:* Aufnahmeanordnung nach DIN EN ISO 17636-2, Bild: *exposure arrangement as per DIN EN ISO 17636-2, Figure:* Detektorpositionsplan: *detector position plan:*

Angewendete Technik *techique applied*
Digitale Radiografie mit Matrixdetektor DDA: ☐ *digital radiography with digital detector array:*
Digitale Radiografie mit Speicherfolien CR: ☐ *digital radiography with imaging plates:*

DDA-Typ: *DDA type:* Verstärkung: *gain:* Pixelgröße: *pixel size:* Kalibrierverfahren: *calibration method:* Basisortsauflösung $SR_b^{Detektor}$: *basic spatial resolution $SR_b^{Detector}$:* Vergrößerung: *magnification:* Einzelbildbelichtungszeit: *single image exposure time:* Anzahl der Bildintegrationen: *number of image integrations:*	CR-Scanner: *CR scanner:* Scanmodus: *scanning mode:* Grauwertauflösung: *grey scale resolution:* SpeicherfolienTyp: *imaging plate type* Kassette: starr ☐ *cassette: rigid* flexibel ☐ *flexible* Vorder-/Hinterfolie (Dicke/Material): mm *front / back screen (thickness/material):* Verstärkung: *gain:* Filter: *filter:* Basisortsauflösung $SR_b^{Detektor}$: µm *basic spatial resolution $SR_b^{Detector}$:* Pixelgröße: µm *pixel size:* Abtastgeschwindigkeit: mm/sec *scanning speed:* Laserintensität: µW/cm² *laser intensity:* Laserspotgröße: µm *laser spot size:*

3

Schweißnaht-Nr./ Bauteil-Nr. *weld no. / part no.*	Prüfabschnitt *section to be tested*	Werkstückdicke *part thickness* mm	Außendurchmesser *outer diameter* mm	Röhrenspannung *plate voltage* kV	Röhrenstrom *plate current* mA	Aktivität *activity* GBq	Belichtungszeit *exposure time* min	Abstand Strahlenquelle-Detektor FDA *distance between source and detector FDA* mm	Bildgüteprüfkörper nach DIN EN ISO 19232-1 und DIN EN ISO 19232-5 *image quality test indicator to DIN EN ISO 19232-1 and DIN EN ISO 19232-5*	Lage *position* Detektornah *close to film*	Lage *position* Detektorfern *far from detector*	Bemerkungen *remarks:*

4 Bemerkungen: *remarks:*

Form A-17a: Radiographic testing report (digital radiography) - page 1

	Prüfbericht über Durchstrahlungsprüfung (Digitale Radiografie) *report on radiographic testing (digital radiography)*	Nachweis-Nr.: *record no.:* **DR-** Seite: *page:* von: *of:*

5

Schweißnaht-Nr./Bauteil-Nr. *weld no. / part no.*	Prüfabschnitt *section to be tested*	Grauwert *grey value* Minimum *minimum*	 Maximum *maximum*	Signal-Rausch-verhältnis SNR_N *signal-to-noise ratio SNR_N* Soll *required*	 Ist *achieved*	Bildgütezahl nach DIN EN ISO 19232-1 *image quality index as per DIN EN ISO 19232-1* Gefordert *required*	 Erreicht *achieved*	Bildunschärfezahl nach DIN EN ISO 19232-5 *image unsharpness value as per DIN EN ISO 19232-5* Gefordert *required*	 Erreicht *achieved*	Beschreibung von Unregelmäßigkeiten *characterization of imperfections* Referenz-Nr. nach DIN EN ISO 6520-1 [1] *reference no. as per DIN EN ISO 6520-1 [1]*	 Ohne Unregelmäßigkeiten *without imperfections*	Die Anforderungen sind: *the requirements have* Erfüllt *been met*	 Nicht erfüllt *not been met*	Bemerkungen *remarks* z. B. Lage der Unregelmäßigkeit mit Längenausdehnung *i.e. location of the imperfections and extension in length*

6 Bemerkungen:
remarks:

Die Anforderungen sind:
The requirements have

☐ Erfüllt *been met*

☐ Nicht erfüllt *not been met*

7

Prüfer/RT-D Stufe 2 [3] (H): *operator/RT-D level 2 [3] (manufacturer)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *Date*	Prüfaufsicht/RT Stufe 3 [3] (H): *supervisor/RT level 3 [3] (manufacturer)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*	(B): *(plant owner)* Name: *name* Unterschrift: *signature* Ort: *place* Datum: *date*	Prüfer/RT-D Stufe 2 [3] (S): *operator/RT-D level 2 [3] (auth. insp.)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*	Prüfaufsicht/RT Stufe 3 [3] (S): *supervisor/RT level 3 [3] (authorized insp.)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*

[1] Zu verwendende Referenznummern (Beispiele) und deren Bedeutung:
Reference numbers (examples) to be used and their meaning:

101 Längsriss *(logitudinal crack)*
102 Querriss *(transverse crack)*
104 Endkraterriss *(crater crack)*
106 Verästelte Risse *(branching cracks)*
2011 Pore *(pore)*
2013 Porennest *(clustered (localized) porosity)*
2015 Gaskanal *(elongated cavity)*
2016 Schlauchpore *(wormhole)*
202 Lunker *(cavity)*
301 Schlackeneinschluss *(slag inclusion)*
304 Metallischer Einschluss *(metallic inclusion)*
401 Bindefehler *(lack of fusion)*
402 Ungenügende Durchschweißung *(lack of penetration)*
5011 Kerbe *(concavity)*
5013 Wurzelkerbe *(root contraction)*
515 Wurzelrückfall *(root concavity)*

[2] Zertifizierungsstufe nach DIN EN ISO 9712.
level of certificate in acc. with DIN EN ISO 9712

Form A-17b: Radiographic testing report (digital radiography) – last page

1 Hersteller: *manufacturer:*	**Protokoll über Wirbelstromprüfung** *report on eddy current testing*	Nachweis-Nr.: *record no.:* **ET-** Seite: *page:* von: *of:*
Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe: *product form/part/subassembly:*
KKS/AKZ: *code acc. to KKS or AKZ identification system:*	PFP/WPP/WB: *test and inspection sequence plan/materials testing and specimen-taking plan/heat treatment:*	Prüf-Nr.: *test no.:*
		Prüfzeitpunkt: *time of testing:*
Hersteller-Auftr.-Nr.: *manufacturer´s contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr.: *plant no./index no.:*
Spezifikation: *specification:* Rev.: *revision:*	Prüfvorschrift: *process spec.:* Rev.: *revision:*	Prüfanweisung: *test instruction:* Rev.: *revision:*
Zeichnungs-Nr.: *technical drawing no.:* Rev.: *revision:*	Werkstoff: *material:*	Prüfgegenstand: *test object:*
	Abmessung: *dimension:*	

2 Referenzfehler: *reference defect:*	Abmessungen (des Referenzfehlers): *dimensions (of the reference defect):* mm
Prüfgerätetyp/Fabrikat: *test equipment/make:*	Prüfbereich: *test area:* mm
	Ungeprüfte Bereiche: *untested areas:* mm
Prüftechnik: *testing technique:*	Sensortyp/Kabel: *type of probe/cable:*
Prüffrequenz: *test frequency:* kHz	Sensorabmessung: *probe dimension:* mm
Prüfempfindlichkeit: *test sensitivity:* dB	Filterart/-stellung: *type/position of filter:*
Prüftiefe: *test depth:* mm	
Prüfgeschwindigkeit: *test velocity:* m/min	Monitoreneinstellung: *monitor setting:* ☐ Rundumauswertung *all-round evaluation* ☐ Horizontalschwelle *horizontal level* ☐ Phasenselektion *phase selection*
Fehler-Markierung: *defect identification:*	Phaseneinstellung: *phase setting:*
Sortierung: *classification:*	Magnetisierung: *magnetization:* Stromstärke: *amperage:* A Tangential-Feldstärke: *tangential field strength* A/cm Entmagnetisierung: *demagnetization:* ☐ ja *yes* ☐ nein *no*
Prüfumfang/Stückzahl: *extent of testing/number of test pieces:* Menge: *quantity:*	

3 Bemerkungen: *remarks:*
Die Anforderungen sind: *The requirements have* ☐ Erfüllt *been met* ☐ Nicht erfüllt *not been met*

4 Prüfer, ET Stufe 2 [1] (H): *operator, ET level 2 [1] (manufacturer)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*	Prüfaufsicht, ET Stufe 3 [1] (H): *supervisor, ET level 3 [1] (manufacturer)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*	(B): *(plant owner)* Name: *name* Unterschrift: *signature* Ort: *place* Datum: *date*	Prüfer, ET Stufe 2 [1] (S): *operator, ET level 2 [1] (auth. insp.)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*	Prüfaufsicht, ET Stufe 3 [1] (S): *supervisor, ET level 3 [1] (authorized insp.)* Name: *name* Zertifikat Nr.: *certificate no.* Unterschrift: *signature* Ort: *place* Datum: *date*

[1] Zertifizierungsstufe nach DIN EN ISO 9712.
level of certificate in acc. with DIN EN ISO 9712

Form A-18: Report on eddy current testing

	Abweichungsbericht *non-conformance report*	Nachweis-Nr.: *record no.:* Seite: *page:* von: *of:*
1 Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe [1] : *product form/part/subassembly [1]:*
KKS/AKZ/Typ, Antrieb, DN [2]: *code acc. to KKS or AKZ identification system / type, drive, DN [2]:*	PFP/WPP [1]: *test and inspection sequence plan/materials testing and specimen-taking plan [1]:*	Prüf-Nr.: *test no.:*
Hersteller-Auftr.-Nr.: *manufacturer´s contract no.:*	Bestell-Nr.: *order no.:*	Werk-/Kennzeichnung-Nr.: *plant no. [2]/index no. [3]:*
Spezifikation: *specification:* Rev.: *revision:*	Prüfvorschrift: *process spec.:* Rev.: *revision:*	Prüfanweisung: *test instruction:* Rev.: *revision:*
Zeichnungs-Nr.: *technical drawing no.:* Rev.: *revision:*	Werkstoff: *material:*	Prüfgegenstand: *test object:*

2 Abweichung festgestellt am: *non-conformance stated on:*	Kategorie: *category:*

Beschreibung der Abweichung:
description of non-conformance:

Anlage:
annex:

3 Unterschrift (H): *signature (manufacturer):* Ort: *place:* Datum: *date:*	Unterschrift (S): *signature (authorized inspector):* Ort: *place:* Datum: *date:*	Unterschrift: *signature:* Ort: *place:* Datum: *date:*

4 Vorgesehene Maßnahmen mit Begründung:
measures intended with reasons:

Anlage:
annex:

5	Zustimmung: *agreed:*	
Unterschrift (H): *signature (manufacturer):* Ort: *place:* Datum: *date:*	Unterschrift (S): *signature (authorized inspector):* Ort: *place:* Datum: *date:*	Unterschrift: *signature:* Ort: *place:* Datum: *date:*

1) Nicht zutreffendes streichen
delete where not applicable

2) Nur für Rohrleitungen, Armaturen und Pumpen
only for pipes, valves and pumps

3) z. B. Schmelze-Nr. oder Coupon-Nr., nicht zutreffend in Verbindung mit PFP/WPP
e.g., melt no. or coupon no, not applicable in connection with test and inspection sequence plan / materials testing and specimen-taking plan

Form A-19: Non-conformance report

	Anhang zu: ***Annex of:***	Nachweis-Nr.: *record no.:* Seite: *page:* von: *of:*
1 Anlage/Projekt: *power plant / project:*	Komponente: *component:*	Erzeugnisform/Bauteil/Baugruppe [1] : *product form/part/subassembly [1]:*
KKS/AKZ/Typ, Antrieb, DN [2]: *code acc. to KKS or AKZ identification system / type, drive, DN [2]:*	PFP/WPP [1]: *test and inspection sequence plan/materials testing and specimen-taking plan [1]:*	Prüf-Nr.: *test no.:*
2		
3 Unterschrift (H): *signature (manufacturer):* Ort: *place:* Datum: *date:*	Unterschrift (S): *signature (authorized inspector):* Ort: *place:* Datum: *date:*	Unterschrift: *signature:* Ort: *place:* Datum: *date:*

1) Nicht zutreffendes streichen
delete where not applicable

2) Nur für Rohrleitungen, Armaturen und Pumpen
only for pipes, valves and pumps

Form A-20: Annnex to test reports as per forms A-13 to A 18

Annex B

Remedial Work, Repairs and Tolerances

(1) If deviations from the requirements of this safety standard or from those of the design approval documents are found, special measures serving their elimination shall be taken.

(2) The deviations shall be divided into 3 categories.

(3) Category 1 deviations and their treatment are represented in **Table B-1**. The categorization shall be effected by the manufacturer. Moreover, the following shall be allocated to Category 1:

a) Minor deviations from the procedure parameters specified in the design approval documents which occur from time to time.

These are deviations which are isolated and the cause of which is generally known.

Remedial work is not required.

Demonstrations: BA (operating records)

Verification: H1, S2

b) Incomplete entries of specifications in the quality verifications and inadequate quality assurance.

This includes documentation deficiencies and gaps in the quality verification which can be removed or filled by revisions of the documentation, by checks or by records from other vouchers (e.g. those issued by the authorized inspector) as well as changes in the manufacturing and testing sequences which do not interfere with the quality characteristics and the performance of tests.

Demonstrations: PP (test record)

Verification: H1, S2 (insofar as these are involved)

(4) Category 2 and Category 3 deviations and their treatment are shown in **Tables B-2** and **B-3**.

Category 1

(1) Deviations which are eliminated in the course of welding

Individual, local deficiencies in accordance with Examples (a) and (b), which are detected by the welder or the welding supervisory personnel, may be removed in accordance with work instructions.

Deviations in accordance with Examples (c) to (e) shall be reported to the welding supervisory personnel. Insofar as possible, the authorized inspector shall be informed before their elimination. The authorized inspector's information does not signify a mandatory hold point.

(2) Deviations which are eliminated by means of rework or may be left as they are on account of additional measures

These deviations concern deficiencies which may be eliminated by means of mechanical rework while adhering to the permissible dimensions, e.g. corrections of shape by means of grinding. Testability and function shall be maintained.

Mechanical rework by means of cold forming may be conducted if the permissible degree of cold forming is not exceeded.

Treatment and type of deviation, Examples	Measures – : not necessary				
	Non-conformance report ↓	Repair plan ↓	Release for elimination by ↓	Demonstration ↓	Verification ↓
Examples for (1):					
a) end craters, poor restarts, undercuts, arc strikes	–	–	H	–	H 1
b) cracks in tack welds, in the weld metal and in the weld metal touching the base metal without renewal of the welding groove	–	–	H	–	H 1
c) weld overlapping defects in the case of claddings	–	–	H	BA	H 1, S 2
d) meltdown of a contact tube during the welding process	–	–	H	BA	H 1, S 2
e) faulty bead for the tempering bead technique	–	–	H	BA	H 1, S 2
Examples for (2)					
a) surface defects with minimum depth magnitude (no cracks)	–	–	H	–	H 1
b) small damage, e.g. transportation damage, handling defects during grinding	–	–	H	–	H 1
c) deviations in the external condition corresponding to the specified acceptance level	–	–	H	–	H 1, S 2
d) dimensional deviations which do not fall below the permissible wall thickness (taking into consideration both tolerance and interference with testability and function)	no remedial work required				H 2
e) non-destructive test indications in weld edges (e.g. metallic or non-metallic inclusions which may be eliminated by means of grinding or left as they are)	–	–	H	–	H 1, S 2
f) surface inspection (MT/PT) indications after the machining of functional surfaces conducted on castings (only applies to pumps and valves)	–	–	H	–	H 1, S 2
g) extensions of destructive tests by means of replacement specimens (reexaminations in order to demonstrate permissibility)	–	–	H	PP	H 1, S 2
h) additional non-destructive test in order to demonstrate the permissibility of indications (e.g. analysis procedure with focussing probes or metallography)	–	–	H	PP	H 1, S 2
i) renewal of circumferential pipe welds if testability is not limited (see Category 3 with regard to limited testability)	–	–	H	–	H 1, S 2

Table B-1: Category 1 deviations

Category 2

(1) Deviations which are repaired in accordance with standard repair plans by means of welding.

This concerns non-permissible, local substandard wall thicknesses as well as local material defects or impermissible defects in welded connections whose cause is known and which do not occur systematically (see Category 3 with regard to systematic defects).

The manufacturing documents shall be valid for the welding repair and the associated tests.

The repair shall be conducted before the last heat treatment and the final pressure test and shall be substantiated by process-based demonstrations.

After the repair has been conducted, the specified quality characteristics shall be fulfilled and the demonstrations submitted.

Additional production control tests are not necessary if a welding procedure qualification is also valid for the welding repair. In the case of repairs conducted on seam welds with a subsequent heat treatment, the entire seam weld shall be subjected, after the repair, to non-destructive testing in accordance with the procedure specified in the test and inspection sequence plan. If a subsequent heat treatment has not been scheduled, only the area which has been repaired plus adequate overlap shall be tested.

The repair plan shall be included in the documentation.

(2) Deviations during the heat treatment which can be eliminated by means of a renewed heat treatment.

The renewed heat treatment is only permitted if it is possible to demonstrate that the total duration of the heat treatment and the temperature is permissible with regard to adherence to the quality characteristics in the case of product forms and part welds.

Treatment and type of deviation, Examples	Measures – : not necessary × : necessary Non-conformance report ↓	Repair plan ↓	Release for elimination by ↓	Demonstration ↓	Verification ↓
Examples for (1):					
a) pores, worm-holes, linear porosity or pore clusters	H	X	H, S1	PFP	H 1, S 2
b) compensating welds in the case of linear misalignment in the cover pass area	H	SP	H, S1	PFP	H 1, S 2
c) incomplete fusions in the case of build-up welds	H	X	H, S1	PFP	H 1, S 2
d) hot cracks	H	X	H, S1	PFP	H 1, S 2
e) metallic and non-metallic inclusions (tungsten, slags, oxides)	H	X	H, S1	PFP	H 1, S 2
f) incomplete fusions	H	X	H, S1	PFP	H 1, S 2
g) damage to weld edges	–	SP	H, S1	–	H 1, S 2
h) single repetition of the repair on account of defects which are known and can be assessed	H	X	H, S1	PFP	H 1, S 2
i) root defects in the case of circumferential pipe welds	H	X	H, S1	PFP	H 1, S 2
Examples for (2):					
Deviations during heat treatment.	H	WBP	H, S1	PFP	H 1, S 2

Table B-2: Category 2 deviations

Category 3

Category 3 includes all deviations which cannot be allocated to Categories 1 or 2

A proposal concerning the further procedure shall be drawn up and submitted to the authorized inspector with the non-conformance report.

(1) Repair plan

If a deviation is to be eliminated by means of a repair, a repair plan shall be drawn up and submitted to the authorized inspector for design approval. This repair plan may be used as a standard repair plan for other similar cases of application if the authorized inspector agrees.

The repair or additional examinations (insofar as they alter the condition of the part) shall only be started after the reviewed and released repair plan has been submitted. The repair plan shall be included in the documentation.

In individual cases, additional production control tests may become necessary for the repairs.

(2) Use-as-is

If a deviation is to be tolerated, an application for use-as-is, together with a substantiation and acceptability demonstration, shall be submitted to the authorized inspector.

Further fabrication is only permitted if:

a) the authorized inspector agrees to the use-as-is disposition or

b) additional examinations for a use-as-is disposition are not interfered with or

c) a repair which may become necessary after all is not interfered with.

Treatment and type of deviation, Examples	Measures – : not necessary × : necessary Non-conformance report ↓	Repair plan ↓	Release for elimination by ↓	Demonstration ↓	Verification ↓
Examples for (1):					
a) systematic defects (same type of defect occurring with great frequency, e.g. underbead cracks, cracks adjacent to the weld and systematic process defects)	H	X	H, S 1	PFP	H 1, S 2
b) stress cracking	H	X	H, S 1	PFP	H 1, S 2
c) defects of unknown cause	H	X	H, S 1	PFP	H 1, S 2
d) multiple repairs (three or more repairs)	H	X	H, S 1	PFP	H 1, S 2
e) repairs conducted after the final heat treatment or after the pressure test	H	X	H, S 1	PFP	H 1, S 2
Examples for (2):					
a) use of other materials	H	–	H, S 1	AB	–
b) omission of production control tests due to a known cause	H	–	H, S 1	AB	–
c) underflushing below the calculated wall thickness (see Section 5.7.1.3 or KTA 3211.2)	H	–	H, S 1	AB	–

Table B-3: Category 3 deviations

Annex C

Documents for Design Approval and Documentation

No.	Allocation [2]				Requirements in accordance with	Document (file) Title	Design approval by S			Documentation
	B	Ar	P	R			Allocation	Times [1] Submission	Release (termination)	
1	x	x	x	x	Section 4.1.1.3.1	Cover sheets A-1a, A-1b, A-1c	VPU 1/ VPU 2	2	2	E
2	x	x	x	x	Table 4-3	Design Data Sheet - (1) to (4), (8) to (14) - (5) to (7), (15) to (17)	VPU 1	 2 4	 2 4	E
3	–	–	–	x	Table 4-3	Pipe Loading Specifications - (1) to (4), (7) to (9) - (6), (14) to (16)	VPU 1	 2 4	 2 4	E
4	x	x	x	x	KTA 3211.1; Section 4.1.1.3.3	Drawings a) assembly drawing for forgings and castings (if required) b) component	VPU 1	 1 2	 1 2	E
5	x	x	x	x	KTA 3211.1; Section 4.1.1.3.4	Materials List	VPU 1	2	2	E
6	x	x	x	x	KTA 3211.2	Dimensioning	VPU 1	2	2	E
7	x	x	x	x	Section 4.1.1.3.6	Test and inspection sequence plans (PFP)	VPU 1	2	2	E
8	x	x	x	x	Section 4.1.1.3.7	Welding procedure specifications	VPU 1	2	2	E
9	x	x	x	x	Section 4.1.1.3.8	Heat Treatment Plans	VPU 1	2	2	E
10	x	x	x	x	Section 4.1.1.3.9; Sections 6 and 8	Materials testing and specimen-taking plan a) product form b) component, sub-unit or part	VPU 1	 1 2	 1 2	E
11	x	x	x	x	Section 4.1.1.3.11; Section 13	Repair Plans (if required)	VPU 1	2	2	E
12	x	x	x	x	Section 4.1.1.3.12	Test Instructions	VPU 1	2	2	E
13	x	–	x	–	Section 4.1.1.3.13	Drawing for nameplate	VPU 1	2	2	E
14	–	–	–	x	Section 4.1.1.3.15	Fabrication isometric drawing	VPU 1	4	4 [4]	E
15	–	–	–	x	Section 4.1.1.3.14	Isometric Items List	VPU 1	4	4 [4]	E
16	–	–	–	x	Section 4.1.1.3.16	Calculation isometry (planning calculation isometry)	VPU 2	4	4 [6]	Z
17	x	x	x	x	Section 8.1 Section 4.1.1.3.7 Section 4.1.1.3.8 Section 4.1.1.3.9	Welding Procedure Qualification a) welding procedure specification b) materials testing and specimen-taking plan c) heat treatment plan (if required) d) Manufacturer's report and authorized inspector's certificate	 VPU 1 VPU 1 VPU 1 –	 2 2 2 2	 2 2 2 –	 – – – Z
18	x	x	x	x	Section 8.2 Section 4.2.1.4 Section 4.1.1.3.8 Section 4.1.1.3.9	Production control test a) welding procedure specification (in accordance with part weld) b) materials testing and specimen-taking plan c) heat treatment plan (if required) d) Manufacturer's report and authorized inspector's certificate	 – – – –	 2 2 2 –	 2 2 2 5	 – – – E [7]
19	x	x	x	–	Section 9.3.9	Pressure test a) strain measurement plan (if required) b) pressure test record	 VPU 1 –	 3 –	 3 –	 E E
20	–	–	–	x	Section 9.3.9 Section 4.1.1.3.10	System pressure test a) pressure test plan b) strain measurement plan (if required) c) pressure test record	 VPU 2 VPU 2 –	 5 5 –	 5 5 –	 E E E
21	–	–	–	x	KTA 3211.2 (planning calculation isometry)	Analysis of mechanical behaviour / stress analysis (comparison of data with the permissible stress resultants of vessels, valves and pumps; No. 2, Design Data Sheet (13))	VPU 2	4	4	Z

Table C-1: Documents for design approval and documentation

No.	Allocation [2]				Requirements in accordance with	Document (file) Title	Design approval by S			Documentation
							Allocation	Times [1] Submission	Release (termination)	
	B	Ar	P	R						
22	x	x	x	–	KTA 3211.2	Analysis of mechanical behavior a) stress analysis b) fatigue analysis c) analytical demonstration of functional capability d) specification of the experimental demonstrations of functional capability e) record of the experimental demonstration of functional capability	VPU 2	 6 7 6 4 –	 6 7 6 6 [8] –	 E E E E E
23	–	–	–	x	KTA 3211.2 (actual calculation isometric) [6]	Analysis of mechanical behaviour a) stress analysis (data comparison with the permissible stress resultants of vessels, valves and pumps, No. 2, Design Data Sheet (13)) b) fatigue analysis	VPU 2	6 7	6 7	E E
24	–	–	–	x	Section 4.1.1.3.16	Calculation isometric (actual calculation isometric) [6]	VPU 2	6	6	E
25	–	–	–	x	—	Commissioning program a) displacement measurements b) vibration measurements c) record	VPU 2	 5 5 –	 6 6 –	 E E E
26	x	x	x	x	Section 13	Non-conformance report or application for use-as-is	Section 13, Annex B			E
27	–	–	x	–	—	Performance test	–	[9]	–	E

[1] Times for the performance of the design approval by the authorized inspector in accordance with "ZPI":

(ZPI: Compilation of information required for review in the course of the licensing and supervisory procedure for nuclear power plants under the Atomic Energy Act - BMU Announcement of October 20, 1982).

1 Before manufacture of the respective product forms

2 Before manufacture of the respective components, subunits or parts

3 Before pressure test at the manufacturer's plant

4 Before assembly of the respective components (parts, spools)

5 Before pressure test of the respective systems

6 Before initial start-up of the respective system

7 The point in time shall be fixed jointly with the authorized inspector in each individual case.

[2] Ar : valves
B : vessels
P : pumps
R : pipes

[3] If a design approval document (VPU) (e.g. Test and inspection sequence plan PFP or Materials List WL) is used in the course of manufacture for documentation purposes (ST, AN), the demonstrations and records required for this purpose shall be allocated to the design approval document (E).

[4] For new plants this test may be performed during fabrication.

[5] Confirmation or demonstration in accordance with the Test and inspection sequence plan (PFP).

[6] An evaluation of dimensional changes is effected after the checking of the actual dimensions (Test No. 4.2.3 of the Inspection Sheet for Final Inspection in accordance with **Table 9-4**).

[7] Filing in the case of direct reference to a component.

[8] Except demonstrations which are scheduled for the first nuclear putting into operation.

[9] The contents of the record shall be discussed and agreed upon with the authorized inspector before the performance test is conducted.

Table C-1: Documents for design approval and documentation (continued)

Annex D

Performance of manual ultrasonic testing

D 1 General requirements

(1) This Annex covers the performance of manual ultrasonic testing.

(2) In this Annex, stipulations have been laid down for the calibration of ultrasonic equipment for the pulse-echo method used in the multiple-echo or through transmission technique and for the description of indications.

D 2 Definitions, symbols, formulae

D 2.1 Definitions

The definitions of DIN EN ISO 5577 apply.

D 2.2 Symbols

In this Annex the following symbols are used:

Symbol	Variable or designation	Unit
A	Sound path length related to near field length in the general DGS diagram	—
a	Projected surface distance	mm
a'	Reduced projected surface distance	mm
a_{LLT}	Reduced projected surface distance in the case of LLT-technique	mm
AVG	Distance / gain / size	—
α_{LW}	Angle of refraction of longitudinal wave	degree
α_{TW}	Angle of incidence of transverse wave on scanning surface of test object	degree
C	Required width of the reference block	mm
c_{LW}	Sound velocity of longitudinal wave	m/s
c_{TW}	Sound velocity of transverse wave	m/s
D_{eff}	Effective transducer dimension according to probe data sheet	mm
D_{FBB}	Diameter of the flat bottom hole	mm
D_{Kon}	Diameter of contact surface of a straight beam probe	mm
D_{KSR}	Diameter of disc shaped reflector	mm
D_Q	Effective transducer dimension perpendicular to the scanning direction	mm
$D_{S\text{-}6dB}$	Beam width for 6 dB decrease of sound pressure relating to central beam	mm
$D_{S\text{-}20dB}$	Beam width for 20 dB decrease of sound pressure relating to central beam	mm
D_z	Diameter of side-drilled hole	mm
d	Curvature diameter of the scanning surface on the test object	mm
d_{ref}	Curvature diameter of opposite surface on the test object	mm
Δf	Band width (difference between upper and lower frequency limit) referred to 3 dB amplitude decrease	MHz
Δ_{SE}	Distance of points of incidence	mm
ES	Receiving transducer	—
f_N	Nominal frequency	MHz
ϕ_{LW}	Angle of incidence of longitudinal wave on reflector	degree
ϕ_{TW}	Angle of refraction of transverse wave on reflector	degree
G	Reflector diameter referred to effective transducer diameter	—
G_K	Instrument gain when setting the reference reflector for reference screen height level	dB
G_T	Instrument gain when setting the transmission indication for reference screen height level	dB
$\overline{G_T}$	Arithmetical average of G_T values	dB
G_R	Instrument gain setting for recording level	dB
γ_6	Beam spread angle at 6 dB limit	degree
H	Echo amplitude referred to screen height	—
HE	Main echo in testing using wave conversion technique	—
KSR	Diameter of disc shaped reflector	mm
κ	Sound attenuation coefficient (deviating from DIN EN ISO 5577; sound attenuation referred to sound path length)	dB/mm
L	Probe scanning surface dimension in direction of curvature	mm
LLT	„Long-Long-Trans" wave conversion technique	—
LW	Longitudinal wave	—
λ	Wave length	mm
N	Near field length	mm
NE1; NE2	Neighbour echoes in testing using wave conversion technique	—
n	Number of individually measured values	—
p	Projected surface distance for indirect scan	mm
p'	Projected surface distance in testing using wave conversion technique in the case of neighbour echo optimization	mm
p''	Projected surface distance in testing using wave conversion technique in the case of main echo optimization	mm
Ra	Arithmetical mean deviation of the assessed profile (average roughness) Ra to DIN EN ISO 4287	µm
R_L	Recording length	mm
R_{LK}	Corrected recording length	mm
S (with and without index)	Sound path length	mm
SEL	Transmitter-receiver longitudinal waves	—
SE	Transmitter - receiver	—
s	Wall thickness, nominal wall thickness	mm
s_j	Thickness of reference block	mm
S/N	Signal-to-noise ratio is the ratio of the echo amplitude of an ultrasonic signal from a reflector to the amplitude of the noise level (noise level means the 95 % value of the cumulative frequency of the heights of the noise signals in the tested volume free from defects)	—
TLL	„Trans-Long-Long" wave conversion	—
TW	Transverse wave	—

Symbol	Variable or designation	Unit
V	Gain in the general DGS diagram	dB
Y_{FBB}	Reflector depth position	mm
Y_s	Distance of scanning zone centre to scanning surface	mm
Z_H	Depth of scanning zone	mm
ΔV	Sensitivity correction	dB
ΔV_κ	Sound attenuation correction referred to a certain sound path length	dB
ΔV_{koppl}	Coupling correction	dB
ΔV_{LLT}	Echo height difference between reference level of front face and maximum of sensitivity curve	dB
ΔV_S	Divergence correction of back reflection curve	dB
$\Delta V^{\sim}$	Gain correction for considering transfer variations	dB
ΔV_T	Transfer correction	dB
ΔV_Z	Gain correction for considering different sound path travel distances when scanning a cylindrical hole	dB

D 2.3 Formulae

The variables to be calculated shall be determined by means of the following equations:

a) Required width of the reference block

$$C \geq D_{S\text{-}20dB} \qquad \text{(D-1)}$$

b) The beam width $D_{S\text{-}20dB}$ referred to a 20 dB echo amplitude decrease:

$$D_{S-20dB} = 2 \cdot \lambda \cdot \frac{S}{D_Q} \qquad \text{(D-2)}$$

c) Conversion of side-drilled hole echo amplitudes to disc shaped reflector echo amplitudes:

$$D_{KSR} = \sqrt{\frac{\sqrt{2}}{\pi} \cdot \lambda \cdot \sqrt{D_Z \cdot S}}\ , \qquad \text{(D-3)}$$

where $S > 1.5 \cdot N$ and $D_Z > 1.5 \cdot \lambda$.

d) The beam diameter $D_{S\text{-}6dB}$ referred to a 6 dB echo amplitude decrease:

$$D_{S\text{-}6dB} = 2 \cdot S \cdot \tan \gamma_6, \qquad \text{(D-4)}$$

e) Average value of instrument gain setting $\overline{G}_T$:

$$\overline{G}_T = \frac{\sum G_T}{n} = \frac{\text{sum of individual values}}{\text{number of individual values}}\ , \qquad \text{(D-5)}$$

f) Corrected recording length R_{LK}:

$$R_{LK} = R_L - D_{S-6dB} \cdot \left(1 - \frac{D_{S-6dB}}{R_L}\right) \qquad \text{(D-6)}$$

g) Sound path length without lateral wall influence:

$$S = \frac{s \cdot D_{eff}}{2 \cdot \lambda} \qquad \text{(D-7)}$$

h) Gain correction $\Delta V^{\sim}$:

$$\Delta V^{\sim} = 1.7 \cdot \sqrt{\frac{\sum G_T^2 - \frac{1}{n} \cdot \left(\sum G_T\right)^2}{n-1}} \qquad \text{(D-8)}$$

or

$$\Delta V^{\sim} = 1.7 \cdot \sqrt{\frac{\sum \left(G_T - \overline{G}_T\right)^2}{n-1}} \qquad \text{(D-9)}$$

i) Sensitivity correction ΔV_Z:

$$\Delta V_Z = 30 \cdot \lg \frac{S_2}{S_1} \qquad \text{(D-10)}$$

k) Resultant instrument sensitivity for adjustment of recording level:

$$G_R = G_K + \Delta V_T + \Delta V^{\sim} \qquad \text{(D-11)}$$

with

$$\Delta V_T = \Delta V_{koppl} + \Delta V_\kappa \qquad \text{(D-12)}$$

l) Zero point displacement at longitudinal wave dual-element probes:

$$S = 1.5 \cdot s + a \qquad \text{(D-13)}$$

m) Sound path travel distance to scanning zone centre with LLT probes:

$$S_{Just} = S_{LW} + 2 \cdot S_{TW} \qquad \text{(D-14)}$$

$$\text{with } S_{LW} = \frac{2 \cdot s - Y_s}{\cos \alpha_{LW}} \qquad \text{(D-15)}$$

$$\text{and } S_{TW} = \frac{Y_s}{\cos \alpha_{TW}} \qquad \text{(D-16)}$$

or approximated for steel

$$S_{Just} = 2 \cdot \frac{s + Y_s}{\cos \alpha_{LW}} \qquad \text{(D-17)}$$

D 3 Requirements to be met by the test object

(1) The scanning surfaces of the test object and its reflecting surfaces shall be large enough to completely cover the examination volume.

(2) The scanning surfaces shall be free from disturbing uneveness and contaminants (e.g. notches, scale, weld spatters, machining grooves). Where the opposite surface is used as reflection surface, the same requirements as for the scanning surface apply to the reflection surface.

(3) The arithmetical mean deviation of the assessed profile (average roughness) Ra to DIN EN ISO 4287 shall not exceed 20 µm on the surfaces to be tested.

(4) In the case of waviness of the scanning surfaces the waviness shall be so little as to provide sufficient probe shoe contact. This is generally the case if the distance between probe shoe surface and scanning surface does not exceed 0.5 mm at any point.

(5) In relation to a reference surface of 40 mm x 40 mm, the deviation from the specified contour of the scanning surfaces shall not exceed 0.5 mm. When selecting other dimensions of reference surfaces, the allocated deviation from the specified contour shall be linearly converted in accordance with the side length of the reference surface selected.

D 4 Requirements to be met by the testing system

D 4.1 Test equipment

(1) The test equipment used including the required measuring instruments and auxiliary equipment shall show appropriate exactness and stability suited for the intended use.

(2) Test instruments and probes shall normally meet the requirements of DIN EN 12668-1 or DIN EN 12668-2. The requirements of DIN EN 12668-3 shall apply to checking the properties of the entire test equipment.

(3) The combination of equipment, cables and probes of various manufacturers is permitted if it is ensured (e.g. by

measurements on reference reflectors) that the exactness of results is not affected.

(4) Probes with sound fields shall be used which ensure the observance of the required testing level (recording level) in the area to be examined.

Note:

In general, a nominal frequency of 4 MHz and a transducer size D_Q of approx. 10 mm are used for nominal wall thicknesses equal to or less than 40 mm, and a nominal frequency of 2 MHz and a transducer size D_Q of approx. 20 mm are used for nominal wall thicknesses exceeding 40 mm.

(5) Straight-beam probes shall be selected such that the distance between the scanning surfaces of the probe and of the test object does not exceed 0.5 mm ($D_{Kon} < \sqrt{2d}$). By the use of protective foils the coupling of a straight-beam transceiver probe may be improved.

(6) The scanning surfaces of transverse wave angle-beam probes shall

a) always be contoured when scanning into concave test object scanning surfaces unless sufficient coupling can be obtained due to large radii of curvature,

b) be contoured when scanning into convex test object scanning surfaces if according to **Figure D-1** for test object diameters up to 200 mm the scanning surface dimension in the direction of curvature is L > d/10 and for diameters exceeding 200 this dimension is L > $\sqrt{2d}$.

(7) For adjustment of the time base range and the testing level as well as for testing the same couplant shall be used. Only such couplants shall be used which do not damage the object (e.g. corrosion). Upon testing, all couplant residues shall be removed from the test object.

(8) Test object, calibration block, reference block and probes shall approximately have the same temperature.

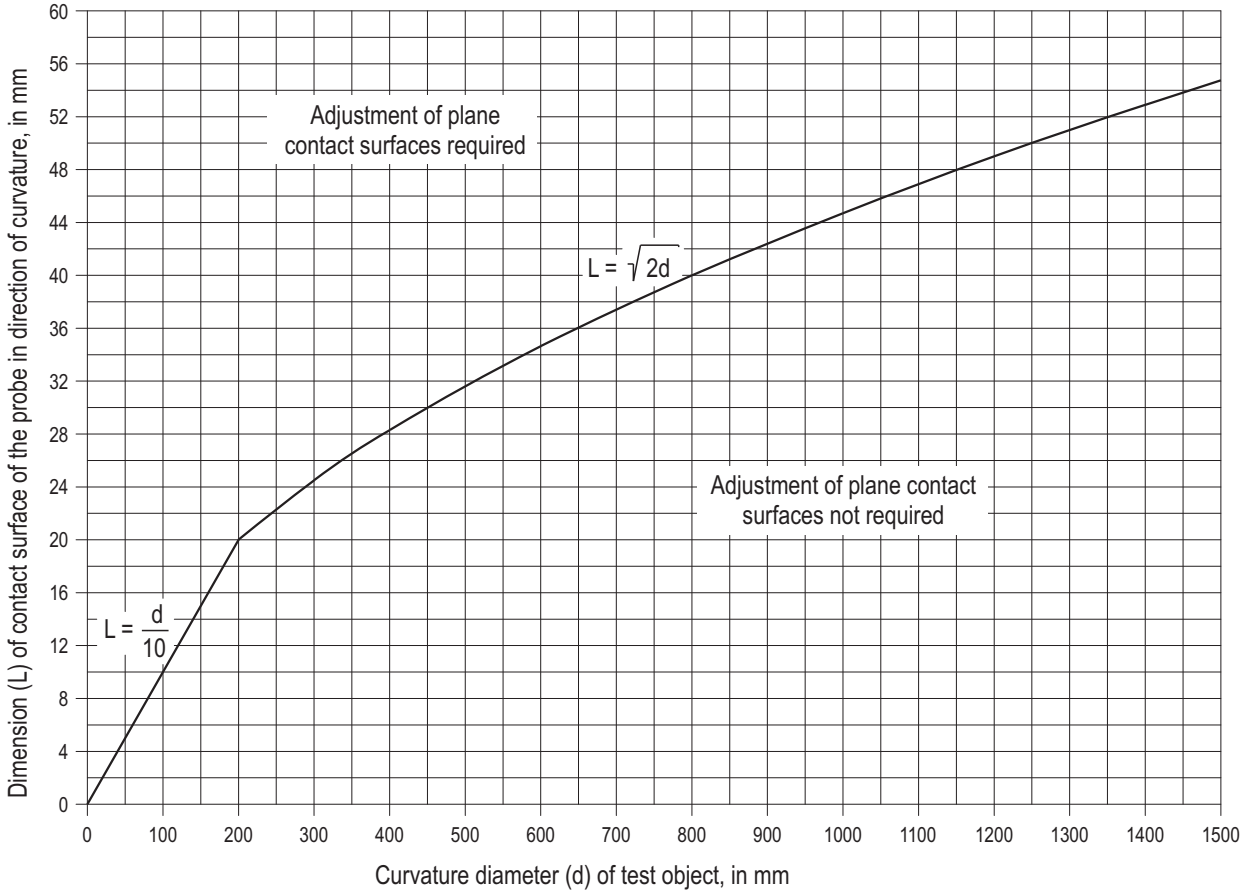


Figure D-1: Conditions for adjusting plane contact surfaces of angle-beam probes when scanning into convex scanning surfaces of the test object

D 4.2 Calibration blocks, reference blocks and reference reflectors

(1) When using differing materials for calibration block or reference block and test object the difference in sound velocities shall be taken into account for range adjustment and for the angular deviation in case of angle beam scanning.

(2) When calibration blocks No. 1 to DIN EN 12223 or No. 2 to DIN EN ISO 7963 are not used for adjusting the testing level, the following applies:

a) to the reference block used:

aa) The reference block shall correspond to the test object as regards the test-relevant characteristics (material, design, shape, wall thickness, cladding if any, heat treatment). The wall thickness of the reference block shall deviate not more than 10 % from that of the component to be tested. When using contoured probes or if the curvature of the opposite surface impairs the reflection behaviour (ratio of wall thickness s to outer diameter d_a of the test objet to exceed 0.2), the deviation of the test object diameter shall not exceed 10 % of the diameter of the component to be tested. Deviating here from plane reference blocks may be used in case of pulse-echo probes if the test object diameter does not require the use of contoured probes, the reflection behaviour is not impaired by the curvature of the opposite surface (ratio of wall thickness s to outer diameter d_a of the test objet less than or equal to 0.2) and no wave conversion technique is used.

ab) Reference blocks for testing of welds on austenitic steels, on nickel alloys or dissimilar welds shall be

similar to the test object. The similar reference block (e.g. from a production control test piece), must correspond to the test object as regards geometry, material, weld design, welding process and surface condition.

ac) The sound beam shall not be impaired in its development, i.e. all dimensions vertical to the main beam path for sound paths up to twice the near field length (N) shall normally be greater than the transducer dimension perpendicular to the scanning direction (D_Q) Decisive for greater sound path travel distances than twice the near field length is the beam width $D_{S\text{-}20dB}$ at the reflector location. In this case, the reference object width is determined to the following formula:

$$C \geq 2 \cdot \lambda \cdot \frac{S_{max}}{D_Q}$$

Exempted from this rule are reference blocks used for testing the area with lateral wall influence on bars in axial direction. In this case, the width of the reference block shall be equal to the width of the test object.

ad) The dimensions of the scanning surface of the test object shall normally exceed 1.5 times the probe scanning surface.

ae) The location of the reference reflectors in the reference block shall be selected such that their echoes do no interfere with each other and cannot be confused with corner echoes.

b) to the reference reflector used:

ba) The back walls shall normally be plane and vertical to the main beam as well as have dimensions exceeding the beam width $D_{S\text{-}20dB}$, but not less than the transducer dimension.

bb) Side-drilled holes shall normally be vertical to the main beam and parallel to the scanning surface. The lengths of the side-drilled holes shall normally be greater than the sound beam width $D_{S\text{-}20dB}$, but not less than the transducer dimension. The diameter shall normally be 3 mm.

bc) The bottom of flat bottom holes shall normally be vertical to the main beam when applying the single-probe technique. Exempted from this rule are specifications for the use of flat-bottom holes when applying the wave conversion technique II and the creeping-wave technique.

bd) The notches shall have a rectangular cross-section. The notch edges shall be vertical to the surface. The notches shall normally have a width ≤ 1.0 mm and, if not specified for the respective product form, have a depth of 1.0 mm. The acoustically effective length of the notches shall normally be 20 mm.

be) Where the echo amplitudes of side-drilled holes are to be converted to echo amplitudes of D_{KSR}, the formula D-3 shall be considered.

D 5 Optimization of the testing technique for ultrasonic testing of austenitic steels or nickel alloys

(1) To maintain a sufficient distance (at least 6 dB) of the recording level to the noise level the test technique shall be optimised, e.g. by taking the following measures:

a) use of probes with low nominal frequency,

b) use of frequency-selective test instruments,

c) use of probes with composite transducers and test instruments suited for this purpose,

d) use of longitudinal waves for angle-beam scanning,

e) electrodynamically excited surface waves and horizontally polarised transverse waves.

(2) As far as the optimization of the testing technique as per (1) does not lead to a sufficient signal-to-noise ratio, testing techniques providing images of the test results shall be used to make evaluation possible, e.g.

a) sectorial and compound scanning with controlled phased arrays,

b) automated testing techniques, e.g. in connection with ALOK (transit-time and amplitude locus-curves).

D 6 Adjustment of test system

Note:

Section D 7 to D 9 contain requirements for the test system adjustment as regards the use of wave conversion and creeping wave techniques.

D 6.1 Range adjustment

(1) The time base range shall normally be calibrated on the calibration block No. 1, the calibration block No. 2, the test object or on a similar reference block (e.g. to **Figure D-2**).

The time base range shall be adjusted by locating known reflectors.

(2) Where probes have to be contoured, the range shall first be calibrated with a non-contoured probe on a plane calibration or reference block. Hereafter, the contoured probe shall be positioned on a suitable shaped reference block to contain at least one reflector on a known time base range. By means of this reflector a zero-point correction shall be made.

(3) For longitudinal wave angle-beam probes a pre-adjustment of the time base range shall be carried out using a straight beam probe on the calibration blocks No. 1 or No. 2, on the test object or on the reference block. Subsequently a correction of zero point shall be effected by means of the angle-beam probe to consider the delay path.

D 6.2 Adjustment of the testing level when applying the DGS method

D 6.2.1 Application of the DGS method

(1) The DGS method may only be used for probes where probe-specific DGS diagrams are available.

(2) In the case of probes with adjusted contact surfaces, the DGS method shall basically not be used. When scanning with angle-beam probes which flat contact surfaces are adjusted the use of the DGS method is permitted on test objects with d exceeding 100 mm where scanning is performed on a concave scanning surface of the test object, if the condition $L < \sqrt{d}$ is satisfied.

(3) The following criteria apply to the use of the of the DGS method:

a) The evaluable sound path begins, for single transducer probe, approximately at $S = 0.7 \cdot N$ and for dual-element probes as well as for focussing probes at the beginning of the focal zone.

b) In the case of a lateral wall influence the DGS method may only be used up to the sound path travel distance given in Section D 2.3, equation D-7.

c) In the case of angle-beam scanning the DGS method can only be applied for wall thicknesses exceeding $5 \cdot \lambda$.

d) Probe-specific DGS diagrams for disc shaped reflectors shall be used to adjust the testing level.

e) In the case of attenuated probes the DGS method may only be used if the ratio of the band width (Δf) to the nominal frequency is less than 0.75.

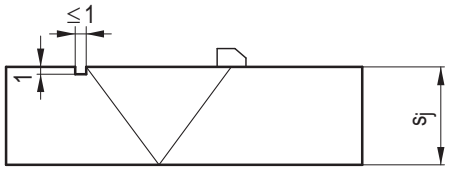
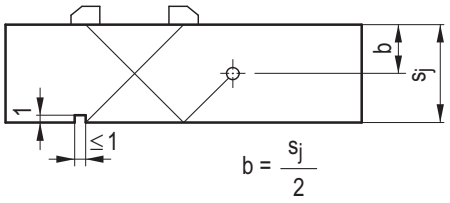
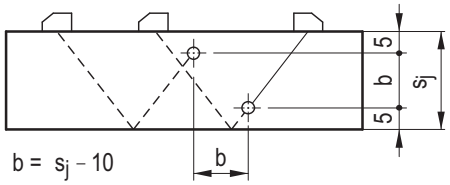
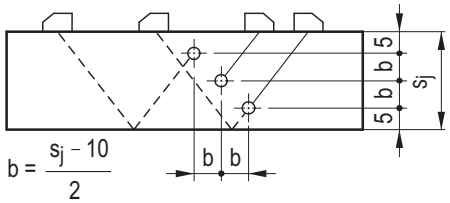
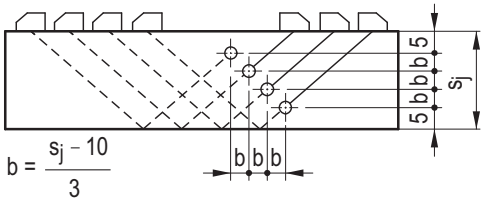
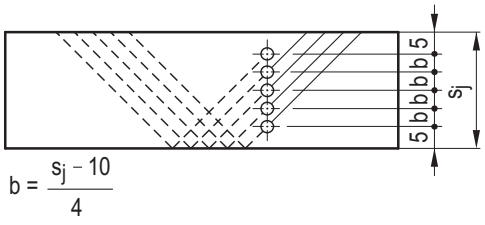
Wall thickness or nominal wall thickness of the test object in mm	Lateral view of the reference block
s ≤ 10	
10 < s ≤ 15	
15 < s ≤ 20	
20 < s ≤ 40	
40 < s ≤ 80	
s > 80	

Figure D-2: Reference blocks for adjusting the testing level for angle beam scanning

D 6.2.2 Reference reflectors to be used

(1) The reference echo heigth shall be determined on reference reflectors meeting the following requirements:

a) The reference reflector for straight beam probes shall be
   - aa) the back wall of the test object provided the back wall meets the requirements according to clause D 4.2 (2) ba),
   - ab) the back wall of the reference block provided the back wall meets the requirements according to clause D 4.2 (2) ba),
   - ac) the back wall of calibration block no. 1 with a thickness of 25 mm or the back wall of calibration block no. 2 with a thickness of 12.5 mm,
   - ad) a side-drilled hole or a flat bottom hole.

b) The reference reflector for angle-beam probes shall be
   - ba) the circular arc R100 of the calibration block no. 1,
   - bb) the circular arc R25 of the calibration block no. 2

   taking the known or determined probe-specific correction values into account,
   - bc) a side-drilled hole or a flat bottom hole.

(2) The diameter of a flat bottom hole (D_{FBB}) corresponds to the diameter of the disc shaped reflector (D_{KSR}) provided that $D_{FBB} > 1.5 \cdot \lambda$.

(3) For the conversion of the echo amplitude of a side-drilled hole into the echo amplitude of a disc shaped reflector equation D-3 shall be used.

D 6.3 Adjustment of the testing level for the reference block method and DAC method

D 6.3.1 Reference block method

(1) In the reference block method the indication from the test object is directly compared to the reference reflector having nearly the same sound path length. This may be done with reference reflectors in the part or reference block.

(2) The testing level shall be adjusted by means of a reference reflector located at the end of the time base range. Where echoes of reflectors are detected in the test, further reference reflectors of the respective reference block may be used which have the same or next greater sound path length. Where different types of reference reflectors are used (see **Figure D-2**) the smaller echo height shall be used as reference level.

D 6.3.2 DAC method

(1) When applying the DAC method for simplifying the echo amplitude description it is recommended to generate a DAC curve by means of one or several equal reflectors located at different depths in reference blocks (e.g. step wedge or to **Figure D-2**) or by means of reference reflectors in the test object located at different distances. Clause D 4.2 (2) b) applies with regard to the requirements for reference reflectors.

(2) The DAC curve shall be generated by at least three responses from the reference reflectors (e.g. side-drilled holes) in various probe distances (see **Figure D-3**). The echo with the highest amplitude shall normally be adjusted for approximately 80 % of the screen height. The DAC curve constructed may be extrapolated by a maximum of 20 % beyond the time base range limited by the reference reflectors. The gain setting of the ultrasonic equipment shall be selected such that the DAC curve is within the time base range between 20 % and 80 % of the screen height. If this is not possible for the entire time base range, the DAC curve shall be staged as per **Figure D-4**.

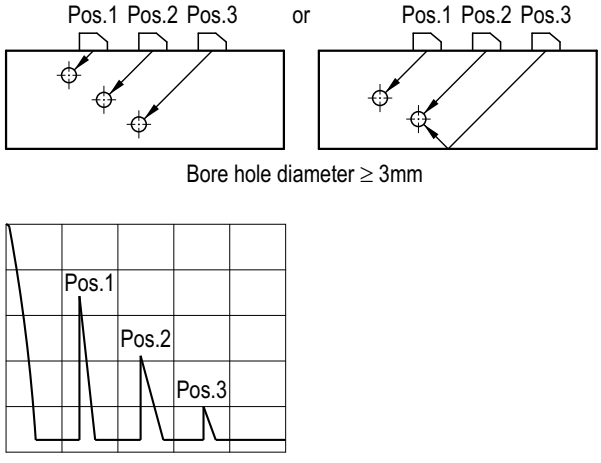


Figure D-3: Generation of reference echo heights from side-drilled holes located at different probe distances for angle beam scanning

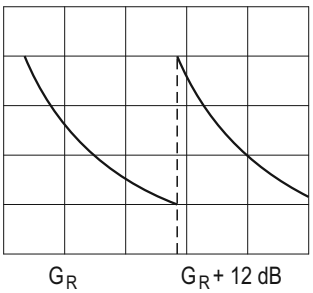


Figure D-4: Staged DAC curve

D 6.4 Corrections of testing level adjustment

D 6.4.1 Transfer correction

(1) The transfer correction shall normally be determined on at least 4 points of the test object in the intended direction of testing.

(2) The transfer correction shall normally be determined in accordance with **Figure D-5** by means of transmission on the calibration block and on the test object.

(3) To consider the transfer correction in angle-beam scanning ΔV_T of the V-transmission or W-transmission shall normally be used. Where ΔV_T exceeds this value by more than 2 dB, the testing level adjusted to D 6.2 of D 6.3 shall be corrected by the values obtained. In the case of ΔV_T values equal to or less than 2 dB these values shall generally be taken as 2 dB when adjusting the testing level.

D 6.4.2 Determination of the sound attenuation

(1) The sound attenuation for straight-beam scanning shall normally be determined as per **Figure D-6** and for angle-beam scanning as per **Figure D-7** at the same reference screen height level respectively in consideration of ΔV_S.

(2) The determination of the sound attenuation may be omitted if it is considered by a constant allowance independent from the sound path length (e.g. by transfer correction in accordance with clause D 6.4.1).

D 6.4.3 Coupling and sound attenuation variations

(1) For the transfer correction the average value of the transmission values obtained from the test object shall be used if the range of variation does not exceed 6 dB. Where the range exceeds 6 dB, the average value from 20 transmission values plus an allowance $\Delta\tilde{V} = 1.7 \cdot$ standard deviation to be calculated in accordance with clause D 2.3 h) shall be used as transfer correction.

(2) Where the $\Delta\tilde{V}$ value thus determined is greater than 6 dB, the test object shall be subdivided into testing sections where the transfer correction of each section shall be considered separately. This subdivision shall be such that in each section $\Delta\tilde{V}$ is equal to or smaller than 6 dB.

D 6.4.4 Consideration of corrections

(1) Taking the aforementioned corrections into account, the resultant instrument sensitivity for adjustment of recording level as per equation D-11 is obtained.

(2) Where sound attenuation in dependence of the sound path length is taken into account this shall be made with the attenuation portion ΔV_κ contained in ΔV_T as per **Figure D-8** when using the DGS method or as per **Figure D-9** when using the DAC method.

(3) If it is not necessary to consider the sound attenuation in dependence of the sound path length, ΔV_T shall contain a constant sound attenuation portion ΔV_κ independent of the sound path length.

(4) Where an additional correction for considering greater variations as per clause D 6.4.3 is required, this shall be done by means of $\Delta\tilde{V}$. Otherwise, the correction value $\Delta\tilde{V}$ in equation D-11 shall be omitted.

D 6.5 Setting of the ultrasonic instrument

(1) Prior to adjusting the testing level it shall be ensured that

a) the amplifier suppression (“grass cutting”) is not used,

b) the amplifier is operated in the correct frequency range,

c) the filter is set such that optimum resolution is obtained,

d) the test instrument impedance, where required, is adapted such that a maximum echo height is obtained at constant resolution,

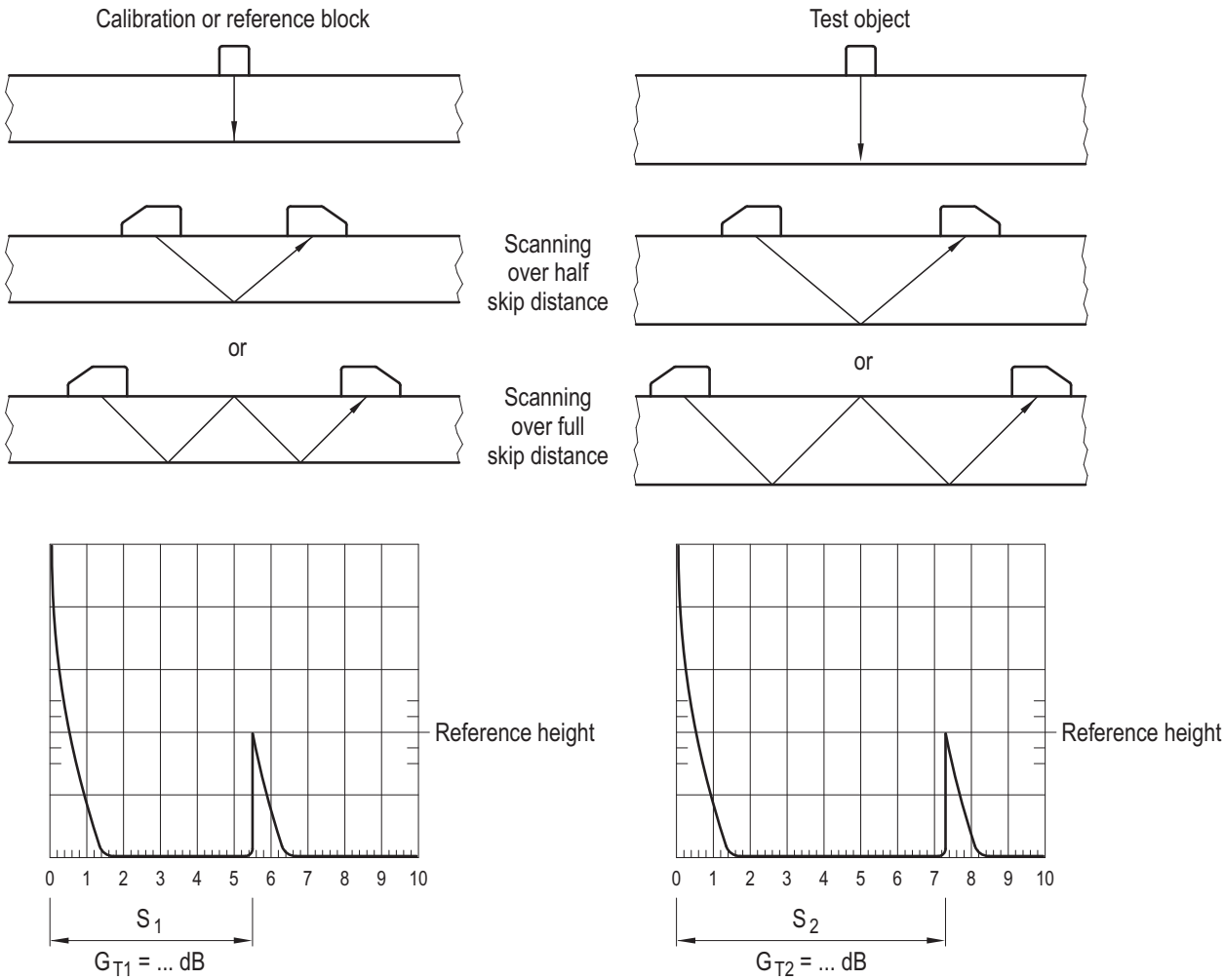
e) the energy for the transmitter pulse is set as low as possible in due consideration of the gain control reserve.

(2) The pulse repetition frequency shall be adjusted such that

a) the detection of all signals to be recorded is ensured,

b) the occurrence of so-called ghost echoes in case of long sound path lengths (especially in the case of materials with low sound attenuation) is avoided.

(3) Taking the corrections according to Section D 6.4 into account the instrument gain shall be adjusted such that all echoes exceeding the recording level attain at least 20 % of the screen height at the end of the respective time base range.



$\Delta V_T = G_{T2} - G_{T1} - \Delta V_S$
Transfer correction during straight and angle beam scanning [dB]

$\Delta V_S = V_{S_2} - V_{S_1}$
Divergence correction of back-wall echo curve of a DGS diagram

V_{S_1} = Gain value for transmission echo on calibration or reference block at reference level [dB]

V_{S_2} = Gain value for transmission echo on test object at reference level [dB]

G_{T1} = Instrument gain for transmission echo on calibration or reference block [dB]

G_{T2} = Instrument gain for transmission echo on test object [dB]

Back-wall echo curve of a DGS diagram

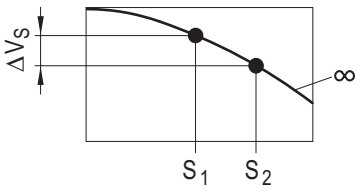
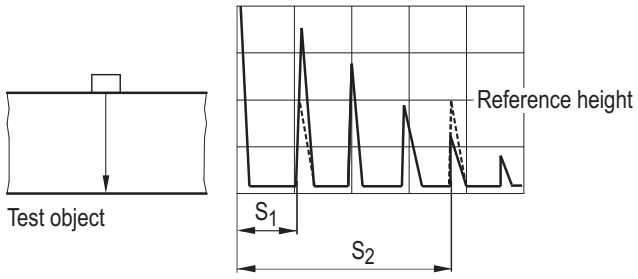


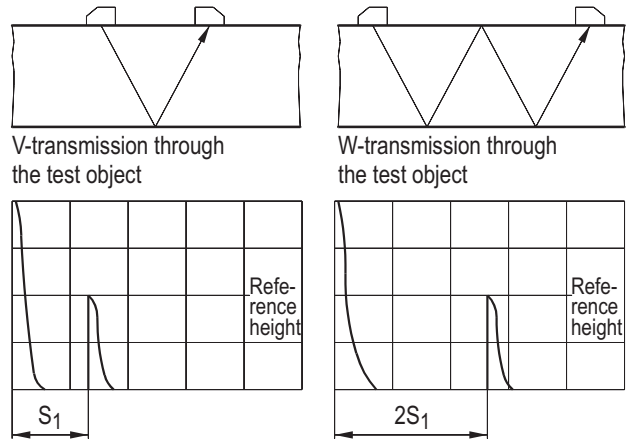
Figure D-5: Determination of transfer correction during straight and angle beam scanning performed as V- or W-transmission



$$\kappa = \frac{G_{T2} - G_{T1} - V_S}{2 \cdot (S_2 - S_1)} \; [\mathrm{dB/mm}]$$

G_{T1} =...dB
G_{T2} =...dB

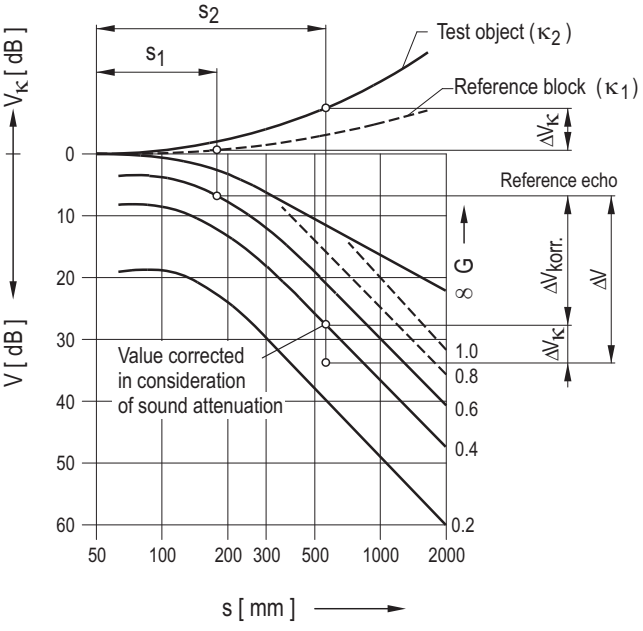
Figure D-6: Determination of sound attenuation for straight-beam scanning (example)



$G_{T1} = \ldots$ dB $\qquad G_{T2} = \ldots$ dB

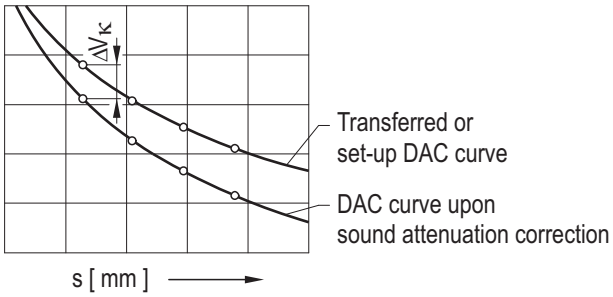
$$\kappa = \frac{G_{T2} - G_{T1} - \Delta V_S}{2 \cdot S_1} \; [\mathrm{dB/mm}]$$

Figure D-7: Determination of sound attenuation for angle-beam scanning



$$\Delta V_\kappa = 2 \cdot (S_2 \cdot \kappa_2 - S_1 \cdot \kappa_1) \; [\mathrm{dB}]$$

Figure D-8: Consideration of sound attenuation in the DGS diagram for $\kappa_2 > \kappa_1$ (example)



$$\Delta V_\kappa = 2 \cdot S \cdot (\kappa_2 - \kappa_1) \; [\mathrm{dB}]$$

Figure D-9: Consideration of sound attenuation for the DAC method for the case $\kappa_2 > \kappa_1$ (example)

D 7 Creeping wave method

D 7.1 Description of method

(1) Longitudinal wave probes with usual angles of incidence of 75 degrees to 80 degrees generate besides a sharp declined transverse wave additionally to the longitudinal main wave a longitudinal wave propagating in parallel to the scanning surface (primary creeping wave).

(2) By the propagation of the primary creeping wave along the scanning surface transverse waves are permanently radiated so that the intensity of the creeping wave rapidly decreases with the sound path length. For example the focal distance in the case of creeping wave dual-element probes with transducer dimensions of $D_0 \approx 6$ mm · 13 mm will be approximately 10 mm, by what a usable ultrasonic beam with a length of approximately 20 mm exists.

(3) Where, for geometric reasons, the primary creeping wave will dip into the volume, e.g. in the case of attachment welds, it will propagate as normal longitudinal wave without radiation. This leads to greater usable sound paths lengths of 30 mm to approximately 50 mm.

D 7.2 Reference block

(1) For the testing level adjustment of creeping wave probes the following reference blocks shall be taken:

a) for testing attachment welds or build-up weldings the reference block as shown in **Figure D-10**, which shall contain flat bottom holes with a diameter of 3 mm distributed over the maximum usable sound path length at equal distances of approximately 5 mm to 10 mm.

b) for testing near-surface areas the reference block as shown in **Figure D-11**, which shall contain a 1 mm deep notch with a length of 20 mm.

(2) When testing with contoured probes, the curvatures of the scanning surfaces of the reference block and the test object shall match.

D 7.3 Testing level adjustment

(1) For testing attachment welds or build-up weldings a DAC curve shall be generated to meet the requirements of Section D 6.3 by means of scanning the respective flat bottom holes in the reference block according to clause D 7.2 (1) a).

(2) For testing near-surface areas the reference echo height shall be the amplitude of the reference reflector according to clause D 7.2 (1) b).

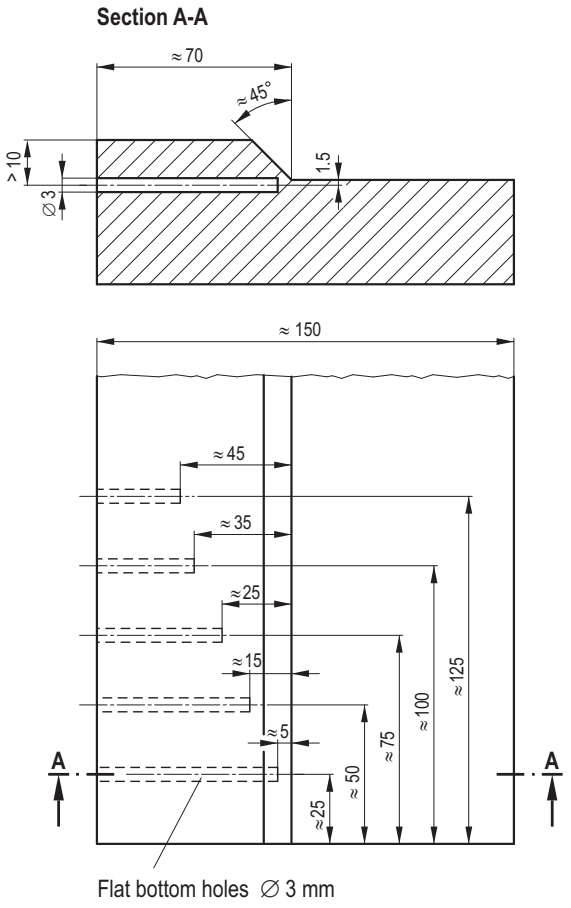


Figure D-10: Reference block for testing level adjustment when using the creeping wave technique (primary creeping wave)

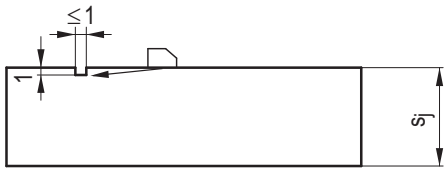


Figure D-11: Reference block for testing level adjustment when using the creeping wave technique (primary creeping wave) for testing near-surface areas

D 7.4 Adaptation of probes

(1) When testing on convex curved scanning surfaces of the test object, the probes shall be selected in accordance with **Figure D-12**.

(2) When testing on concave scanning surfaces of the test object, specific probes with properly contoured contact surfaces shall be used.

D 8 Wave conversion method I (secondary creeping wave)

D 8.1 Description of method

(1) **Figure D-13** shows the principle of reflection with wave conversion in scanning with a longitudinal wave angle-beam probe. When transverse waves in steel hit an opposite face at an angle less than 31 degrees, besides reflection of the transverse wave a wave conversion occurs. A longitudinal wave (secondary creeping wave) is generated at an angle of incidence of approximately 31 degrees which contains portions nearly parallel to the surface. The angle of incidence of approximately 31 degrees is obtained, in the case of test objects with parallel surfaces, by the accompanying transverse wave of a 70-degree longitudinal wave angle-beam probe (**Figure D-14**).

(2) Due to its near-surface linear propagation the secondary creeping wave is e.g. used to cover the root area of a welded joint without being significantly influenced by the excess penetration. In this case it shall be taken into account that

a) the intensity of the secondary creeping wave will rapidly decrease with the sound path subject to the permanent radiation of transverse waves,

b) the secondary creeping wave may be influenced by irregularities (e.g. edges, grooves) in the root area.

(3) During scanning with the longitudinal wave angle-beam probe on test objects having plane-parallel surfaces neighbour echoes are generated which are called NE 1 and NE 2 (**Figure D-15**). For the detection of reflectors the echo NE 2 is used. The echo NE 1 may be used for reflector depth estimation.

(4) When scanning thin test objects (wall thickness up to approximately 20 mm depending on the material) with the longitudinal wave probe (type 70 degree SEL) an analyzable echo amplitude is generated which contains both the longitudinal wave portion (main echo-HE) and the converted transverse wave portion (sequence of secondary echoes-NE) (**Figure D-16**).

Note:

Echoes due to geometric discontinuities may be generated due to the transverse wave generated simultaneously with the beam entry into the test object, since the transverse wave entering at a very steep angle is highly sensitive to irregularities of the probe-remote surface (e.g. gauge marks, identification markings) and reacts to deviations from shape. Therefore, it is especially important to

a) consider the probe position in relation to the centre of the welded joint,

b) know the sound velocities and the related angle of incidence of the transverse wave,

c) know the various echo dynamics.

When exactly allocating the indication to the welded joint and considering the fact that a reflector - contrary to the accompanying transverse wave - has a great dynamic effect when being scanned with 70 degree longitudinal waves, a distinction between such spurious echoes and real defects is possible.

*Scanning with secondary creeping waves in accordance with subpara (2) and (3) is purposeful beginning with a wall thickness exceeding 15 mm. In the case of wall thicknesses 8 mm < s ≤ 20 mm the examination shall be performed with longitudinal wave probes (Type 70 degree SEL). The presence of the main echo HE and the neighbour echo NE shows that the sound waves are reflected at deep material discontinuities. Indications of root notches of little depth are distinguished from deep defects due to the fact that secondary echoes are not obtained (**Figure D-16**).*

D 8.2 Probe

(1) In the case of plane-parallel surfaces of the test object single transducer or dual-element angle-beam longitudinal wave probes with beam angles of 70 degrees are used.

(2) For the testing test objects with none plane-parallel surfaces probes with beam angles shall be used, where the angle of incidence of the transverse wave on the opposite surface is approx. 31 degrees.

Note:

The wall thickness to be tested, the nominal frequency and the transducer dimension as well as the amplitudes of the echo NE 2 obtained from the different deep notches shall be decisive with regard to the selection of the probe.

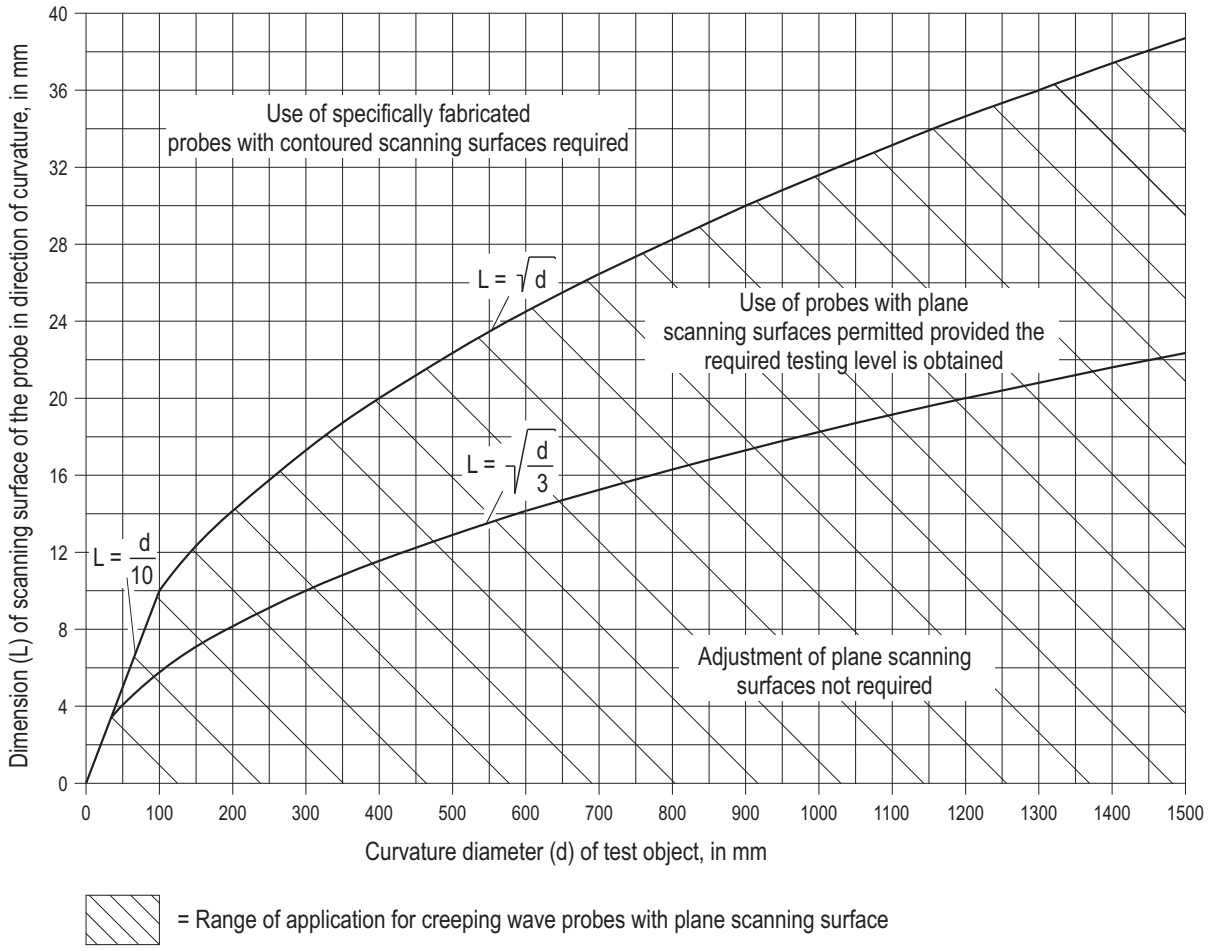


Figure D-12: Ranges of application of creeping wave probes with and without contouring of scanning surfaces for testing on convex test object scanning surfaces

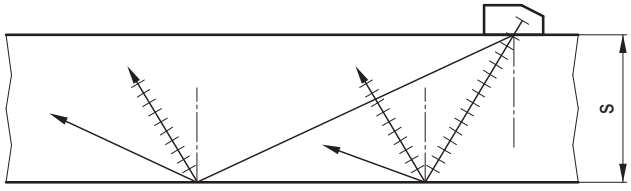


Figure D-13: Reflexion with wave conversion for longitudinal wave angle-beam probe

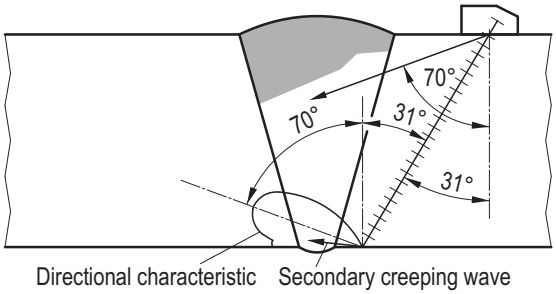


Figure D-14: Testing of internal near-surface area of welded joints by means of secondary creeping waves

D 8.3 Range calibration

(1) The time base range shall be pre-adjusted in accordance with D 6.1 (3).

(2) Hereafter, the zero-point correction for the longitudinal wave angle-beam probe shall be effected. In this case the following procedure may be followed, unless performed on the 100 mm circular arc profile (R100) of calibration block no.1:

A notch with rectangular cross-section provided on the reference block or test object shall be scanned (**Figure D-15**) in which case the transverse wave portion of the longitudinal wave angle-beam probe shall be included. The neighbour echo NE2 shall be optimised by displacing the probe. On the scanning surface the projected surface distance (p') from the point of incidence to the scanned notch shall be determined. By means of the following equation

$$S_{NE2} = 1.5 \cdot s + p'$$

the value of the sound path length of the angle beam probe shall be determined by approximation.

Note:

The neighbour echo NE 1 may be used for controlling the range calibration. The sound path position of the echo NE1 is determined by approximation by means of the formula $S_{NE1} = 2 \cdot s$ at a maximum value of the echo NE2.

D 8.4 Testing level adjustment

(1) The testing level shall be adjusted on a reference block.

(2) To generate a reference echo notches as per clause D 4.2 (2) bd) shall be used.

(3) By displacing the probe on the reference block the echo NE 2 reflected from the notch shall be optimized and thus the reference echo height be determined.

(4) In the case of testing as per clause D 8.1 (4) the testing level shall be adjusted on corresponding notches with rectangular cross-section using longitudinal waves. The recording level is the reference echo amplitude of the direct longitudinal wave minus 6 dB. The indication of the edge on the reference block shall exceed the recording level by at least 10 dB. Otherwise, the recording level shall be reduced accordingly.

D 8.5 Corrections during testing level adjustment

D 8.5.1 Transfer correction

The difference of the acoustic properties between the similar reference block and the test object shall be determined and be considered during testing. This may be done by a global transfer measurement.

D 8.5.2 Correction of sound attenuation caused by the weld metal

Different testing levels caused by the weld metal shall be determined by suitable means and be taken into account.

D 8.6 Performance of testing

(1) Range calibration according to the requirements of Section D 8.3

a) pre-adjustment with straight-beam probe,

b) zero-point correction with longitudinal wave angle-beam probe on the 100 mm circular arc profile (R100) of calibration block no.1,

c) determination of probe index point where required for the longitudinal wave angle-beam probe.

(2) Testing level adjustment according to the requirements of Section D 8.4

a) positioning of probe index point of the longitudinal wave angle-beam probe above the notch of the respective reference block,

b) determination of the distance p' in case of optimised NE2 to reference echo (see **Figure D-15**),

c) consideration of respective allowances for testing level.

(3) Displacement of the probe

The longitudinal wave angle-beam probe shall be displaced vertically to the weld so that the defined testing area is completely covered at the opposite surface.

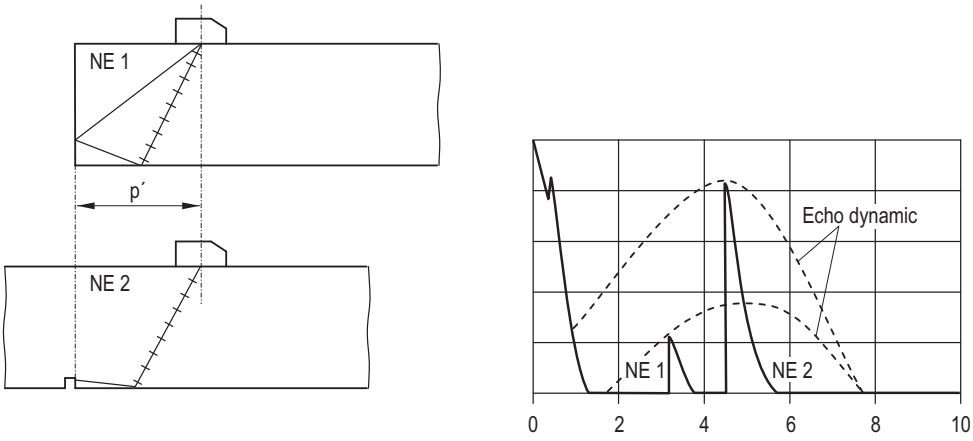
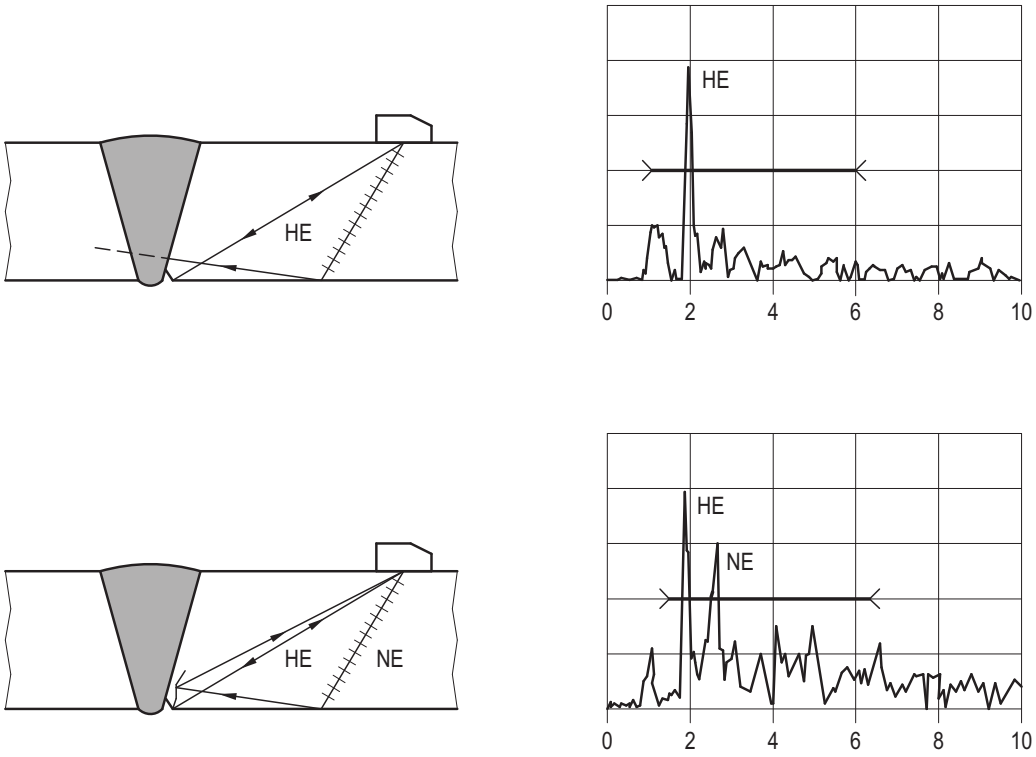


Figure D-15: Sound field geometry during transverse wave conversion



HE: Main echo, NE: Neighbour echo

Figure D-16: Testing of components with nominal wall thicknesses 8 mm < s ≤ 20 mm by means of longitudinal waves (70 degree SEL probe)

D 9 Wave conversion method II (LLT technique)

D 9.1 General

(1) The LLT technique is used to detect reflectors vertical or nearly vertical to the surface during volumetric testing of test objects with parallel or concentrically curved surfaces and up to a nominal wall thickness of 80 mm.

(2) The functional principle of the LLT technique is shown in **Figure D-17**. The transmitting transducer generates a longitudinal wave with an angle of α_{LW} ranging between 7 and 45 degrees. This wave is reflected on the test object back-wall and hits the vertical reflector. Here, the greatest portion of the wave energy is converted to form a transverse wave which is reflected at an angle α_{TW} and is received from the receiving transducer.

(3) The advantage of the LLT technique is the compact design of the LLT probes with the transmitting and receiving transducer being arranged in one housing.

D 9.2 Probes, scanning zones, reference blocks, LLT sensitivity diagrams

D 9.2.1 Use of probes

(1) Due to their specific arrangement of transmitting and receiving transducers the probes are designed for testing of a certain depth zone (scanning zone) at the respective wall thickness and curvature of the test object. The range of application shall be determined by means of probe-specific data sheets.

(2) LLT probes designed for the examination of flat test objects may be used in testing of surfaces concentrically curved in the direction of testing, where great radii of curvature (R exceeding 1000 mm) exist.

D 9.2.2 Probes and their scanning zones

D 9.2.2.1 Location and height of scanning zones

(1) LLT probes are sensitive only in a limited scanning zone (depth zone). The location of the scanning zone is determined by the beam angle α_{LW}, the angle of incidence α_{TW} and by the arrangement of the transducers.

(2) The scanning zone height is determined by the depth area (Z_{H_a}, Z_{H_b}, **Figure D-17**) where the sensitivity has decreased by half the value (-6 dB) compared to the maximum value in the scanning zone centre (Y_{S_a}, Y_{S_b}, **Figure D-17**). The height of the scanning zone depends on the wall thickness, the nominal frequency and the dimensions oft the transmitting and receiving transducer.

D 9.2.2.2 Subdivision of scanning zones

(1) The scanning zones shall cover the volume to be tested, and the scanning zones shall overlap.

Note:

The volume to be examined normally comprises the non-subsurface area as of a depth of 10 mm distanced from the probe-remote surface and probe-adjacent surface.

(2) The subdivision of scanning zones may be estimated based on probe-specific data sheets. Where no probe-specific data sheets are, the location and dimensions of the scanning zones shall be determined by means of measurements with the selected probes on reference blocks with flat bottom holes.

D 9.2.3 Reference blocks

(1) The reference block used for determining the scanning zone dimension and location shall correspond to the test object as regards the geometry and acoustic properties. The reference reflectors are flat bottom holes with the same size as the disc shaped reflectors to be recorded. The reference reflectors shall be provided on the front-face side in the centre of the scanning zone (depth location, distance Y_{S_a}, Y_{S_b}, **Figure D-17**) laid down by the given probe. To confirm proper subdivision of scanning zones, additional reference reflectors shall be provided in the overlapping areas of the zone edges.

(2) The distance of the reference reflectors to the front faces shall be at least 20 mm.

D 9.2.4 Establishment of LLT sensitivity diagrams

(1) With the aid of sensitivity diagrams the testing level adjustment may be simplified.

(2) The diagrams shall be established by means of measurements on flat bottom holes of the reference block in accordance with clause D 9.2.3 for the respective scanning zone. The echo heights (signal amplitudes) measured on the flat bottom holes shall be entered over the depth location (Y_{FBB}, **Figure D-18**). The reference height of the front face (maximum of front-face echo) shall also be entered in the diagram. The distance between the reference height of the front face and the peak of the sensitivity curve from the echo heights of the flat bottom holes defines the value ΔV_{LLT}.

(3) To generate a depth scale the reflector depth location shall be entered in a further diagram over the sound path travel distance (see **Figure D-19**). To this end, at least three flat bottom holes provided at the front-face side of the reference block are necessary.

D 9.3 Range adjustment

(1) The respective LLT probe shall be operated such that at first only the receiving transducer is activated in the pulse-echo mode to generate transverse waves. Range adjustment shall be made at the 100 mm circular arc profile of the calibration block No. 1. The range shall be adjusted such that the sound path travel distance to the centre of the scanning zone is located in the middle of the time base range (S_{Just}). The time base range shall be calculated and adjusted in accordance with formulae D-14 to D-17.

Hereafter, the transmitting transducer shall also be connected and the ultrasonic instrument shall change over to the dual-element mode.

(2) To estimate the depth location of reflectors a depth scale determined in accordance with clause D 9.2.4 shall be used.

D 9.4 Testing level adjustment

D 9.4.1 General

(1) The testing level shall be adjusted using the following reference reflectors:

a) end faces (front faces) or flat bottom holes vertical to the scanning surface of the test object or reference block

or

b) flat-bottom holes which, depending on the testing task, are oblique to the scanning surface of the test object.

The flat bottom holes shall be of the same size as the disk shaped reflectors to be recorded.

(2) During testing level adjustment the zone edge allowance and transfer correction shall be considered.

D 9.4.2 Adjustment on end faces vertical to the scanning surface of the test object (front faces)

(1) For this type of adjustment probe-specific LLT sensitivity diagrams shall be submitted in accordance with clause D 9.2.4.

(2) When setting the testing level the value ΔV_{LLT} shall be taken from the probe-specific LLT sensitivity diagram (see **Figure D-18**) for the centre of the scanning zone (Y_s) and be increased by 6 dB for the zone edge. The setting shall be checked by means of flat bottom holes.

D 9.4.3 Adjustment on flat-bottom holes

Where no sensitivity diagrams are available or reference reflectors oblique to the test object scanning surface are to be found, the testing level shall be adjusted on flat bottom holes in a reference block. For each scanning zone at least three flat bottom holes shall be provided.

D 9.5 Transfer correction

(1) In the case of ferritic steels the transfer correction may globally be assumed to be 2 dB.

(2) In the case of austenitic steels and nickel alloys the difference of the acoustic properties between the similar reference block and the test object shall be determined and be considered. This may also be done by assuming a global transfer measurement.

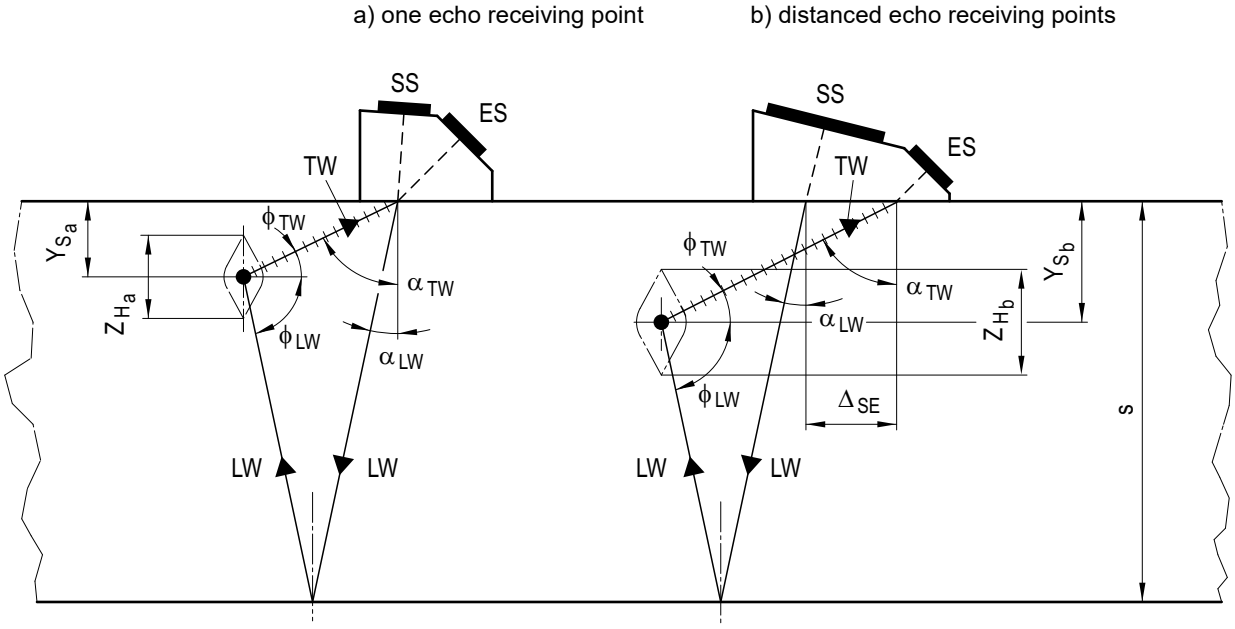
D 9.6 Performance of testing

(1) The testing using the LLT technique shall be performed separately for each scanning zone.

(2) The probe shall be coupled on the test object for each scanning zone at a distance a'_{LLT} (see **Figure D-18**) to the centre of the weld. The distances a'_{LLT} shall be determined on the reference block.

(3) The probes shall be moved over each scanning zone vertically to the direction of weld progress such that the volume to be tested is completely covered.

(4) The LLT probe coupling shall be monitored by observing the noise.



$$\alpha_{TW} = \arccos\left(\frac{c_{TW}}{c_{LW}} \cdot \cos \alpha_{LW}\right)$$

$$Y_{S_a}, Y_{S_b} = \frac{2\,s \cdot \tan \alpha_{LW} + \Delta_{SE}}{\tan \alpha_{TW} + \tan \alpha_{LW}}$$

Z_{H_a}, Z_{H_b} : depth zone

Figure D-17: Principle of LLT technique

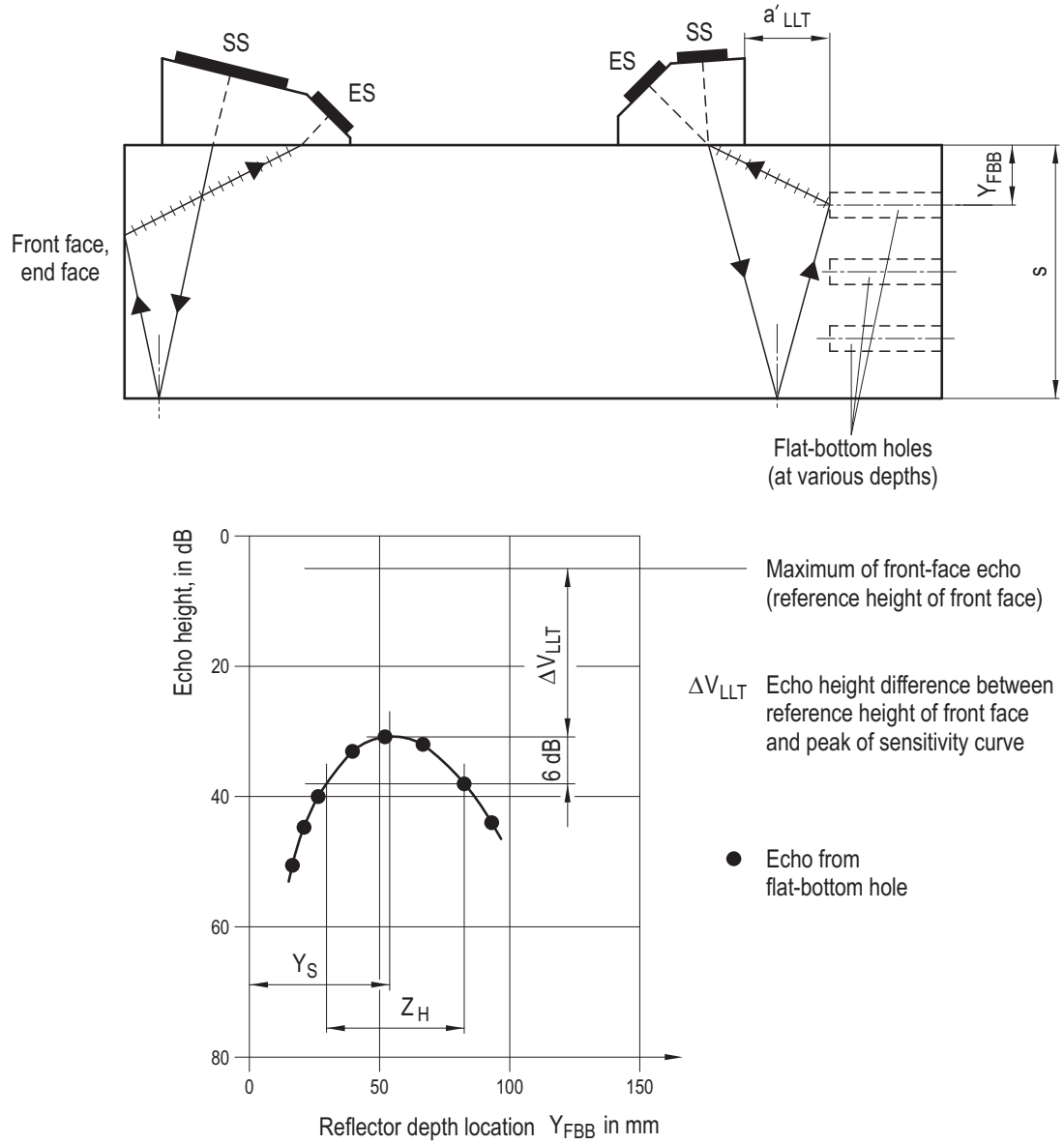


Figure D-18: Example for a LLT sensitivity diagram

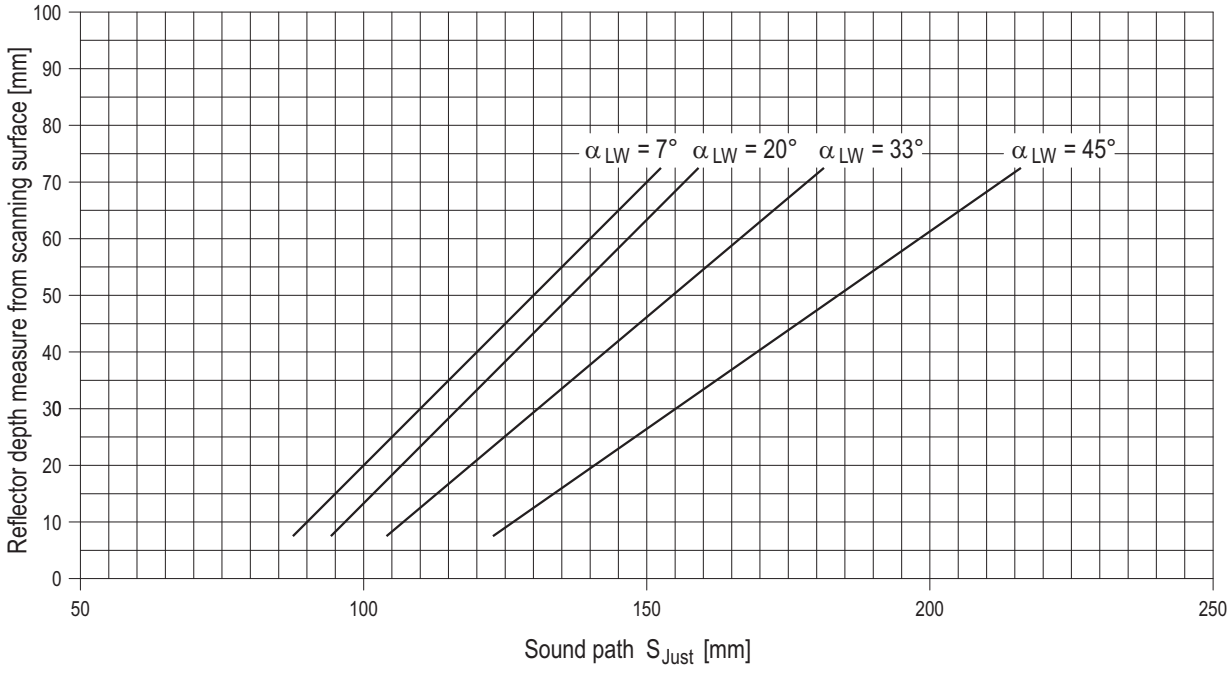


Figure D-19: Example for LLT reflector depth scales

D 10 Performance of testing

D 10.1 Overlap

To ensure complete coverage during testing the distance between two adjacent scanning tracks in the examination volume shall be smaller than the beam width $D_{B\text{-}6dB}$ transverse to the scanning direction.

D 10.2 Rate of probe movement

When selecting the rate of probe movement the pulse repetition frequency, the operator's ability of detecting signals and the test instrument's capability of recording signals shall be taken into account.

During manual scanning the rate of probe movement should not exceed 150 mm/s.

D 10.3 Adjustment and check of the test system

(1) Prior to testing, the testing level and range adjustments shall be made after the warm-up periods given by the instrument manufacturer. To this end, suitable calibration or reference blocks shall be used. The instrument setting shall be maintained during scanning and shall be controlled regularly during and at the end of testing.

(2) Where deviations from the checks made before are found, all tests performed after the last check without deviations shall be repeated with a corrected adjustment.

D 11 Description of indications

D 11.1 Echo amplitude

The maximum echo amplitude of an indication referred to the respective valid recording level is to be indicated in dB.

Note:
The reproduceability of the echo amplitude determination is generally ± 3 dB.

D 11.2 Extension of indications

D 11.2.1 General requirements

Lengths of indications equal to or greater than 10 mm shall be measured. Shorter indication lengths shall be recorded as „< 10".

D 11.2.2 Determination of the recording length at fixed recording level

The extension of reflector (see **Figure D-20**) shall be given by the probe displacement range. This range is determined as the distance between locations where the echo amplitude is lower the recording level by either 0 dB, 6 dB or 12 dB. Where the noise level is reached, the recording length shall be indicated to cover the point where the echo reaches the noise level. Here, the distance of the recording level to the noise level shall be recorded.

D 11.2.3 Determination of half-amplitude length

When measuring the half-amplitude length of indications, the related probe displacements at echo amplitude decreases of 6 dB compared to the maximum echo amplitude shall be determined. Here, for dual-element probes the acoustic separating line and for line focussing probes the line focus shall be vertical to the extension direction of the indication.

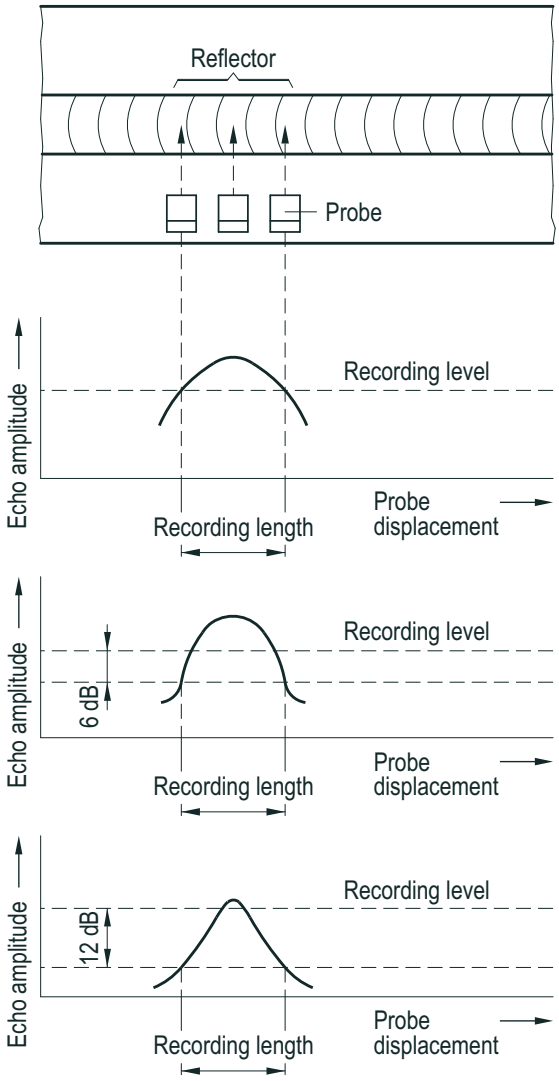


Figure D-20: Determination of recording length

D 11.2.4 Methods for the exact determination of indication extension

The determination of the indication extension may be optimized by one of the corrections described in clauses D 11.2.4.1 to D 11.2.4.4 or by examinations according to clause D 11.2.5.

D 11.2.4.1 Correction for curved surfaces

For curved surfaces the length shall be determined mathematically or graphically in the reflector depth determined.

D 11.2.4.2 Selection of probe

Scan positions and beam angle shall be selected such that the scan path length shows the slightest deviation from 1.0 · N however is greater than 0.7 · N. In such a case, a higher nominal frequency than during the test may be used.

D 11.2.4.3 Consideration of sound beam width

(1) The sound beam width $D_{S\text{-}6dB}$ shall be determined at the reflector location. If the measured indication length exceeds this measured beam width the length of indication shall be the corrected recording length calculated as per equation D-6.

(2) The beam width shall be determined by calculation or experimental analysis.

(3) In the case of calculation equation D-4 shall be used if probes are used, the contact surface of which has not been adapted. In the case of angle beam scanning the horizontal included angle shall be inserted for γ_6. The included angle shall be taken from the data sheets on the probes used.

(4) Where the beam width has to be determined by experimental analysis, measurements shall be made on a reference block to Section D 3.3. A reference reflector shall be provided into this reference block at the same depth location like for the reflector to be gauged. As reference reflector a flat bottom hole of 3 mm diameter may be suited. The half-amplitude length shall be determined on the reference reflector on the same sound path travel distance as for the reflector to be gauged. The value determined such shall correspond to the beam width at the respective depth of reflector.

D 11.2.4.4 Use of dual-element probes and focussing probes

(1) By means of dual-element probes or focussing probes with suitable sound field the indication length shall be measured in the focal zone using the half-amplitude method.

(2) In this case several echo dynamics may be recorded from the reflector on a grid pattern to increase the measuring accuracy and to improve the reproduceability in the case of focussing probes. The grid-line distances shall be smaller than the diameter of the focussing beam of the probe.

D 11.2.5 Use of additional ultrasonic testing techniques for the determination of indication extension

Where additional ultrasonic testing techniques are to be used to determine the indication extension (length or depth), the procedural requirements shall be laid down in a test instruction.

Note:

Examples for ultrasonic testing techniques for a more exact determination of indication extension are:

a) Synthetic aperture focussing technique (SAFT),

b) Time-of-flight diffraction technique (TOFD),

c) Crack-tip signal detection technique,

d) Echo tomography.

D 11.3 Indications due to geometric discontinuities

(1) Where indications from the root area of a weld are to be classified as indications due to geometric discontinuities, control measurements shall be made to determine the cause of indication.

(2) If it is to be proved that the indications recorded from both weld sides arise on the two flanks of the excess penetration and are not caused by weld defects, the control measurement may be made by measuring the projected-surface distance on the test piece (see **Figure D-21 a**). The exact projected-surface distances shall be determined on notches having rectangular cross-section with a depth and width of 1 mm each on a reference block (see **Figure D-21 b**). Where it is found out that the projected-surface distances of the respective indications clearly overlaps [(2a - a') equal to or greater than 3 mm], the indications are considered to be caused by geometric discontinuities. Where a smaller distance than 3 mm is found, the indications shall no more be treated separately.

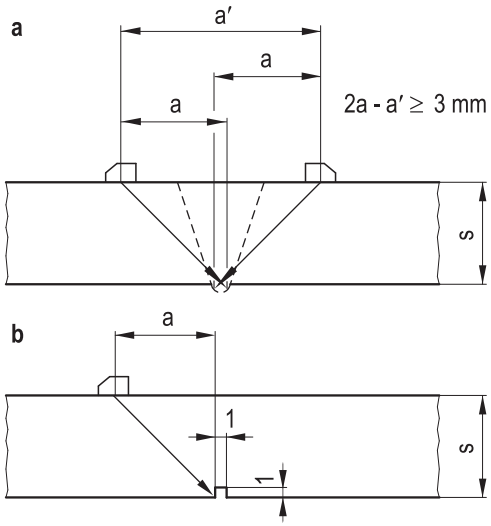


Figure D-21: Proof of indications caused by structural discontinuities from the root area of single-side welds

Annex E

Performance of surface inspections by magnetic particle and penetrant methods

E 1 General requirements

E 1.1 Surface condition

(1) The surfaces to be inspected shall show a condition suitable for testing.

(2) They shall be free from scale, weld spatter or other disturbing impurities.

(3) Grooves and notches affecting the test result shall be removed.

E 1.2 Viewing conditions

(1) The viewing conditions of DIN EN ISO 3059 shall be observed. In addition, the requirements as per (2) to (5) shall be met.

(2) The eyes of the operator shall have at least 5 minutes to adapt to the light conditions.

(3) For the purpose of better detectability of defects sufficient contrast shall be provided in magnetic particle testing by the use of suitable media (e.g. fluorescent detection media or application of a thin colour coat only slightly covering the underground). Ultraviolet radiation of type UVA may additionally be used to improve the contrast in penetrant testing using fluorescent penetrants.

(4) During the inspection the angle of viewing shall not deviate by more than 30 degrees from the surface normal. During viewing the distance to the examination surface shall normally be approximately 300 mm.

(5) For the inspection auxiliary means (e.g. magnifying glasses, contrast-improving spectacles, mirrors) are permitted.

E 1.3 Post-cleaning

Upon completion of inspection, the parts shall be properly cleaned to remove residues from the test fluid.

E 2 Magnetic particle testing

E 2.1 Methods and performance of testing

Magnetic particle testing shall be performed to DIN EN ISO 9934-1 to meet the following requirements.

E 2.1.1 Methods

(1) Where magnetisation is achieved in partial areas by current flow technique or yoke magnetisation, AC magnetisation shall normally be used.

(2) The DC magnetisation method shall only be used upon agreement by the authorized inspector.

(3) The residual magnetic field strength shall not exceed 800 A/m unless a lower value is required for the fabrication. Where the specified value is exceeded, the part shall be demagnetised and the value of the residual magnetic field strength be recorded.

(4) For the magnetic particle testing techniques the following identifying characters shall be used:

Magnetic particle testing technique		Characters
Yoke magnetization	with permanent magnet	JD
	with electromagnet	JE
Magnetization by current carrying-conductors	with coil	LS
	with other conductors (cable)	LK
Magnetization by current flow	self-induced current	SS
	induced current flow	SI

E 2.1.2 Contact areas in case of direct magnetisation

(1) Where the test is performed by current flow technique, consumable electrodes (e.g. lead fin alloys) shall be used, if possible. It shall be ensured that in the contact areas overheating of the material to be tested is avoided.

(2) Where overheating has occurred the overheated areas shall be marked, ground over after the test and be examined for surface cracks, preferably by magnetic particle testing using yoke magnetisation.

E 2.1.3 Direction of magnetisation

Each location on the surface shall be tested from two directions of magnetisation offset by approximately 90 degrees.

E 2.1.4 Magnetic field strength

(1) In the case of AC magnetisation the tangential field strength on the surface shall normally be at least 2 kA/m and shall not exceed 6.5 kA/m.

Note:

a) The required magnetic flux density in the test object surface of at least 1 Tesla will be obtained in low-alloy or low-carbon steels with high relative permeability as early as at a tangential field strength of 2 kA/m.

b) For other steels with lower permeability a higher field strength may be required.

c) Where magnetisation is too high, structural indications (spurious indications) may cover relevant indications.

(2) It shall be checked by measurements that these values are adhered to or test conditions shall be determined under which these values may be obtained.

E 2.1.5 Magnetisation times

The following guide values apply with respect to the application of the magnetic particles and magnetisation:

a) Magnetisation and application: at least 3 seconds

b) Subsequent magnetisation: at least 5 seconds

E 2.2 Inspection medium

According to DIN EN ISO 9943-2 sample-tested media shall be used. Verification of such sample testing shall be submitted to the authorized inspector.

E 2.2.1 Wet particle inspection method

(1) Magnetic particles with an average grain size smaller than or equal to 8 µm shall be used. Depending on application, black, fluorescent or coloured powders may be used.

Note:

The required average grain size ensures comparability with in-service inspections, cf. DIN 25435-2.

(2) Prior to bathing the surface care shall be taken to ensure that the magnetic powder is distributed uniformly in the vehicle fluid and is kept in suspension. Prior to and during testing the powder suspension shall be spot-checked by suitable pre-magnetised test units.

E 2.2.2 Dry particle method

(1) The dry particle method shall only be used for an intermediate test in warm condition.

(2) The device for applying the powder shall make possible such a fine spraying that no accumulations of powder occurs. It shall be ensured that the powders used do not agglomerate under the influence of the workpiece temperature.

E 2.3 Test instruments

The test instruments shall meet the requirements of DIN EN ISO 9934-3.

E 3 Penetrant testing

E 3.1 Testing system

(1) Colour contrast penetrants shall preferably be used. Fluorescent penetrants or fluorescent colour contrast penetrants may also be used.

(2) Solvents or water or both in combination may be used as penetrant remover.

(3) Only wet developers suspended in an aqueous solvent shall be used. Dry developers may only be applied on the testing surface by electrostatic charging.

(4) For the examination system at least sensitivity class „highly sensitive“ to DIN EN ISO 3452-2 shall be adhered to.

(5) The suitability of the testing system (penetrant, solvent remover and developer) shall be demonstrated by means of a sample examination as to DIN EN ISO 3452-2. The results of the demonstration by sample testing shall be submitted to the authorized inspector.

(6) Penetrants in test equipment and partly used open tanks (except for aerosol cans) shall be monitored by the user with flux indicator 2 to DIN EN ISO 3452-3. In this test the maximum penetration and development times shall not exceed the minimum times specified for the evaluation. The testing sensitivity obtained shall be recorded.

E 3.2 Performance

(1) Penetrant testing shall be performed to DIN EN ISO 3452-1 to meet the following requirements.

(2) The penetration time shall normally be at least half an hour.

(3) Immediately after drying of the developer a first inspection shall normally be made. A further inspection shall normally be made not earlier than half an hour after the first inspection has passed.

(4) Further inspection times are required if during the second inspection indications are detected which were not visible during the first inspection.

Note:

Further inspection times may also be suitable if during the second inspection significant changings or additional indications are detected.

(5) The evaluation shall be made in consideration of the results of all inspections.

Annex F

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.)

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 Promulgated on March 3rd 2015 (BAnz AT 30.03.2015 B2)
Interpretations	(2015-03)	Interpretations of the Safety Requirements for Nuclear Power Plants of November 22nd 2012, as Amended on March 3rd 2015 (BAnz. AT 30.03.2015 B3)
KTA 1401	(2017-11)	General Requirements Regarding Quality Assurance
KTA 1404	(2013-11)	Documentation during the Construction and Operation of Nuclear Power Plants
KTA 1408.1	(2017-11)	Quality Assurance for Weld Filler Materials and Weld Additives for Pressure and Activity Retaining System in Nuclear Power Plants; Part 1: Suitability Testing
KTA 1408.2	(2017-11)	Quality Assurance for Weld Filler Materials and Weld Additives for Pressure and Activity Retaining System in Nuclear Power Plants; Part 2: Manufacturing
KTA 1408.3	(2017-11)	Quality Assurance for Weld Filler Materials and Weld Additives for Pressure and Activity Retaining System in Nuclear Power Plants; Part 3: Processing
KTA 2201.1	(2011-11)	Design of Nuclear Power Plants against Seismic Events; Part 1: Principles
KTA 3201.1	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 1: Materials and Product Forms
KTA 3201.3	(2017-11)	Components of the Reactor Coolant Pressure Boundary of Light Water Reactors; Part 3: Manufacture
KTA 3205.2	(2015-11)	Non-integral Component Supports; Part 2: Non-integral Component Supports for Pressure and Activity Retaining Components in Systems outside the Primary Circuit
KTA 3205.3	(2006-11)	Non-integral Component Supports; Part 3: Series-produced Standard Supports
KTA 3206	(2014-11)	Verification Analysis for Rupture Preclusion for Pressure Retaining Components in Nuclear Power Plants
KTA 3211.1	(2017-11)	Pressure and Activity Retaining Components of Systems outside the Primary Circuit; Part 1: Materials
KTA 3211.2	(2013-11)	Pressure and Activity Retaining Components of Systems outside the Primary Circuit; Part 2: Design and Analysis
KTA 3211.4	(2017-11)	Pressure and Activity Retaining Components of Systems outside the Primary Circuit; Part 4: Inservice Inspections and Operational Monitoring
DIN EN ISO 148-1	(2017-05)	Metallic materials - Charpy pendulum impact test - Part 1: Test method (ISO 148-1:2016); German version EN ISO 148-1:2016
DIN EN 287-1	(2011-11)	Qualification test of welders - Fusion welding - Part 1: Steels; German version EN 287-1:2011
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 636:2015); German version EN ISO 636:2015
DIN EN 1011-1	(2009-07)	Welding - Recommendations for welding of metallic materials - Part 1: General guidance for arc welding; German version EN 1011-1:2009
DIN 1910-11	(1979-02)	Welding; terms dependent on materials for metal welding
DIN 1910-100	(2008-02)	Welding and allied processes - Vocabulary - Part 100: Metal welding processes with additions to DIN EN 14610:2005

DIN EN ISO 2400	(2013-01)	Non-destructive testing - Ultrasonic testing - Specification for calibration block No. 1 (ISO 2400:2012); German version EN ISO 2400:2012
DIN 2559-2	(2007-09)	Edge preparation for welding - Part 2: Matching of inside diameter for circumferential welds on seamless pipes
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 ISO 2768-1	(1991-06)	General tolerances; tolerances for linear and angular dimensions without individual tolerance indications; identical with ISO 2768-1:1989
DIN ISO 2768-2	(1991-04)	General tolerances; geometrical tolerances for features without individual tolerances indications; identical with ISO 2768-2:1989
DIN EN ISO 3059	(2013-03)	Non-destructive testing - Penetrant testing and magnetic particle testing - Viewing conditions (ISO 3059:2012); German version EN ISO 3059:2012
DIN EN ISO 3452-1	(2014-09)	Non-destructive testing - Penetrant testing - Part 1: General principles (ISO 3452-1:2013, Corrected version 2014-05-01); German version EN ISO 3452-1:2013
DIN EN ISO 3452-2	(2014-03)	Non-destructive testing - Penetrant testing - Part 2: Testing of penetrant materials (ISO 3452-2:2013); German version EN ISO 3452-2:2013
DIN EN ISO 3452-3	(2014-03)	Non-destructive testing - Penetrant testing - Part 3: Reference test blocks (ISO 3452-3:2013); German version EN ISO 3452-3:2013
DIN EN ISO 3580	(2011-05)	Welding consumables - Covered electrodes for manual metal arc welding of creep-resisting steels - Classification (ISO 3580:2010); German version EN ISO 3580:2011
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 3651-2	(1998-08)	Determination of resistance to intergranular corrosion of stainless steels - Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels - Corrosion test in media containing sulfuric acid (ISO 3651-2:1998); German version EN ISO 3651-2:1998
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 4287	(2010-07)	Geometrical Product Specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters (ISO 4287:1997 + Cor 1:1998 + Cor 2:2005 + Amd 1:2009); German version EN ISO 4287:1998 + AC:2008 + A1:2009
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 5178	(2011-05)	Destructive tests on welds in metallic materials - Longitudinal tensile test on weld metal in fusion welded joints (ISO 5178:2001); German version EN ISO 5178:2011
DIN EN ISO 5577	(2017-05)	Non-destructive testing - Ultrasonic testing - Vocabulary (ISO 5577:2017); German version EN ISO 5577:2017
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 6507-4	(2006-03)	Metallic materials - Vickers hardness test - Part 4: Tables of hardness values (ISO 6507-4:2005); German version EN ISO 6507-4:2005
DIN EN ISO 6508-1	(2016-12)	Metallic materials - Rockwell hardness test - Part 1: Test method (ISO 6508-1:2016); German version EN ISO 6508-1:2016
DIN EN ISO 6520-1	(2007-11)	Welding and allied processes - Classification of geometric imperfections in metallic materials - Part 1: Fusion welding (ISO 6520-1:2007); Trilingual version EN ISO 6520-1:2007
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 7963	(2010-12)	Non-destructive testing - Ultrasonic testing - Specification for calibration block No. 2 (ISO 7963:2006); German version EN ISO 7963:2010
DIN 8580	(2003-09)	Manufacturing processes - Terms and definitions, division
DIN EN ISO 9013	(2017-05)	Thermal cutting - Classification of thermal cuts - Geometrical product specification and quality tolerances (ISO 9013:2017); German version EN ISO 9013:2017
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 9606-4	(1999-06)	Approval testing of welders - Fusion welding - Part 4: Nickel and nickel alloys (ISO 9696-4:1999); German version EN ISO 9606-4:1999
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 ISO 9906	(2013-03)	Rotodynamic pumps - Hydraulic performance acceptance tests - Grades 1, 2 and 3 (ISO 9906:2012); German version EN ISO 9906:2012
DIN EN ISO 9934-1	(2017-03)	Non-destructive testing - Magnetic particle testing - Part 1: General principles (ISO 9934-1:2016); German version EN ISO 9934-1:2016
DIN EN ISO 9934-2	(2015-12)	Non-destructive testing - Magnetic particle testing - Part 2: Detection media (ISO 9934-2:2015); German version EN ISO 9934-2:2015
DIN EN ISO 9934-3	(2015-12)	Non-destructive testing - Magnetic particle testing - Part 3: Equipment (ISO 9934-3:2015); German version EN ISO 9934-3:2015
DIN EN 10204	(2005-01)	Metallic products - Types of inspection documents; German version EN 10204:2004
DIN EN 10216-2	(2014-03)	Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties; German version EN 10216-2:2013
DIN EN 10216-5	(2014-03)	Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 5: Stainless steel tubes; German version EN 10216-5:2013 (Corrigendum 2015-01)
DIN EN 10217-2	(2005-04)	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties; German version EN 10217-2:2002 + A1:2005
DIN EN 10217-5	(2005-04)	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 5: Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties; German version EN 10217-5:2002 + A1:2005
DIN EN 10217-7	(2015-01)	Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes; German version EN 10217-7:2014
DIN EN ISO 10675-1	(2013-12)	Non-destructive testing of welds - Acceptance levels for radiographic testing - Part 1: Steel, nickel, titanium and their alloys (ISO 10675-1:2008); German version EN ISO 10675-1:2013
DIN ISO 10816-7	(2009-08)	Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts - Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts (ISO 10816-7:2009)
DIN EN ISO 11699-1	(2012-01)	Non-destructive testing - Industrial radiographic films - Part 1: Classification of film systems for industrial radiography (ISO 11699-1:2008); German version EN ISO 11699-1:2011
DIN EN 12266-1	(2012-06)	Industrial valves - Testing of metallic valves - Part 1: Pressure tests, test procedures and acceptance criteria - Mandatory requirements; German version EN 12266-1:2012
DIN EN 12266-2	(2012-04)	Industrial valves - Testing of metallic valves - Part 2: Tests, test procedures and acceptance criteria - Supplementary requirements; German version EN 12266-2:2012
DIN EN 12668-1	(2010-05)	Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 1: Instruments; German version EN 12668-1:2010
DIN EN 12668-2	(2010-06)	Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 2: Probes; German version EN 12668-2:2010

DIN EN 12668-3	(2014-02)	Non-destructive testing - Characterization and verification of ultrasonic examination equipment - Part 3: Combined equipment; German version EN 12668-3:2013
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 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 weld 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	(2010-04)	Welding consumables - Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels - Classification (ISO 14343:2009); German version EN ISO 14343:2009
DIN EN 14610	(2005-02)	Welding and allied processes - Definitions of metal welding processes; Trilingual version EN 14610:2004
DIN EN 14700	(2014-07)	Welding consumables - Welding consumables for hard-facing; German version EN 14700:2014
DIN EN ISO 14731	(2006-12)	Welding coordination - Tasks and responsibilities (ISO 14731:2006); German version EN ISO 14731:2006
DIN EN ISO 14732	(2013-12)	Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732:2013); German version EN ISO 14732:2013
DIN EN ISO 15614-1	(2012-06)	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1:2004 + Amd 1:2008 + Amd 2:2012); German version EN ISO 15614-1:2004 + A1:2008 + A2:2012
DIN EN ISO 15614-8	(2016-11)	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 8: Welding of tubes to tube-plate joints (ISO 15614-8:2016); German version EN ISO 15614-8:2016
DIN EN ISO 15614-11	(2002-10)	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 11: Electron and laser beam welding (ISO 15614-11:2002); German version EN ISO 15614-11:2002
DIN EN ISO 17636-1	(2013-05)	Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film (ISO 17636-1:2013); German version EN ISO 17636-1:2013
DIN EN ISO 17636-2	(2013-05)	Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2:2013); German version EN ISO 17636-2:2013
DIN EN ISO 17637	(2011-05)	Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637:2003); German version EN ISO 17637:2011
DIN EN ISO 19232-1	(2013-12)	Non-destructive testing - Image quality of radiographs - Part 1: Determination of the image quality value using wire-type image quality indicators (ISO 19232-1:2013); German version EN ISO 19232-1:2013
DIN EN ISO 19232-3	(2014-02)	Non-destructive testing - Image quality of radiographs - Part 3: Image quality classes (ISO 19232-3:2013); German version EN ISO 19232-3:2013
DIN EN ISO 19232-5	(2013-12)	Non-destructive testing - Image quality of radiographs - Part 5: Determination of the image unsharpness value using duplex wire-type image quality indicators (ISO 19232-5:2013); German version EN ISO 19232-5:2013
DIN ISO 21940-11	(2017-03)	Mechanical vibration - Rotor balancing - Part 11: Procedures and tolerances for rotors with rigid behaviour (ISO 21940-11:2016)
DIN 24299-1	(1985-05)	Name plates for pumps; general specification
DIN 25410	(2012-07)	Nuclear facilities - Surface cleanliness of components
DIN 25435-1	(2014-01)	In-service inspections for primary coolant circuit components of light water reactors - Part 1: Automated ultrasonic testing
DIN 25435-2	(2014-01)	In-service inspections for primary coolant circuit components of light water reactors - Part 2: Magnetic particle and penetrant testing
DIN 25435-7	(2014-01)	In-service inspections for primary coolant circuit components of light water reactors - Part 7: Radiographic testing

DIN 50125	(2016-12)	Testing of metallic materials - Tensile test pieces
DIN CEN ISO/TR 15608	(2013-08)	Welding - Guidelines for a metallic materials grouping system (ISO/TR 15608:2013); German version CEN ISO/TR 15608:2013
AD 2000-Merkblatt A 2	(2015-04)	Safety devices against excess pressure - Safety valves
AD 2000-Merkblatt HP 0	(2013-02)	Genral principles of design, manufacture and associated tests
AD 2000-Merkblatt HP 2/1	(2017-06)	Procedure testing for joining processes - Procedure testing for welded joints
AD 2000-Merkblatt HP 3	(2014-11)	Welding supervisors, welders
AD 2000-Merkblatt W 0	(2016-05)	General principles for materials

Annex G (informative)

Changes with respect to the edition 2012-11

(1) The section “Fundamentals” was adapted in paragraph 1 to the formulation obligatory for all KTA safety standards. Paragraph 2 was supplemented to include stipulations from the “Safety Requirements for Nuclear Power Plants” (SiAnf) and from the “Interpretations on the Safety Requirements for Nuclear Power Plants”. In addition, a reference to KTA 3206 was amended in paragraph 2.

(2) The entire safety standard was adapted to the current state of standardization and the normative references in Annex F were updated. In this context the material group 4.1, which was indicated for the material 20 MnMoNi 5 5 in clauses 3.3.2.3 (1) and 3.3.3.3 (1) as well as in Tables 8-1, 8-3, 8-7, 8-8 and 8-9, was replaced by material group 4.2. Furthermore, the materials given in Tables 7-1 and 8-1 as well as the materials mentioned in clauses 5.3 (7) and 5.5.3 (3) b) were adapted to KTA 3211.1 (2015-11).

(3) Section 2 “Definitions” was supplemented to contain the definitions “echo height evaluation” and “room temperature”.

(4) In paras. 3.3.2 and 3.3.3 the requirements for welding personnel were revised in consideration of the current standards, here changes were made due to the following facts:

a) The current standard DIN EN ISO 9606-1:2013-12 is not equivalent to the preceding standard DIN EN 287-1:2011-11, since the weld filler metal is the basis for qualification and not the base metal (as in DIN EN 287-1:2011-11). In addition, the scope for the qualification of base metals was extended compared to Table 2 of DIN EN 287-1:2011-11.

   To maintain the equivalence to the former requirements, sub-para. 3.3.2.3 (1) was supplemented to include, in addition to the requirements of DIN EN ISO 9606-1, that the scope for base metals as per Table 2 of DIN EN 287-1:2011-11 has to be satisfied.

b) Sub-para. 3.3.2.3 (2) b) and clause 3.3.2.5 were adapted to the current edition of AD-2000 Merkblatt HP 3 (2014-11).

(5) In section 3.3.4, the formerly lacking requirements for personnel performing leak tests (LT) were added, since leak-testing is required in section 9.3.9.

(6) Section 5 was changed as follows:

a) In compliance with KTA 3201.3 and in consideration of the requirements for product forms in KTA 3211.1, the requirements regarding tempering colours in sub-para. 5.5.4 (2) were put more precisely.

b) In para. A 3.5.4 (1) it was clarified that the acceptance criteria for non-destructive testing specified in section 11 shall apply for external irregularities on welds and not the requirements of DIN EN ISO 5817.

(7) Section 8 was changed as follows:

a) The requirements in section 8.1.1.3.3 were put more precisely by taking over the stipulations laid down in KTA 3201.3.

b) Some clarifications have been included in Tables 8-3 to 8-9. Furthermore, the specification contained in KTA 3211.1 regarding the use of specimens with a width less than 10 mm has been introduced in a footnote of Table 8-5.

c) The former row „Materials for heat exchanger tubes” in Table 8-5 was deleted, since due to the dimensions the notched bar impact test cannot be performed.

(8) The marking procedures "electric engraving" (instead of the former mentioned "vibratooling") and "laser marking" have been included in clause 9.1.1 (4).

(9) Section 11 “Non-destructive tests and examinations” was changed as follows:

a) In Section 11.2.3.4 it was clarified that for ultrasonic testing the requirements for the test object as specified in Section D 3 shall apply. Furthermore, based on the experience gained when applying the edition KTA 3201.4 (2010-11), it was set down in addition to the requirements of Table 5-4 and clause 5.1 (3) that the inner surface of dissimilar welds shall be ground flush without any notches in any case.

b) New stipulations regarding the use of digital radiography were included in section 11.2.4.2. The specifications in Tables 4-2 and 9-4 as well as in sub-clause 9.3.6.4 b) were adapted accordingly and a new form for digital radiography was included in Annex A. The last sentence in sub-clause (3) c) was deleted, since this requirement is already covered by the current edition of DIN 25435-7.

c) Experience gained during testing of welds between austenitic steels as well as between ferritic and austenitic steels has shown that the limits of reliable manual testing are generally exceeded when the tests according to 11.4.2.3 and 11.5.4 are performed. Therefore, the requirement in sections 11.2.4.3 and 11.4.2.3.1 was changed to require that these welds shall be tested by mechanized testing.

d) In addition to the requirements of clause 9.3.6.2.2 (1) and Table 9-5, section 11.3.4.1 was changed to clarify that welds on ferritic steels shall be subjected to ultrasonic testing for longitudinal and transverse defects.

e) The criteria mentioned in section 11.4.2.3.2 regarding the suitability of techniques for the testing of butt welds and unclad base metals were revised and adapted to the requirements in KTA 3201.4 (2016-11). The revised stipulations now make a clear distinction between cases where echo height evaluation is possible and cases where pattern recognition is to be applied. The revision was made based on experience gained with the application of the requirements laid down in KTA safety standard 3201.4 (2010-11). The criteria to be satisfied are shown in the new Table 11-18. Cases 1 and 2 now shown in this Table cover all relevant practical applications for the testing of butt welds and unclad base metals. Consequently, the requirements regarding the recording levels and the acceptance criteria were adapted accordingly.

f) A reference to section 9.3.15 was included in section 11.5.4.1, since section 9.3.15 contains additional requirements for testing dissimilar welds after welding.

g) The specifications for pores in Table 11-5 were deleted. Thus, the requirements for pores comply with the requirements of DIN EN ISO 5817.

(10) The samples for forms in Annex A were revised based on the current standards. Forms for digital radiographic testing were added.

(11) Annex D “Performance of manual ultrasonic testing” was revised and updated based on KTA 3211.1 (2015-11).

(12) In Annex E “Performance of surface inspections by magnetic particle and penetrant methods” some requirements were simplified and and put more precisely to adapt them to the current editions of the relevant DIN-standards referred to in this Safety Standard.